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TDA7402

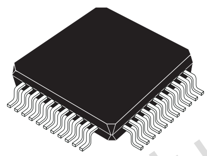
Car radio signal processor

Features

- 3 stereo inputs
- 3 mono inputs
- Dynamic-compression-stage for cd
- Soft Step volume
- Bass, treble and loudness control
- Voice-band filter
- Direct mute and Soft Mute
- Internal beep
- Four independent speaker-outputs
- Stereo subwoofer output
- Independent second source-selector
- Full mixing capability
- Pause detector

Stereo decoder

- RDS mute
- No external adjustments
- AM/FM noiseblanker with several trigger controls
- Programmable multipath detector
- Quality detector output



LQFP44

Digital control

- I^2C bus interface

Description

The device includes a high performance audioprocessor and a stereo decoder-noise blanker combination, with the whole low frequency signal processing necessary for state of the art, as well as future car radios. The digital control allows a programming in a wide range of all the filter characteristics. The stereo decoder part also offers several possibilities of programming, especially for the adaptation to different IF devices.

Table 1. Device summary

Order code	Package	Packing
TDA7402	LQFP44 (10x 10x 1.4mm)	Tray

Contents

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1 Pin connections and block diagram

Figure 1. Pin connections (top view)

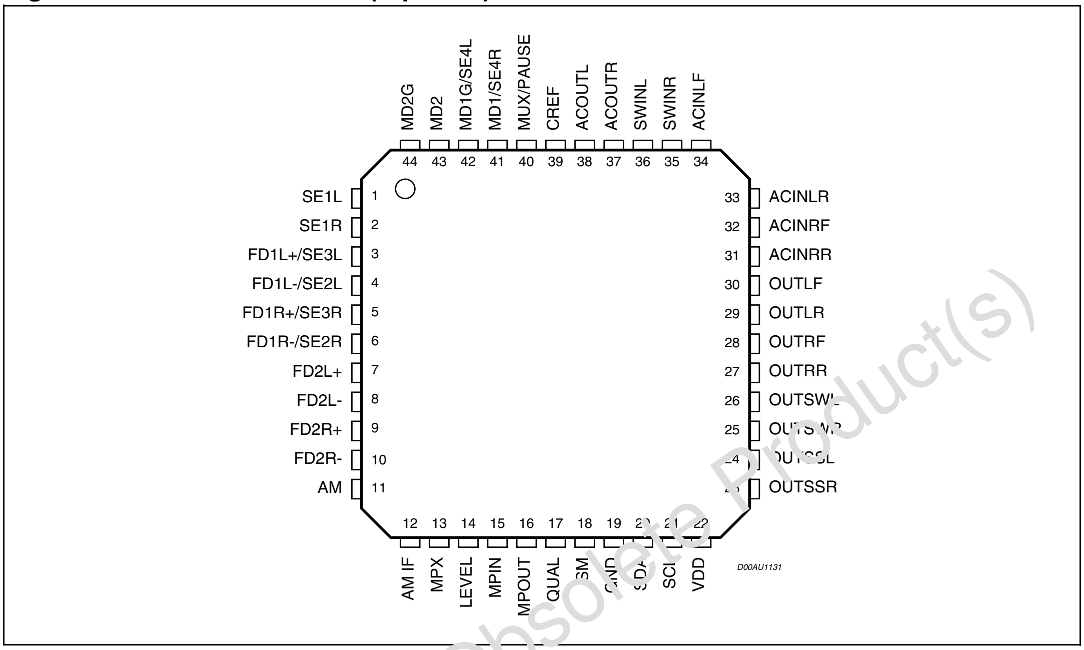
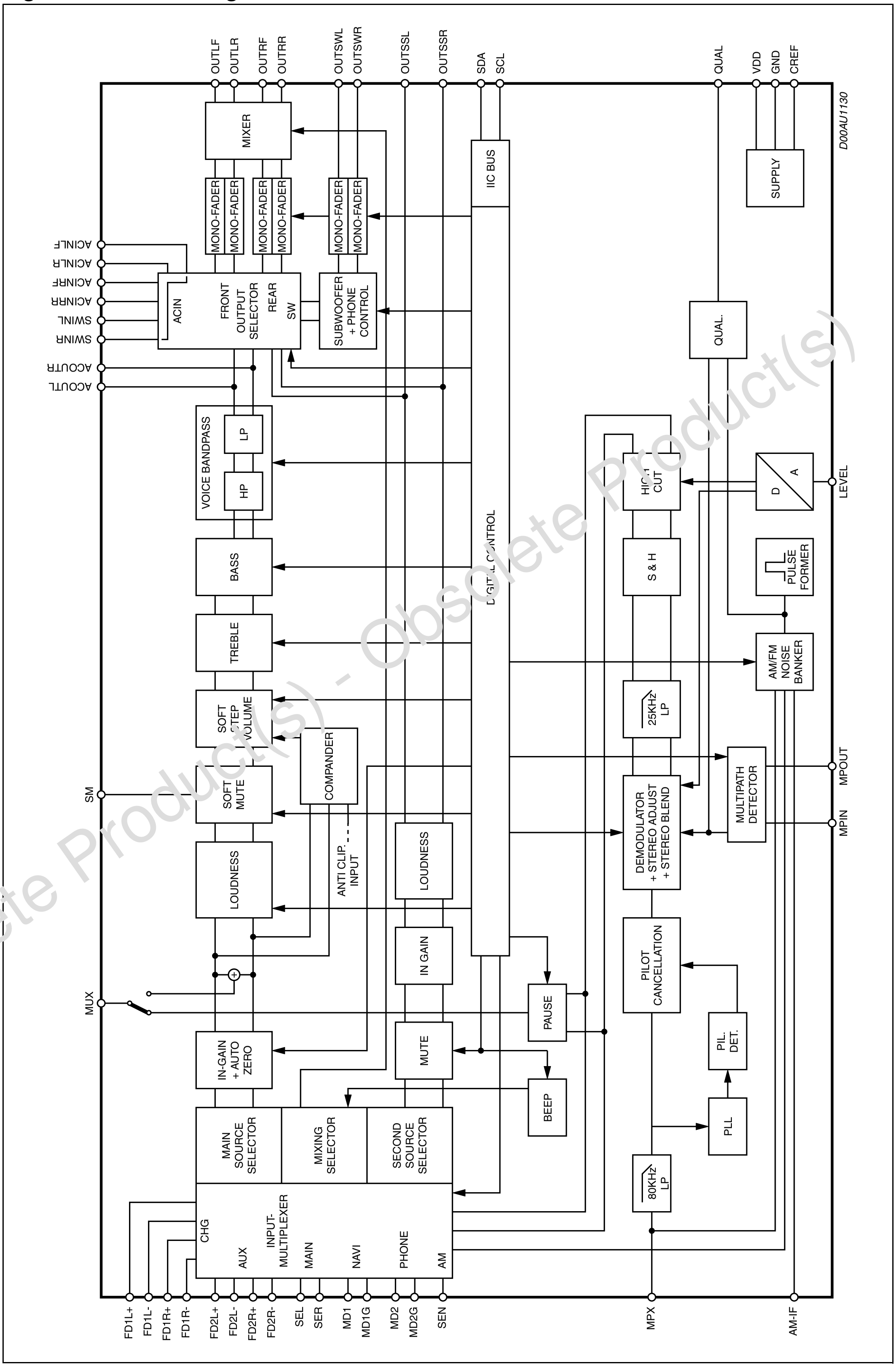


