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TDA7405

EQUALIZER CARRADIO SIGNAL PROCESSOR

1 FEATURES

- 3 STEREO INPUTS
- 3 MONO INPUTS
- DYNAMIC-COMPRESSION-STAGE FOR CD
- BASS, TREBLE AND LOUDNESS CONTROL
- EQ-FILTERS FOR SEPARATE FRONT/REAR-EQUALIZATION
- VOICE-BAND-FILTER FOR MIXING-CHANNEL
- DIRECT MUTE AND SOFTMUTE
- INTERNAL BEEP
- FOUR INDEPENDENT SPEAKER-OUTPUTS
- INDEPENDENT SECOND SOURCE-SELECTOR
- FULL MIXING CAPABILITY
- PAUSE DETECTOR

1.1 Stereodecoder

- RDS MUTE
- NO EXTERNAL ADJUSTMENTS
- AM/FM NOISEBLANKER WITH SEVERAL TRIGGER CONTROLS
- PROGRAMMABLE MULTIPATH DETECTOR
- QUALITY DETECTOR OUTPUT

Figure 1. Package

TQFP44

Table 1. Order Codes

Part Number	Package
TDA7405	TQFP44

1.2 Digital control

- I^2C-BUS INTERFACE

2 DESCRIPTION

The device includes a high performance audioprocessor and a stereodecoder-noiseblanker combination with the whole low frequency signal processing necessary for state-of-the-art as well as future carradios. The digital control allows a programming in a wide range of all the filter characteristics. Also the stereodecoder part offers several possibilities of programming especially for the adaptation to different IF-devices.

Figure 2. BLOCK DIAGRAM

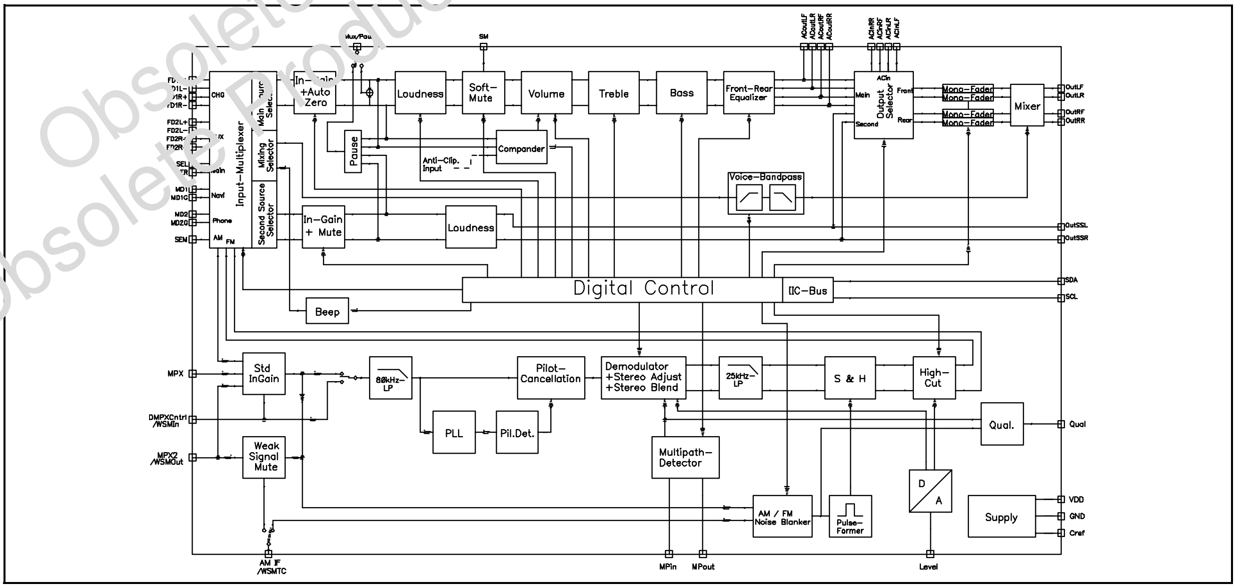


Table 2. SUPPLY

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_S	Supply Voltage		7.5	9	10.5	V
I_S	Supply Current	V_S = 9V	45	65	85	mA
SVRR	Ripple Rejection @ 1KHz	Audioprocessor(all Filters flat)		60		dB
		Stereodecoder + Audioprocessor		55		dB

Table 3. THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{Th\ j\text{-}pins}$	Thermal Resistance Junction-pins max	65	°C/W

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 ESD

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

Figure 3. PIN CONNECTION (Top view)