Figure 2. Block diagram



2 Electrical specifications

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

Table 2. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Input selector						
R_{in}	Input resistance	all single ended Inputs	70	100	130	kΩ
V_{CL}	Clipping level		2.2	2.6		V_{RMS}
S_{IN}	Input separation		80	100		dB
$G_{IN\ MIN}$	Min. input gain		-1	0	+1	dB
$G_{IN\ MAX}$	Max. input gain		13	15	17	dB
G_{STEP}	Step resolution		0.5	1	1.5	dB
V_{DC}	DC steps	Adjacent gain steps	-5	1	5	mV
		G_{MIN} to G_{MAX}	-10	6	10	mV
V_{offset}	Remaining offset with autozero			0.5		mV
Differential stereo inputs						
R_{in}	Input resistance (see *Figure 3*)	Differential	70	100	130	kΩ
G_{CD}	Gain	only at true differential input	-1	0	1	dB
			-5	-6	7	dB
			-11	-12	-13	dB
CMRR	Common mode rejection ratio	V_{CM} = 1V_{RMS} @ 1kHz	46	70		dB
		V_{CM} = 1V_{RMS} @ 10kHz	46	60		dB
e_{NO}	Output-noise @ speaker outputs	20Hz - 20kHz, flat; all stages 0dB		9	15	µV
Differential mono inputs						
R_{in}	Input impedance	Differential	40	56	72	kΩ
CMRR	Common mode rejection ratio	V_{CM} = 1V_{RMS} @ 1kHz	40	70		dB
		V_{CM} = 1V_{RMS} @ 10kHz	40	60		dB
Beep control						
V_{RMS}	Beep level	Mix-gain = 6dB	250	350	500	mV
f_{Beep}	Beep frequency	f_{Beep1}	570	600	630	Hz
		f_{Beep2}	740	780	820	Hz
		f_{Beep1}	1.48	1.56	1.64	kHz
		f_{Beep1}	2.28	2.4	2.52	kHz

Table 2. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Mixing control						
M_{LEVEL}	Mixing ratio	Main / mix source		-6/-6		dB
G_{MAX}	Max. gain		13	15	17	dB
A_{MAX}	Max. attenuation		-83	-79	-75	dB
A_{STEP}	Attenuation step		0.5	1	1.5	dB
Multiplexer output (1)						
R_{OUT}	Output impedance			225	300	W
R_L	Output load resistance		2			kΩ
C_L	Output load capacitance				10	nF
V_{DC}	DC voltage level		4.3	4.5	4.7	V
Loudness control						
A_{STEP}	Step resolution		0.5	1	1.5	dB
A_{MAX}	Max. attenuation		-21	-19	-17	dB
f_{Peak}	Peak frequency	f_{P1}	180	200	220	Hz
		f_{P2}	360	400	440	Hz
		f_{P3}	540	600	660	Hz
		f_{P4}	720	800	880	Hz
Volume control						
G_{MAX}	Max. gain		30	32	34	dB
A_{MAX}	Max. attenuation		-83	-79.5	-75	dB
A_{STEP}	Step resolution		0	0.5	1	dB
E_A	Attenuation set error	G = -20 to +20dB	-0.75	0	+0.75	dB
		G = -80 to -20dB	-4	0	3	dB
E_T	Tracking error				2	dB
V_{DC}	DC steps	Adjacent attenuation steps		0.1	3	mV
		From 0dB to G_{MIN}		0.5	5	mV
Soft mute						
A_{MUTE}	Mute attenuation		80	100		dB
T_D	Delay time	T1		0.48	1	ms
		T2		0.96	2	ms
		T3	70	123	170	ms
		T4	200	324	600	ms
$V_{TH\ low}$	Low threshold for SM Pin(2)				1	V
$V_{TH\ high}$	High threshold for SM Pin		2.5			V

Table 2. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
R_{PU}	Internal pull-up resistor		32	45	58	kΩ
V_{PU}	Internal pull-up voltage			3.3		V
Bass control						
C_{RANGE}	Control range		±14	±15	±16	dB
A_{STEP}	Step resolution		0.5	1	1.5	dB
f_C	Center frequency	f_{C1}	54	60	66	Hz
		f_{C2}	63	70	77	Hz
		f_{C3}	72	80	88	Hz
		f_{C4}	81	90	99	Hz
		f_{C5}	90	100	110	Hz
		f_{C6}	117	130	143	Hz
		f_{C7}	135	150	165	Hz
		f_{C8}	180	200	220	Hz
Q_{BASS}	Quality factor	Q_1	0.9	1	1.1	
		Q_2	1.1	1.25	1.4	
		Q_3	1.3	1.5	1.7	
		Q_4	1.8	2	2.2	
DC_{GAIN}	Bass-DC-gain	DC = off	-1	0	+1	dB
		DC = on	4	4.4	6	dB
Treble control						
C_{RANGE}	Control range		±14	±15	±16	dB
A_{STEP}	Step resolution		0.5	1	1.5	dB
f_C	Center frequency	f_{C1}	8	10	12	kHz
		f_{C2}	10	12.5	15	kHz
		f_{C3}	12	15	18	kHz
		f_{C4}	14	17.5	21	kHz
Pause detector[3]						
V_{TH}	Zero crossing threshold	Window 1		40		mV
		Window 2		80		mV
		Window 3		160		mV
I_{DELAY}	Pull-up current		15	25	35	µA
V_{THP}	Pause threshold			3.0		V

Table 2. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Speaker attenuator						
R_{in}	Input impedance		35	50	65	kΩ
G_{MAX}	Max. gain		14	15	16	dB
A_{MAX}	Max. attenuation		-83	-79	-75	dB
A_{STEP}	Step resolution		0.5	1	1.5	dB
A_{MUTE}	Output mute attenuation		80	90		dB
E_E	Attenuation set error				2	dB
V_{DC}	DC steps	Adjacent attenuation steps		0.1	5	mV
Audio outputs						
V_{CLIP}	Clipping level	d = 0.3%	2.2	2.6		V_{RMS}
R_L	Output load resistance		2			kΩ
C_L	Output load capacitance				10	nF
R_{OUT}	Output impedance			30	100	W
V_{DC}	DC voltage level		4.3	4.5	4.7	V
Voice bandpass						
f_{HP}	Highpass corner frequency	f_{HP1}	81	90	99	Hz
		f_{HP2}	122	135	148	Hz
		f_{HP3}	162	180	198	Hz
		f_{HP4}	194	215	236	Hz
		f_{HP5}	270	300	330	Hz
		f_{HP6}	405	450	495	Hz
		f_{HP7}	540	600	660	Hz
		f_{HP8}	675	750	825	Hz
f_{LP}	Lowpass corner frequency	f_{LP1}	2.7	3	3.3	kHz
		f_{LP2}	5.4	6	6.6	kHz
Subwoofer attenuator						
R_{in}	Input impedance		35	50	65	kΩ
G_{MAX}	Max. gain		14	15	16	dB
A_{ATTN}	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				2	dB
V_{DC}	DC steps	Adjacent attenuation steps		1	5	mV

Table 2. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Subwoofer lowpass						
f_{LP}	Lowpass corner frequency	f_{LP1}	72	80	88	Hz
		f_{LP2}	108	120	132	Hz
		f_{LP3}	144	160	176	Hz
Differential outputs[(4)]						
R_L	load resistance at each output	$1V_{RMS}$; AC coupled; THD=1%	1			kΩ
		$2V_{RMS}$; AC coupled; THD=1%	2			kΩ
R_{DL}	load resistance differential	$1V_{RMS}$; AC coupled; THD=1%	2			kΩ
		$2V_{RMS}$; AC coupled; THD=1%	4			kΩ
C_{LMAX}	Capacitive load at each output	C_{Lmax} at each output to ground			10	nF
C_{DLMAX}	Capacitive load differential	C_{Lmax} between output terminals			5	nF
V_{Offset}	DC offset at pins	Output muted	-10		10	mV
R_{OUT}	Output impedance			30	100	W
V_{DC}	DC voltage level		4.3	4.5	4.7	V
e_{NO}	Output noise	Output muted		6	15	μV
Compander						
G_{MAX}	max. compander gain	Vi < -46dB		19		dB
		Vi < -46dB, Anti-clip = on		29		dB
t_{Att}	Attack time	t_{Att1}		6		ms
		t_{Att2}		12		ms
		t_{Att3}		24		ms
		t_{Att4}		49		ms
t_{Rel}	Release time	t_{Rel1}		390		ms
		t_{Rel2}		780		ms
		t_{Rel3}		1.17		s
		t_{Rel4}		1.56		s
V_{REF}	Compander reference input-level (equals 0dB)	V_{REF1}		0.5		V_{RMS}
		V_{REF2}		1.0		V_{RMS}
		V_{REF3}		2.0		V_{RMS}
C_F	Compression factor	Output signal / input signal		0.5		

Table 2. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
General						
e_{NO}	Output noise	BW = 20Hz - 20kHz output muted all gains = 0dB single ended inputs		3 10	15 20	μV μV
S/N	Signal to noise ratio	all gains = 0dB flat; $V_O = 2V_{RMS}$		106		dB
		bass, treble at +12dB; a-weighted; $V_O = 2.6V_{RMS}$		100		dB
d	distortion	$V_{IN} = 1V_{RMS}$; all stages 0dB		0.005	0.1	%
		$V_{OUT} = 1V_{RMS}$; bass & treble = 12dB		0.05	0.1	%
S_C	Channel separation left/right		80	100		dB
E_T	Total tracking error	A_V = 0 to -20dB	-1	0	1	dB
		A_V = -20 to -60dB	-2	0	2	dB

1. If configured as multiplexer-output
2. The SM Pin is active low (mute = 0)
3. If configured as pause-output
4. If programmed as subwoofer diff. output

Table 3. 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
V_{ESD}	ESD protection (human body mode)	±2000	V
V_{ESD}	ESD protection (machine mode)	±200	V

Table 4. Thermal data

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

Table 5. Supply

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_S	Supply voltage		7.5	9	10	V
I_S	Supply current	V_S = 9V	35	50	65	mA
SVRR	Ripple rejection @ 1kHz	Audioprocessor (all Filters flat)		60		dB

3 Audioprocessor part

3.1 Audioprocessor part features

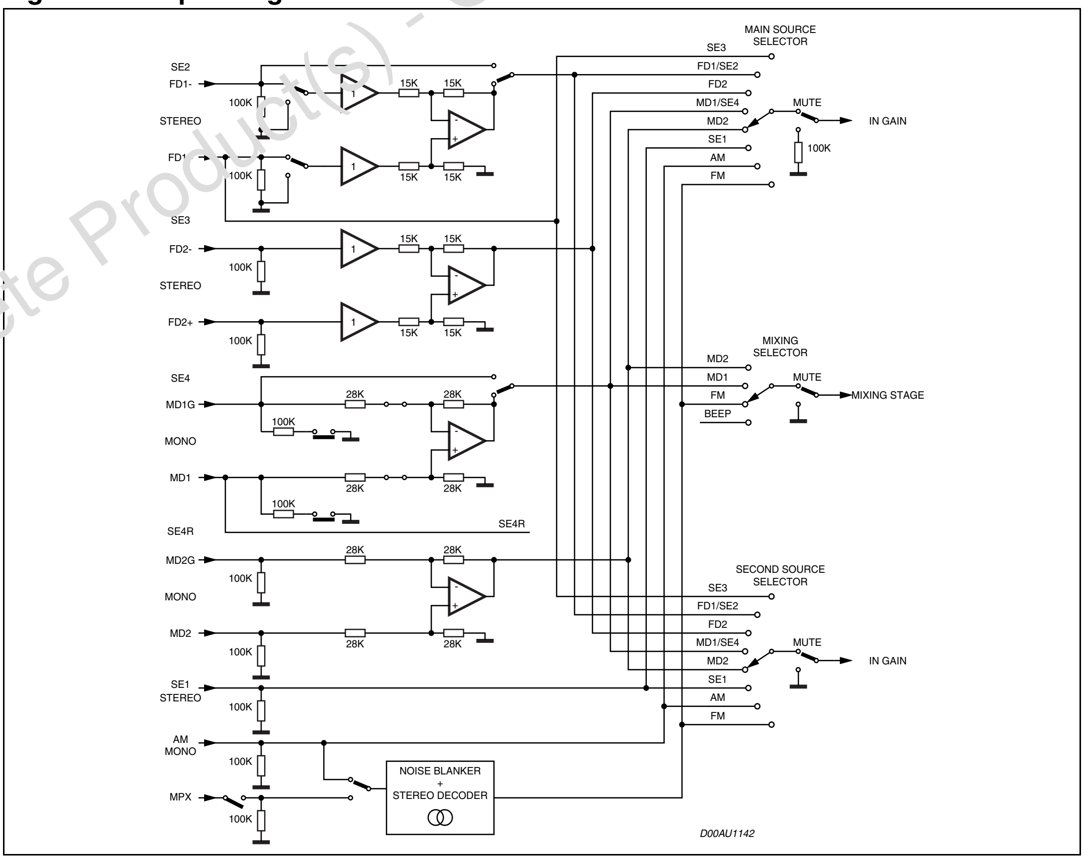
- Input multiplexer
  - 2 fully differential CD stereo inputs with programmable attenuation
  - 1 single ended stereo input
  - 2 differential mono input
  - 1 single ended mono input
  - In-gain 0..15dB, 1dB steps
  - internal offset cancellation (AutoZero)
  - separate second source selector
- Beep
  - internal beep with 4 frequencies
- Mixing stage
  - Beep, phone and navigation mixable to all speaker outputs
- Loudness
  - programmable center frequency and frequency response
  - 15 x 1dB steps
  - selectable flat-mode (constant attenuation)
- Volume
  - 0.5dB attenuator
  - 100dB range
  - soft-step control with programmable times
- Compander
  - dynamic range compression for use with CD
  - 2:1 compression rate
  - programmable max. gain
- Bass
  - 2nd order frequency response
  - center frequency programmable in 8 steps
  - DC gain programmable
  - $\pm$ 15 x 1dB steps
- Treble
  - 2nd order frequency response
  - center frequency programmable in 4 steps
  - $\pm$15 x 1dB steps
- Voice bandpass
  - 2nd order butterworth highpass filter with programmable cut off frequency
  - 2nd order butterworth lowpass filter with programmable cut off frequency
  - selectable flat mode