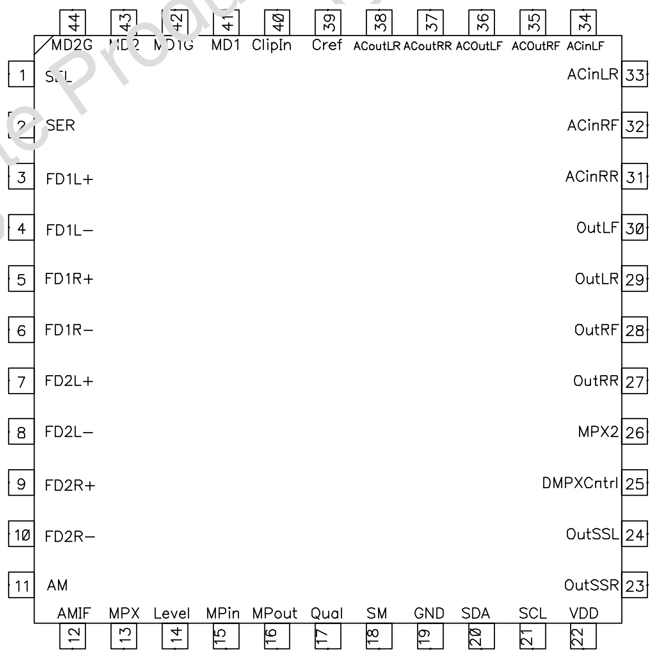
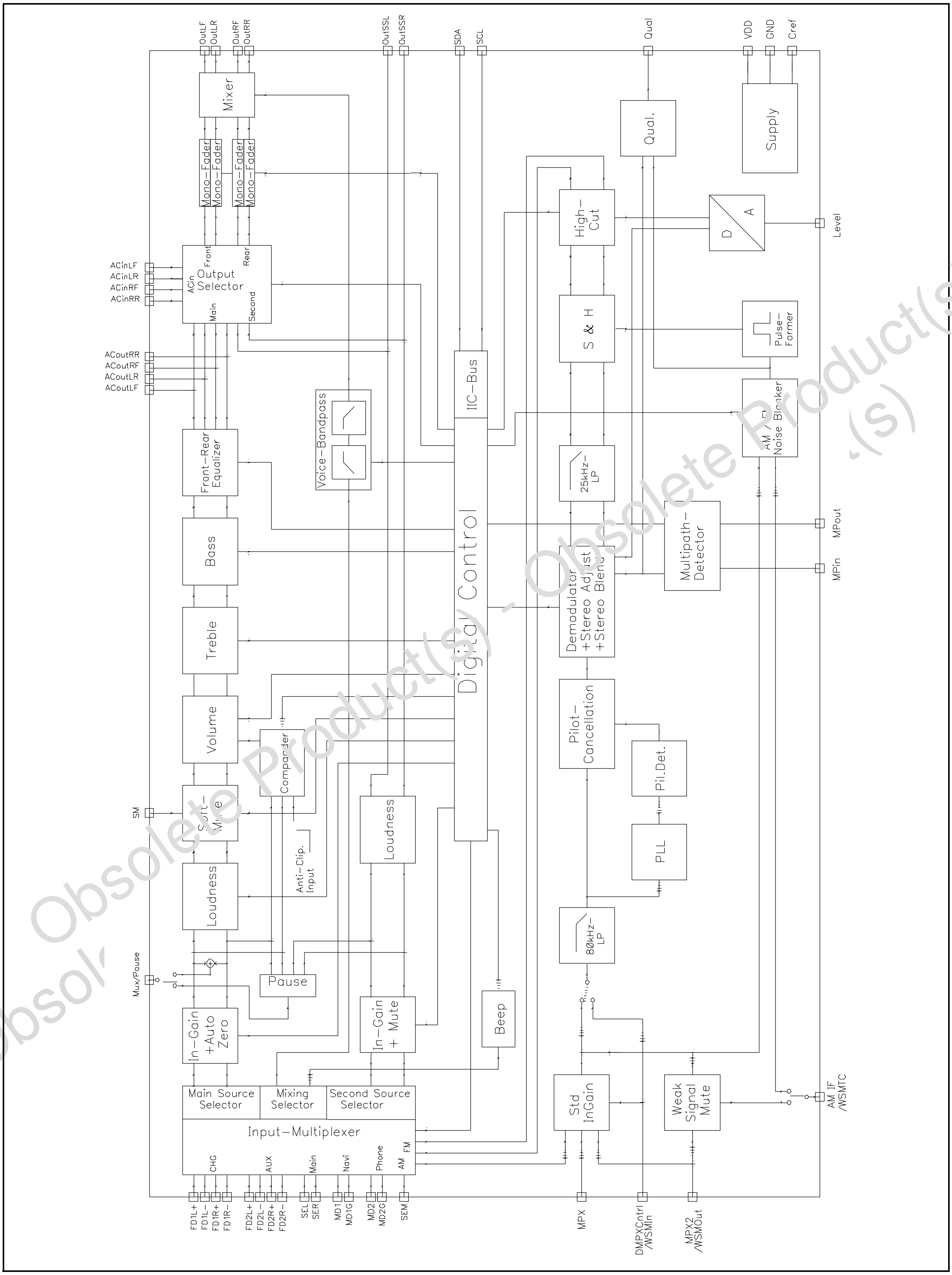


Figure 4. BLOCK DIAGRAM (Enlarged view)