- Speaker
  - 4 independent speaker controls in 1dB steps
  - control range 95dB
  - separate Mute
- Subwoofer
  - single ended stereo output
  - independent stereo level controls in 1dB steps
  - control range 95dB
  - separate Mute
- Mute Functions
  - direct mute
  - digitally controlled Soft Mute with 4 programmable mute-times
- Pause Detector
  - programmable threshold

3.2 Input stages

In the basic configuration two full differential, two mono differential, one single ended stereo and one single ended mono input are available. In addition a dedicated input for the stereo decoder MPX signal is present.

Figure 3. Input-stages



3.2.1 Full differential stereo input 1 (FD1)

The FD1 input is implemented as a buffered full-differential stereo stage with 100kΩ input impedance at each input. The attenuation is programmable in 3 steps from 0 to -12dB in order to adapt the incoming signal level. A 6dB attenuation is included in the differential stage, the additional 6dB are done by a following resistive divider. This input is also configurable as two single ended stereo inputs (see pin-out).

3.2.2 Full differential stereo input 2 (FD2)

The FD2 input has the same general structure as FD1, but with a programmable attenuation of 0 or 6dB embedded in the differential stage.

3.2.3 Mono differential input 1 (MD1)

The MD1 input is designed as a basic differential stage with 56kΩ input impedance. This input is configurable as a single ended stereo input (see pin-out).

3.2.4 Mono differential input 2 (MD2)

The MD2 input has the same topology as MD1, but without the possibility to configure it to single ended.

3.2.5 Single ended stereo input (SE1), single ended mono input (AM) and FM-MPX input

All single ended inputs offer an input impedance of 100kΩ. The AM pin can be connected by software to the input of the stereo-decoder in order to use the AM noiseblanker and AM High Cut feature.

3.3 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. **0.3ms** for the alignment. To avoid audible clicks the Audioprocessor is muted before the loudness stage during this time. The AutoZero feature is only present in the main signal path.

3.3.1 AutoZero for stereo decoder selection

A special procedure is recommended for selecting the stereo decoder at the **main** input-selector to guarantee an optimum offset cancellation:

1. Soft Mute or Mute the signal-path
2. Temporary deselect the stereo decoder at all input selectors
3. Configure the stereo decoder via IIC-Bus
4. Wait 1ms
5. Select the stereo decoder at the main input selector first

The root cause of this procedure is, that after muting the stereo decoder (Step 1), the internal stereo decoder filters have to settle in order to perform a proper offset cancellation.

3.3.2 AutoZero remain

In some cases, for example if the µP is executing a refresh cycle of the I^2C 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 outputs. For such applications the TDA7402 could be switched in the **AutoZero Remain Mode** (Bit 6 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.

3.4 Pause detector / MUX-output

The pin number 40 (Pause/MUX) is configurable for two different functions:

1. During pause detector OFF this pin is used as a mono output of the main input selector. This signal is often used to drive a level/equalizer display on the car radio front panel.
2. During pause detector ON the pin is used to define the time constant of the detector by an external capacitor. The pause detector is driven by the internal stereo decoder outputs in order to use pauses in the FM signal for alternate frequency jumps. If the signal level of both stereo decoder channels is outside the programmed voltage window, the external capacitor is abruptly discharged. Inside the pause condition the capacitor is slowly recharged by a constant current of 25µA. The pause information is also available via I^2C Bus (see I^2C Bus programming).

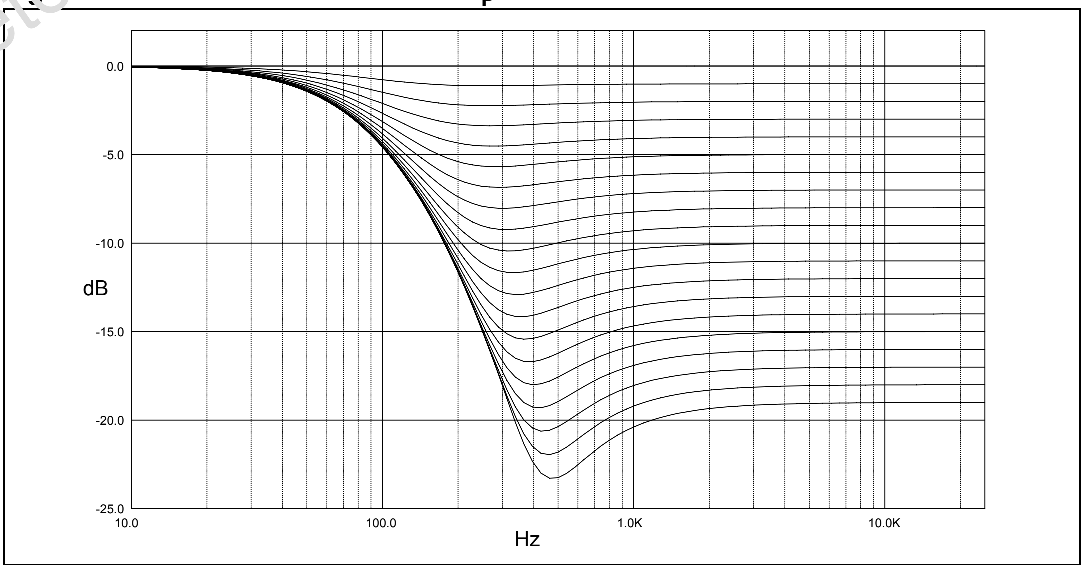
3.4.1 Loudness

There are four parameters programmable in the loudness stage:

3.4.2 Attenuation

Figure 4 shows the attenuation as a function of frequency at f_P = 400Hz

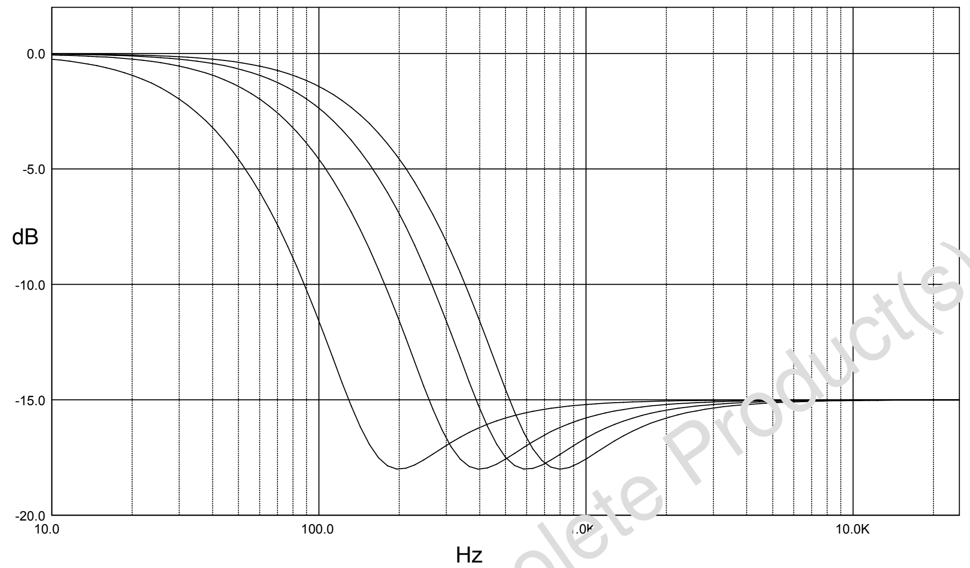
Figure 4. Loudness attenuation @ f_P = 400Hz.



3.4.3 Peak frequency

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

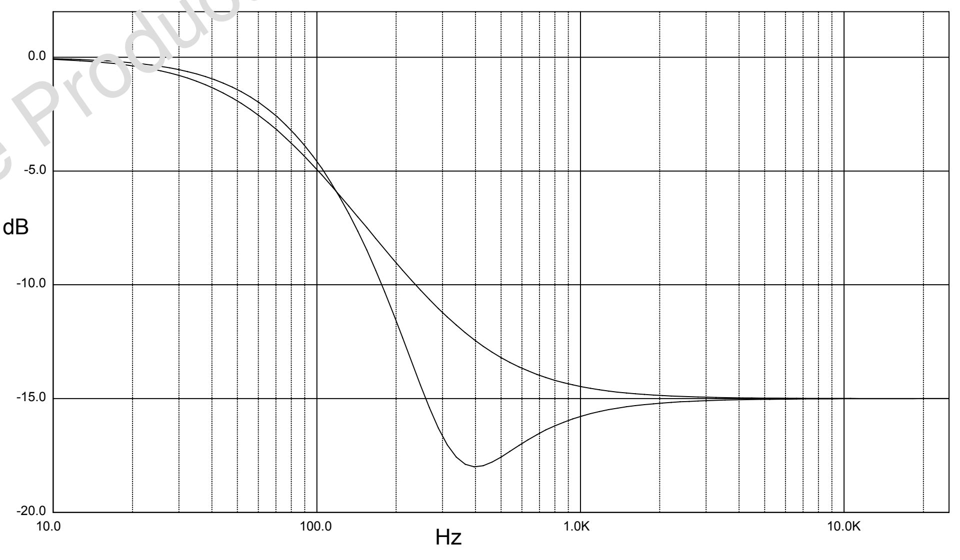
Figure 5. Loudness center frequencies @ Attn. = 15dB.



3.4.4 Loudness order

Different shapes of 1st and 2nd-order loudness

Figure 6. 1st and 2nd order loudness @ Attn. = 15dB, f_P=400Hz



3.4.5 Flat mode

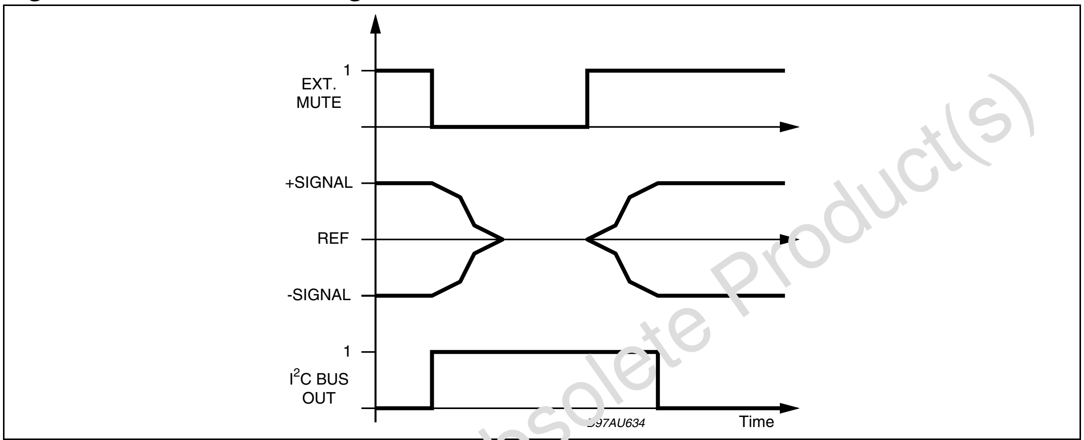
In flat mode the loudness stage works as a 0dB to -19dB attenuator.

3.5 Soft Mute

The digitally controlled Soft Mute stage allows muting/demuting the signal with a I^2C bus programmable slope. The mute process can either be activated by the Soft Mute 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 7*).

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 de-muting.