4 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 3 frequencies + diagnostic setting (19kHz tone)
Mixing stage	Beep, Phone,Navigation and FM mixable to all speaker-outputs (see Figure 20)
	programmabe Voice-Band Filter
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
Bass	2nd order frequency response
	center frequency programmable in 8 steps
	DC gain programmable
	± 15 x 0.5dB steps
Treble	2nd order frequency response
	center frequency programmable in 4 steps
	± 15 x 1dB steps
Equalizer	two stereo equalizing-filters for separate front/rear adaption
	1st filter center-frequency programmable in 16 steps (4 steps/octave, min 63Hz, max 840Hz)
	2nd filter center-frequency programmable in 16 steps (4 steps/octave, min 300Hz, max 4kHz)
	quality factor programmable in 4 steps
	± 15 x 1dB steps
	selectable flat-mode
Speaker	4 independent speaker controls in 1dB steps
	control range 95dB
	separate Mute
Mute Functions	direct mute
	digitally controlled SoftMute with 4 programmable mute-times
Pause Detector	programmable threshold
Compander	dynamic range compression for use with CD
	2:1 compression rate
	programmable max. gain

Table 5. ELECTRICAL CHARACTERISTICS

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

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		2.0	2.2		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	1	10	mV
V_{offset}	Remaining offset with AutoZero			0.5		mV
DIFFERENTIAL STEREO INPUTS						
R_{in}	Input Resistance (see Fig. 1)	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	46	70		dB
		V_{CM} = 1V_{RMS} @ 10kHz	46	60		dB
BEEP CONTROL						
V_{RMS}	Beep Level	Mix-Gain = 6dB	250	350 [1)]	500	mV
f_{Beep}	Beep Frequency	f_{Beep1}	470	500	530	Hz
		f_{Beep2}	740	780	820	Hz
		f_{Beep3}	1.7	1.8	1.9	kHz
		f_{Beep4}	18	19	20	kHz

1. The Level for the 19kHz-Testtone is 2.1V_{RMS}

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}	Attennuation Step		0.5	1	1.5	dB

Table 5. ELECTRICAL CHARACTERISTICS (continued)

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

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
MULTIPLEXER OUTPUT[2]						
R_{OUT}	Output Impedance			800	1000	Ω
R_L	Output Load Capacitance		2			kΩ
C_L					10	nF
V_{DC}	DC Voltage Level		4.3	4.5	4.7	V

2. If confgured as Multiplexer-Output

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
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[3]				1	V
$V_{TH\ high}$	High Threshold for SM - Pin		2.5			V
R_{PU}	Internal pull-up resistor		32	45	58	kΩ
V_{PU}	Internal pull-up Voltage			3.3		V

3. The SM-Pin is active low (Mute = 0)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
BASS CONTROL						
C_{RANGE}	Control Range		±14	±15.5	±16	dB
A_{STEP}	Step Resolution		0.1	0.5	1.0	dB

Table 5. ELECTRICAL CHARACTERISTICS (continued)

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

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
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[4)]

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

4. If configured as Pause-Output

SPEAKER ATTENUATORS

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

Table 5. ELECTRICAL CHARACTERISTICS (continued)

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

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
E_E	Attenuation Set Error				2	dB
V_{DC}	DC Steps	Adjacent Attenuation Steps		0.1	5	mV
MONO VOICE BANDPASS						
f_{HP}	Highpass corner frequency	f_{HP1}	81	90	99	Hz
		f_{HP2}	120	135	150	Hz
		f_{HP3}	162	180	198	Hz
		f_{HP4}	193	215	237	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
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		
AUDIO OUTPUTS						
V_{CLIP}	Clipping Level	d = 0.3%	2.0	2.2		V_{RMS}
R_L	Output Load Resistance		2			kΩ
C_L	Output Load Capacitance				10	nF
R_{OUT}	Output Impedance			30	120	Ω
V_{DC}	DC Voltage Level		4.3	4.5	4.7	V

Table 5. ELECTRICAL CHARACTERISTICS (continued)

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

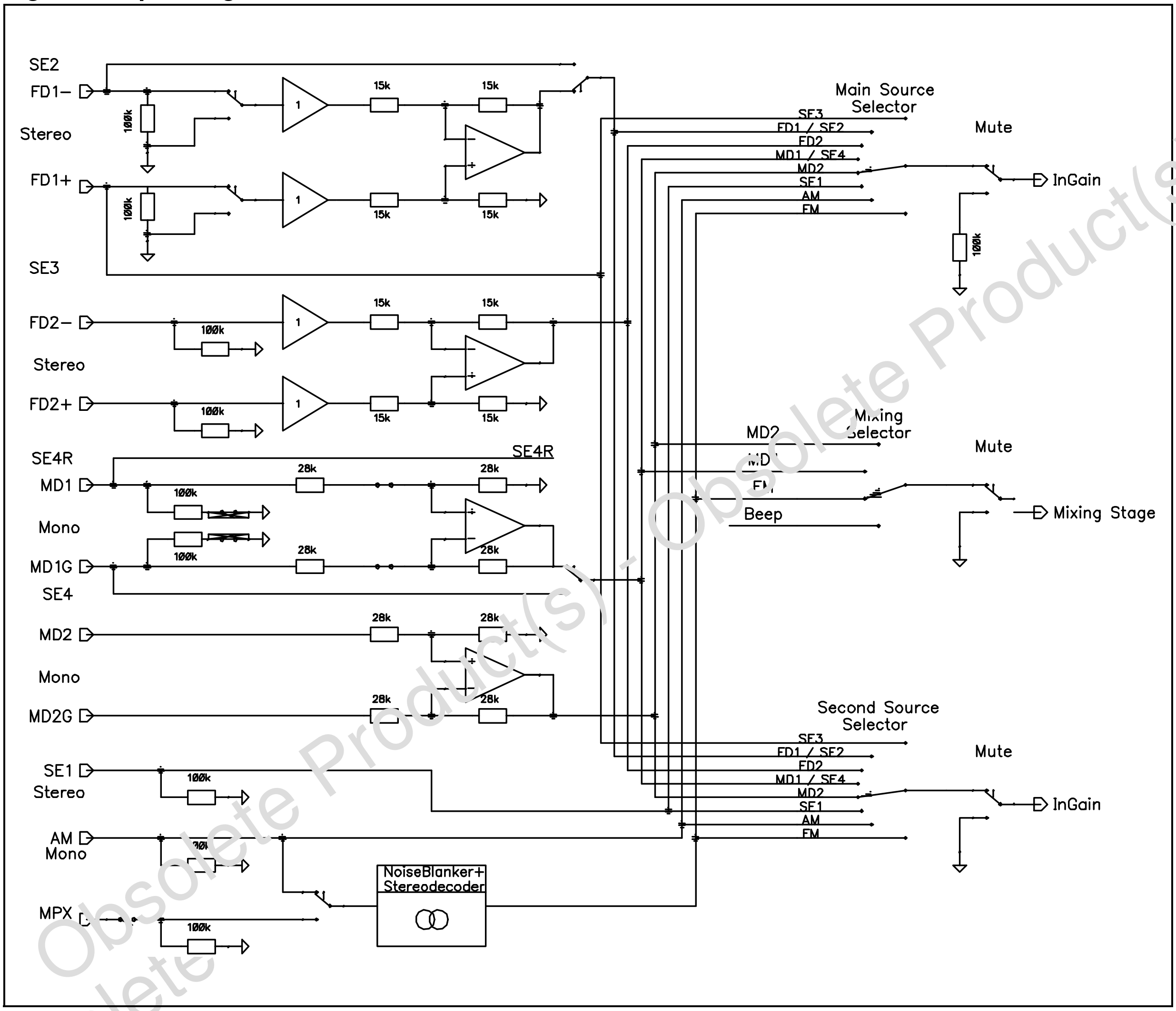
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
GENERAL						
e_{NO}	Output Noise	BW = 20Hz - 20kHz;output muted		3	15	µV
		BW = 20Hz - 20kHz all gains = 0dB single ended inputs		10	20	µV
S/N	Signal to Noise Ratio	all gains = 0dB flat; V_O = 2V_{RMS}		106		dB
		bass, treble at +12dB; a-weighted; 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

5 DESCRIPTION OF THE AUDIOPROCESSOR PART

5.1 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 stereodecoder MPX-signal is present.

Figure 5. Input stages



5.1.1 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).

5.1.2 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.

5.1.3 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).

5.1.4 Mono-differential Input 2 (MD2)

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

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

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

5.2 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.

5.2.1 AutoZero for Stereodecoder-Selection

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

(Step 0: SoftMute or Mute the signal-path)

Step 1: Temporary deselect the stereodecoder at all input-selectors

Step 2: Configure the stereodecoder via IIC-Bus

Step 3: Wait 1ms

Step 4: Select the stereodecoder at the main input selector first

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

5.2.2 AutoZero-Remain

In some cases, for example if the µP 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 outputs. For such applications the A631 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.

5.3 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 carradio 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 stereodecoder-outputs in order to use pauses in the FM-signal for alternate-frequency-jumps. If the signal-level of both stereodecoder 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 IIC-Bus (see IIC-Bus programming).