Figure 7. Soft Mute timing

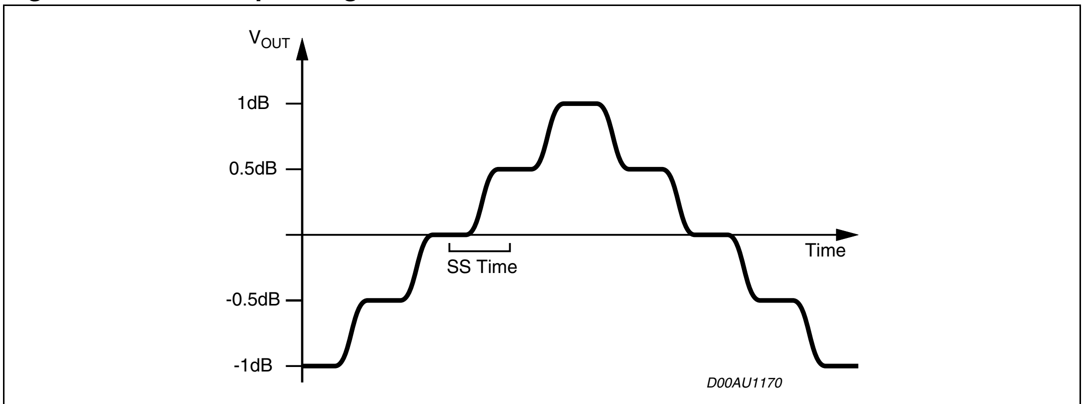


Note: Please notice that a started mute action is always terminated and could not be interrupted by a change of the mute -signal.

3.6 Soft Step volume

When the volume level is changed audible clicks could appear at the output. The root cause of those clicks could either be a DC offset before the volume stage or the sudden change of the envelope of the audio signal. With the Soft Step feature both kinds of clicks could be reduced to a minimum and are no more audible. The blend time from one step to the next is programmable in four steps.

Figure 8. Soft Step timing



Note: For steps more than 0.5dB the Soft Step mode should be deactivated because it could generate a hard 1dB step during the blend time.

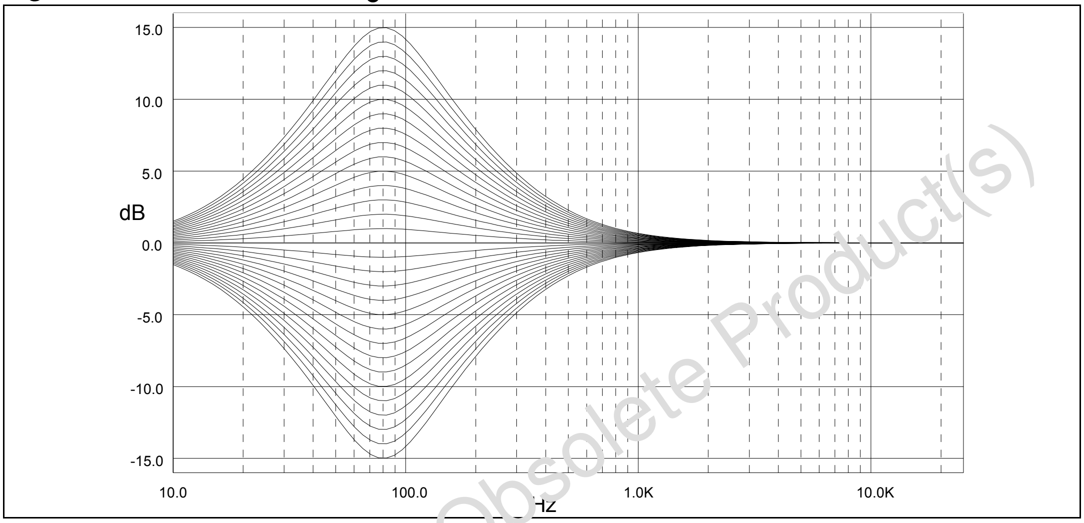
3.7 Bass

There are four parameters programmable in the bass stage:

3.7.1 Attenuation

Figure 9 shows the attenuation as a function of frequency at a center frequency of 80Hz.

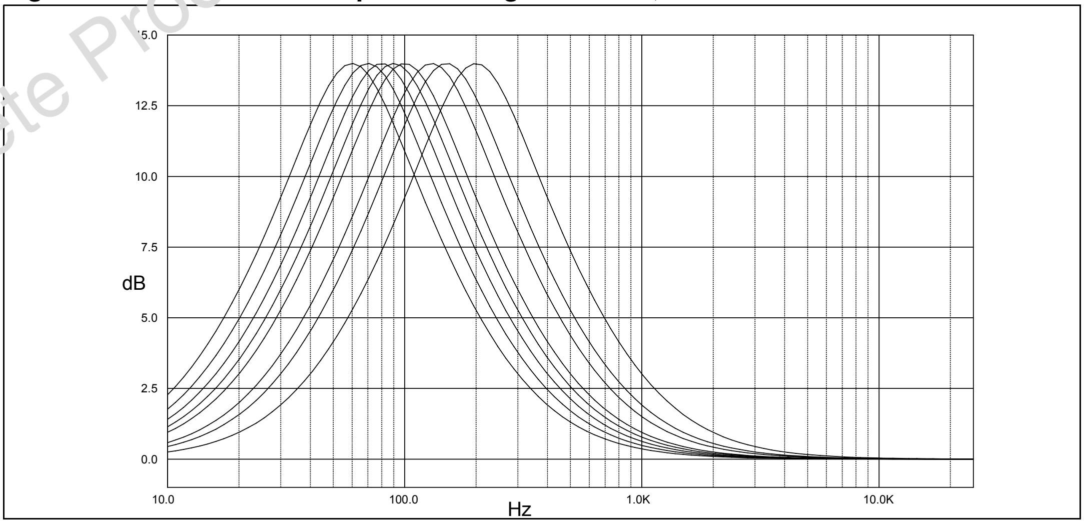
Figure 9. Bass control @ f_C = 80Hz, Q = 1



3.7.2 Center frequency

Figure 10 shows the eight possible center frequencies 60, 70, 80, 90, 100, 130, 150 and 200Hz.

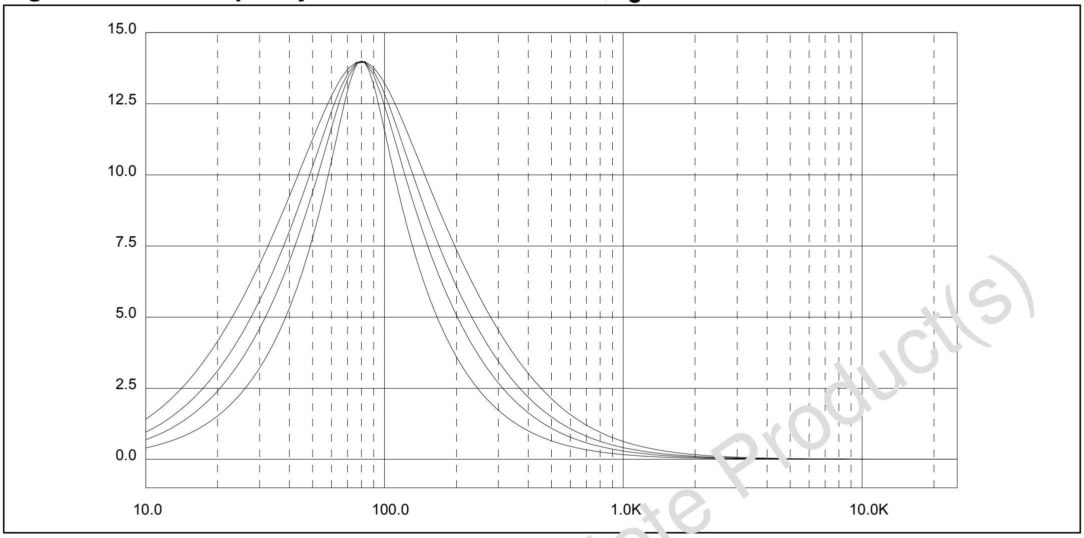
Figure 10. Bass center frequencies @ gain = 14dB, Q = 1