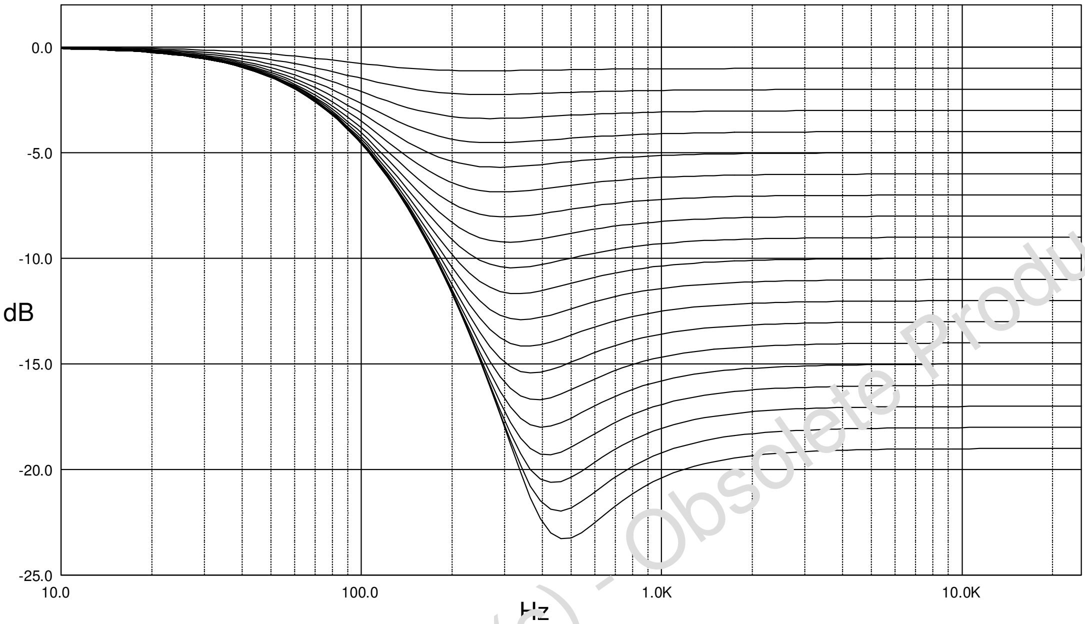
5.4 Loudness

There are four parameters programmable in the loudness stage:

5.4.1 Attenuation

Figure 6 shows the attenuation as a function of frequency at fP = 400Hz.

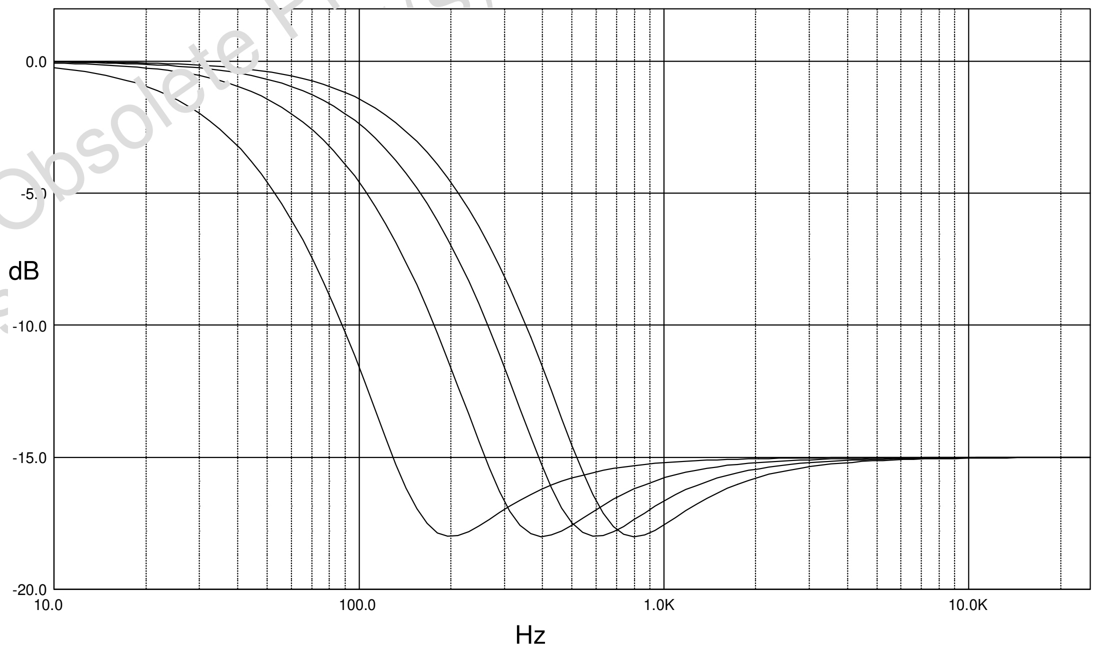
Figure 6. Loudness Attenuation @ fP = 400Hz



5.4.2 Peak Frequency

Figure 7 shows the four possible peak-frequencies at 200, 400, 600 and 800Hz

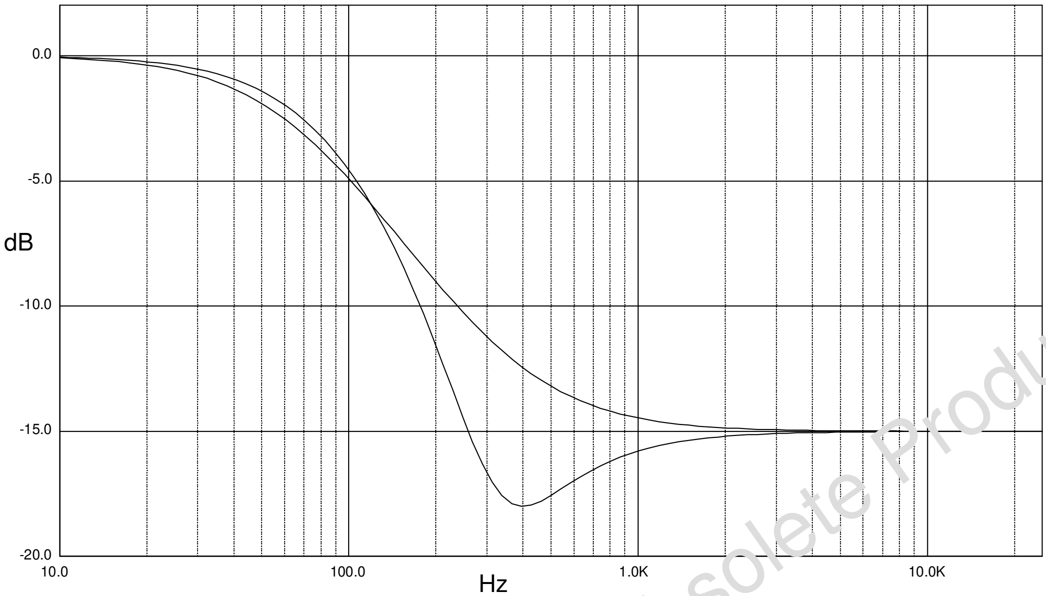
Figure 7. Loudness Center frequencies @ Attn. = 15dB