3.7.3 Quality factors

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

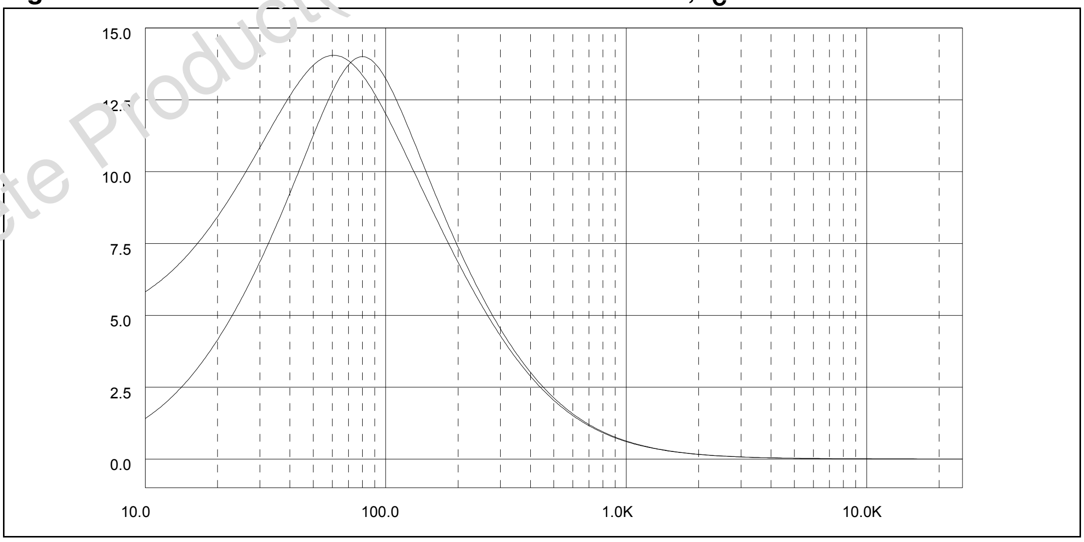
Figure 11. Bass quality factors @ Gain = 14dB, f_C = 80Hz



3.7.4 DC mode

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

Figure 12. Bass normal and DC Mode @ Gain = 14dB, f_C = 80Hz



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

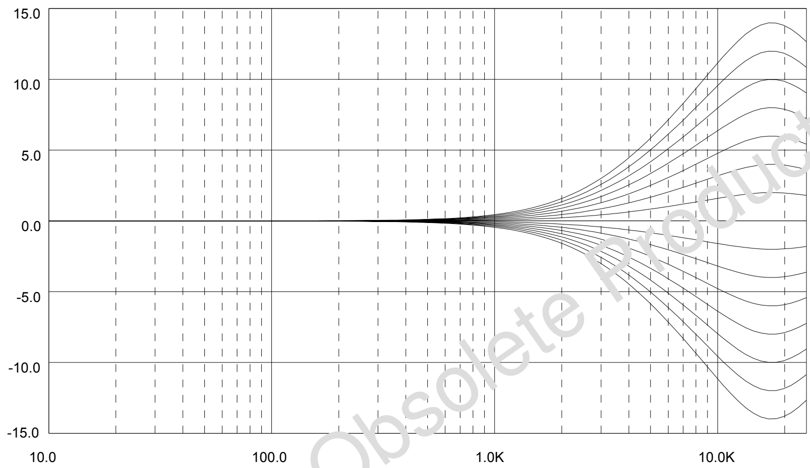
3.8 Treble

There are two parameters programmable in the treble stage:

3.8.1 Attenuation

Figure 13. shows the attenuation as a function of frequency at a center frequency of 17.5kHz.

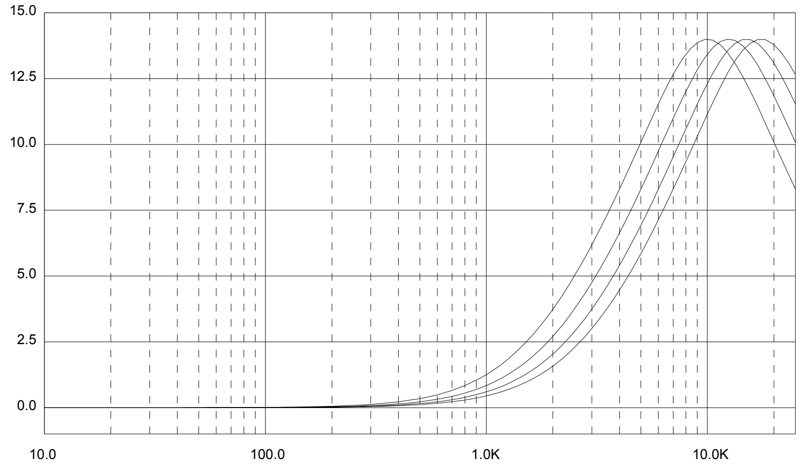
Figure 13. Treble control @ f_C = 17.5kHz



3.8.2 Center frequency

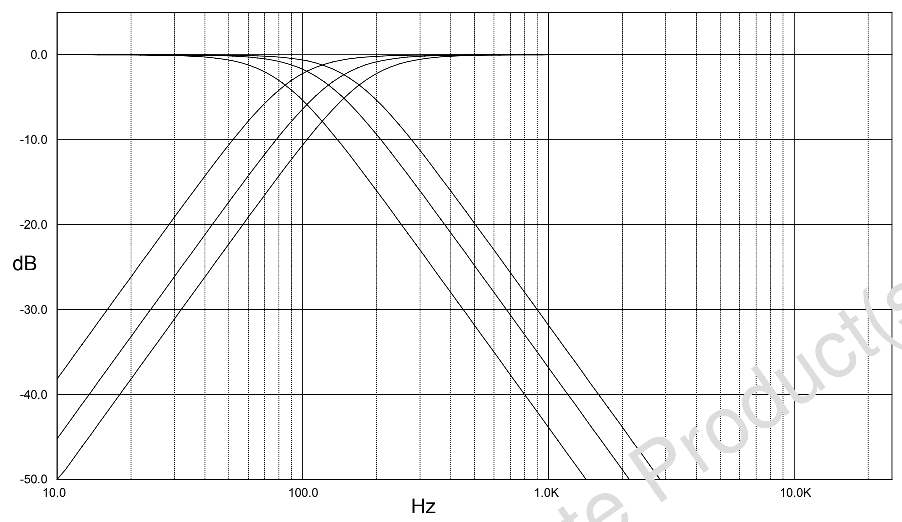
Figure 14. shows the four possible center frequencies 10k, 12.5k, 15k and 17.5kHz.

Figure 14. Treble center frequencies @ gain = 14dB



3.9 Subwoofer application

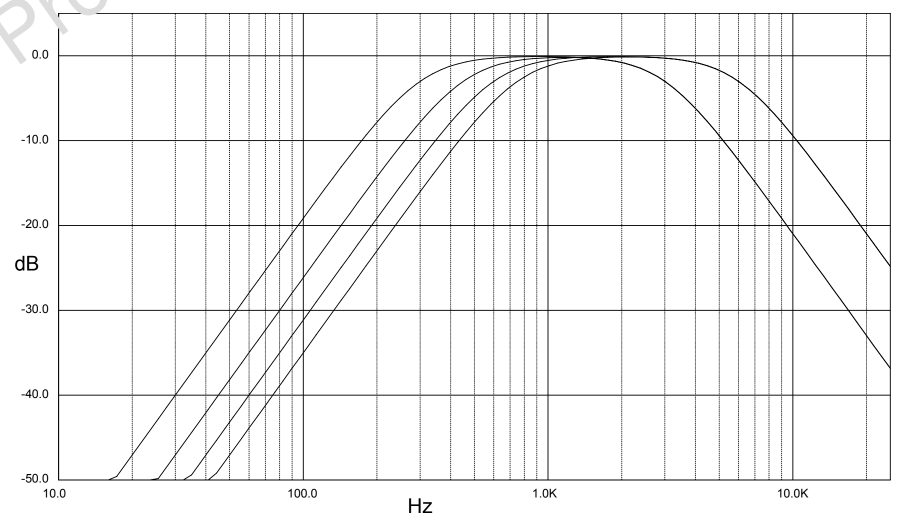
Figure 15. Subwoofer application with LPF 80/120/160Hz and HPF 90/135/180Hz



Both filters, the lowpass and the highpass-filter, have butterworth characteristics so that their cut off frequencies are not equal, but shifted by the factor 1.125 to get a flat frequency response.

3.10 Voice band application

Figure 16. Voiceband application with HPF 300/450/600/750Hz and LPF 3k/6kHz



3.11 Compander

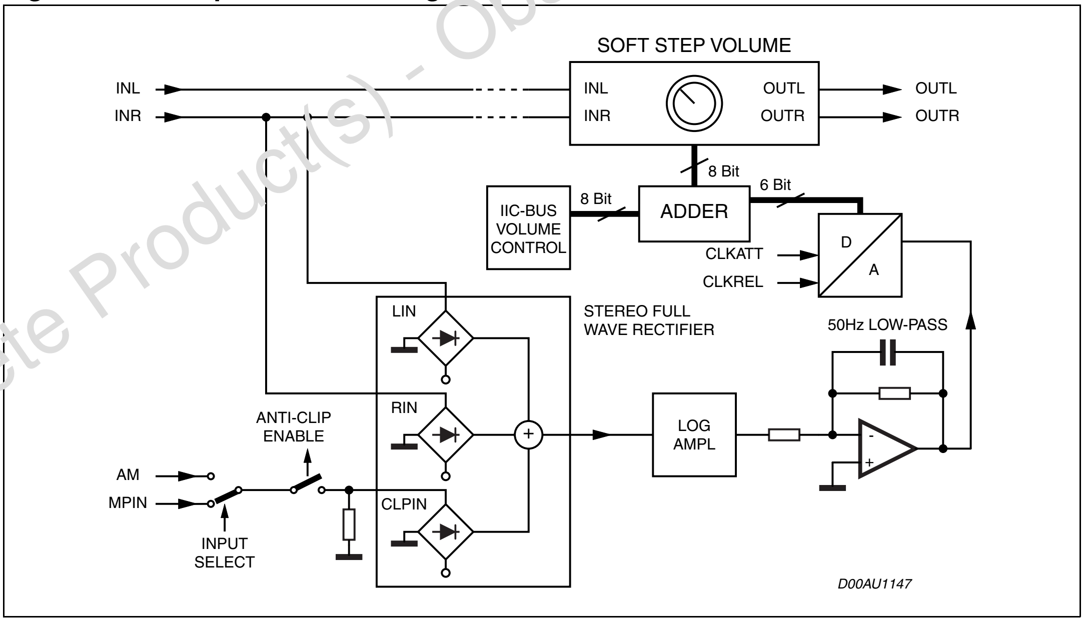
Signal compression

A fully integrated signal compressor with programmable attack and decay times is present in the TDA7402 (see *Figure 17*).

The compander consists of a signal level detection, an A/D Converter plus adder and the normal Soft Step volume stage. First of all the left and the right InGain-signal is rectified, respectively, and the logarithm is build from the summed signal. The following low-pass smooth the output-signal of the logarithm amplifier and improves the low frequency suppression. The low pass output-voltage then is A/D converted an added to the current volume-word defined by the I^2C bus. Assuming reference level or higher at the compander input, the output of the ADC is 0. At lower levels the voltage is increasing with 1Bit/dB. It is obvious that with this configuration and a 0.5dB-step volume stage the compression rate is fixed to 2:1 (1dB less at the input leads to 0.5dB less at the output).

The internal reference level of the compander is programmable in three steps from $0.5V_{RMS}$ to $2V_{RMS}$. For a proper behavior of the compression circuit it is mandatory to have at a 0dB input signal exactly the programmed reference level after the InGain-stage. E.g. at a configured reference-level of $0.5V_{RMS}$ the output of the InGain stage has to have also $0.5V_{RMS}$ at 0dB source-signal (Usually the 0dB for CD is defined as the maximum possible signal-level). To adapt the external level to the internal reference level the programmable attenuation in the differential stages and the InGain can be used.

Figure 17. Compander block diagram



3.11.1 Anti-clipping

In a second application the compander-circuit can be used for a anti-clipping or limiting function. In this case one of the dedicated inputs (AM or MPin) is connected directly to the clip-detector of the power-amplifier. if no clipping is detected, the open-collector output of the power-amplifier is highohmic and the input-voltage of the rectifier is V_{REF}. The level detector interprets this as a very small signal and reacts with the maximum programmed compander gain. In the application this gain has to be compensated by decreasing the