5.4.3 Loudness Order

Different shapes of 1st and 2nd-Order Loudness

Figure 8. 1st and 2nd Order Loudness @ Attn. = 15dB, fP=400Hz



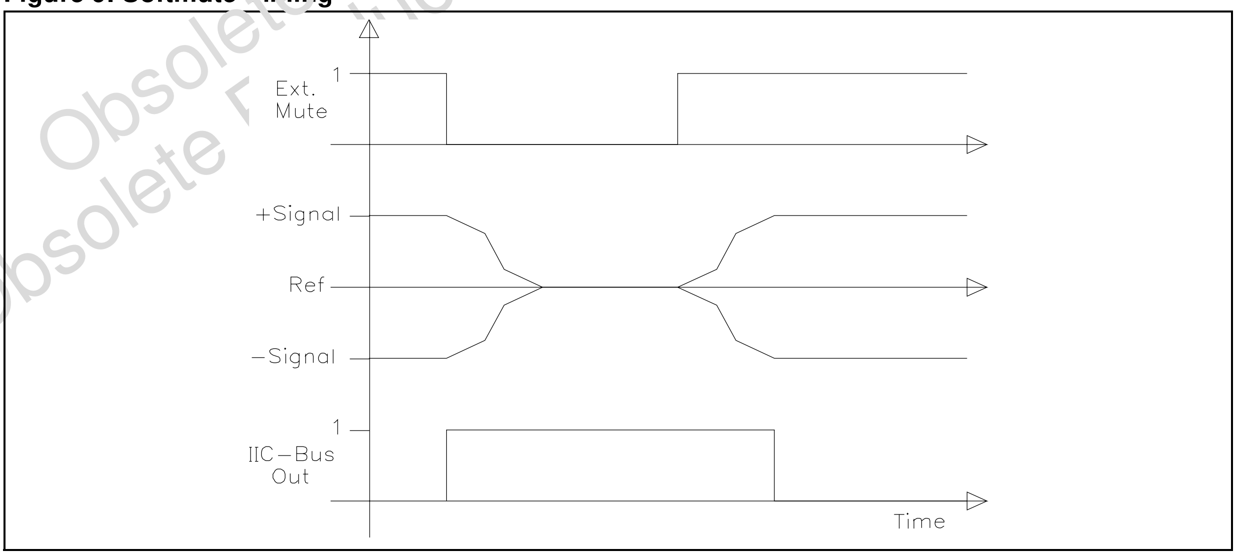
5.4.4 Flat Mode

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

5.5 SoftMute

The digitally controlled SoftMute stage allows muting/demuting the signal with a I2C-bus programmable slope. The mute process can either be activated by the SoftMute 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 9). For timing purposes the Bit of the I2C-bus output register is set to 1 from the start of muting until the end of de-muting.

Figure 9. Softmute-Timing

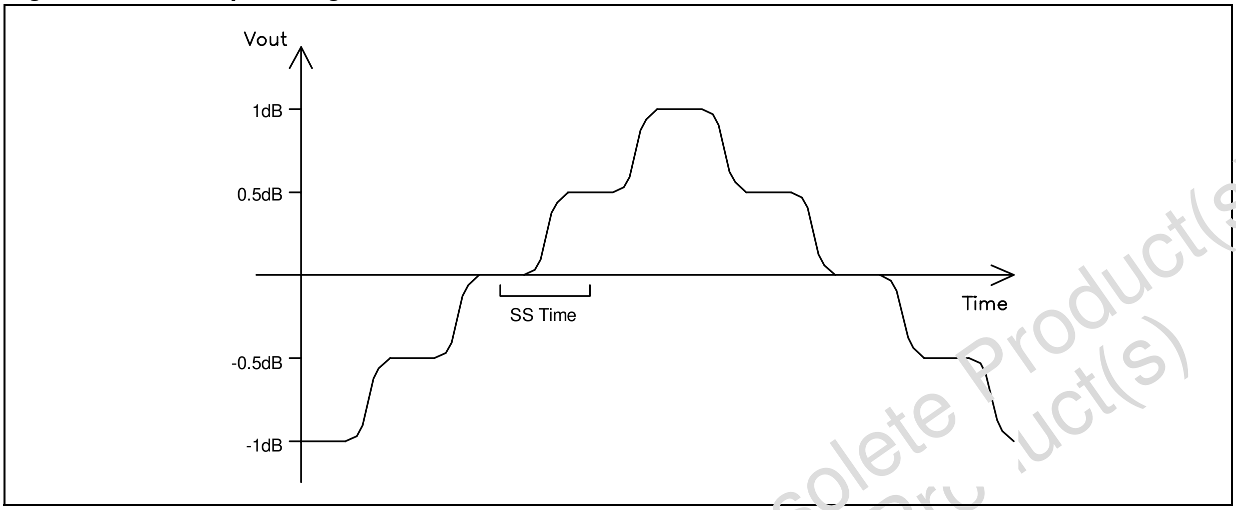


Note: Please notice that a started Mute-action is always terminated and could not be interrupted by a change of the mute -signal.

5.6 SoftStep-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 audiosignal. 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 in four steps.

Figure 10. SoftStep-Timing



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

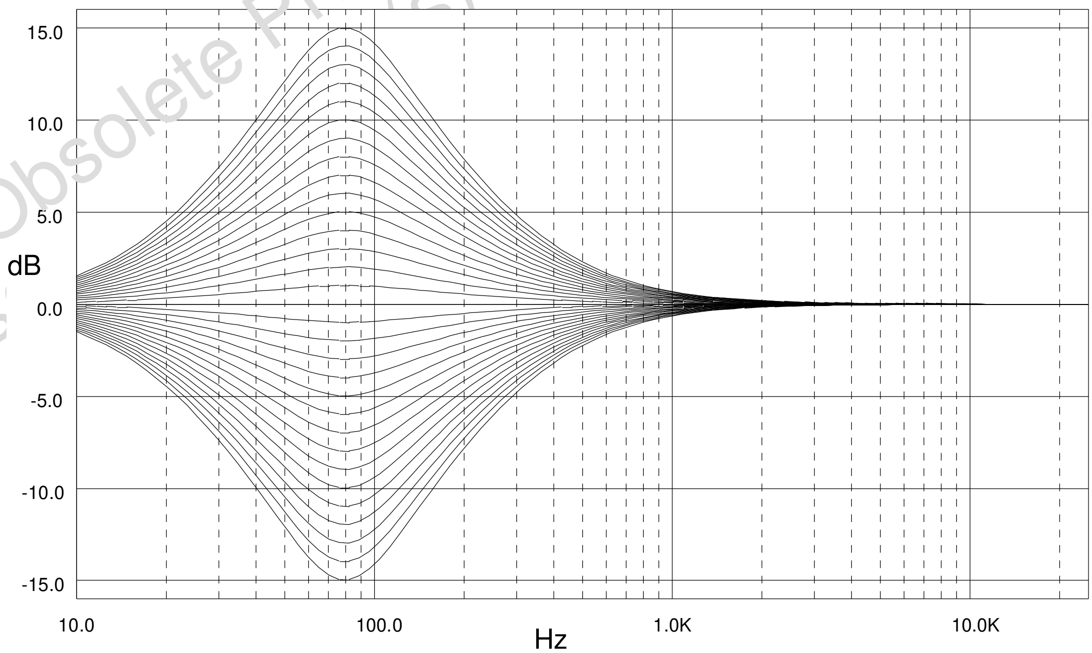
5.7 Bass

There are four parameters programmable in the bass stage:

5.7.1 Attenuation

Figure 11 shows the attenuation as a function of frequency at a center frequency of 80Hz.

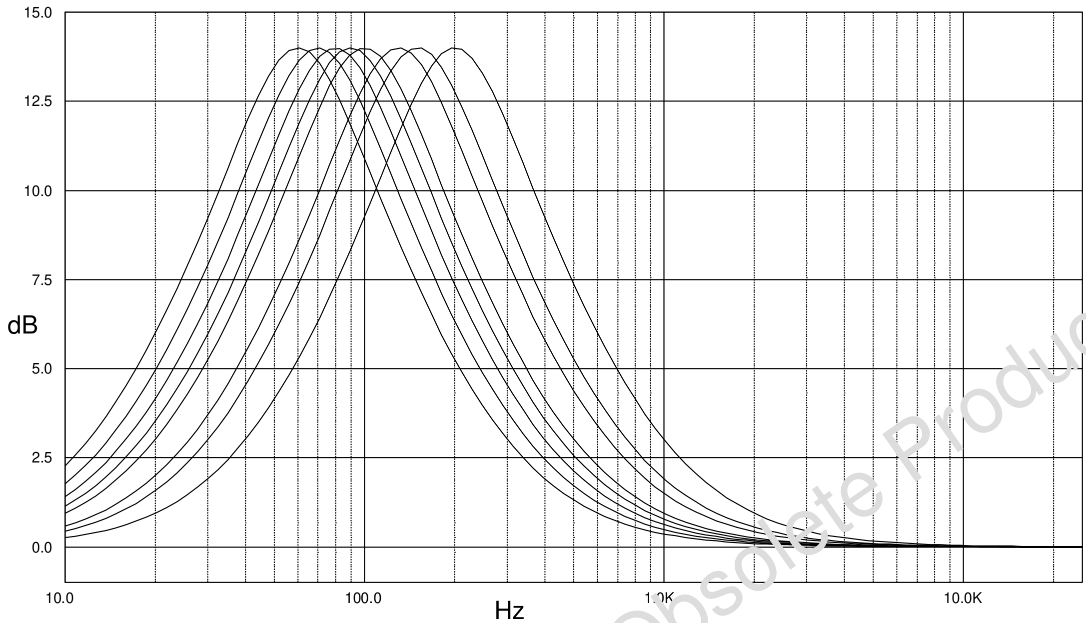
Figure 11. Bass Control @ fC = 80Hz, Q = 1



5.7.2 Center Frequency

Figure 12 shows the eight possible center frequencies 60, 70, 80, 90, 100, 130, 150 and 200Hz.

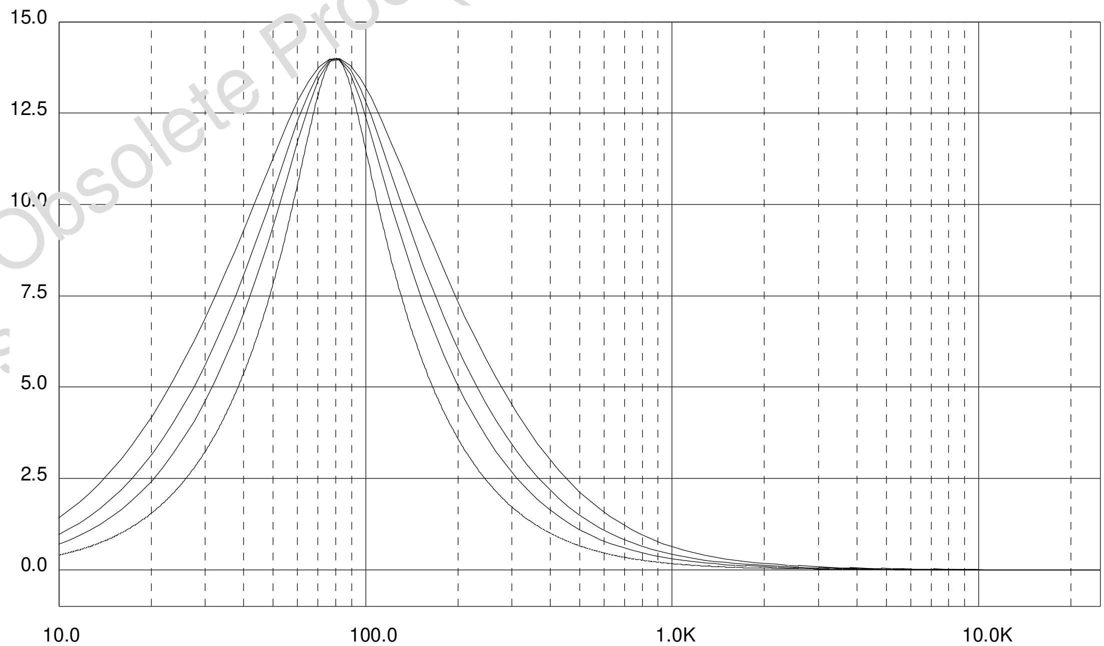
Figure 12. Bass center Frequencies @ Gain = 14dB, Q = 1



5.7.3 Quality Factors

Figure 13 shows the four possible quality factors 1, 1.25, 1.5 and 2.

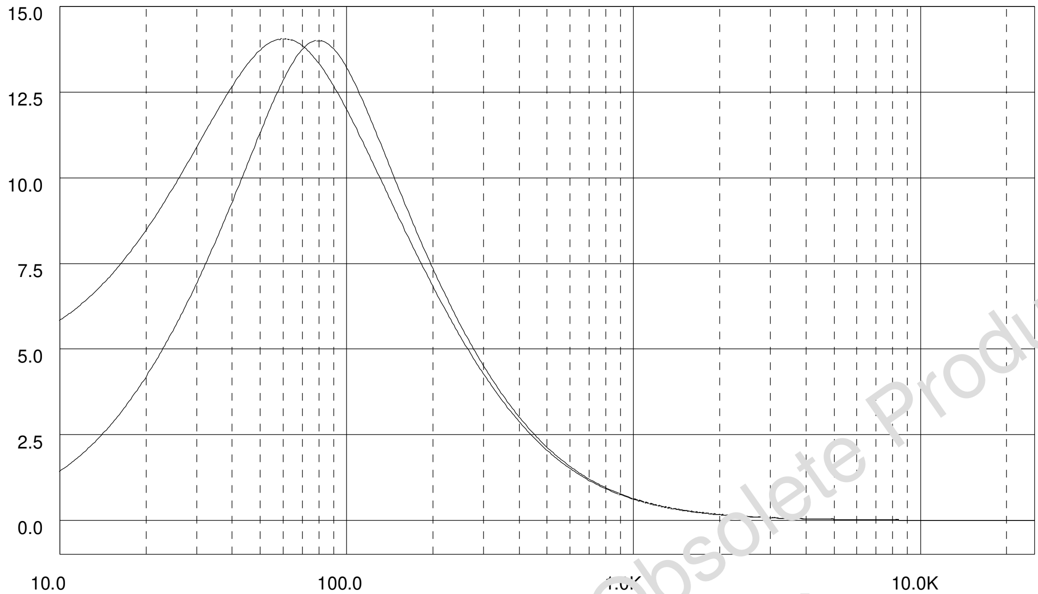
Figure 13. Bass Quality factors @ Gain = 14dB, fC = 80Hz



5.7.4 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 14. Bass normal and DC Mode @ Gain = 14dB, fC = 80Hz



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

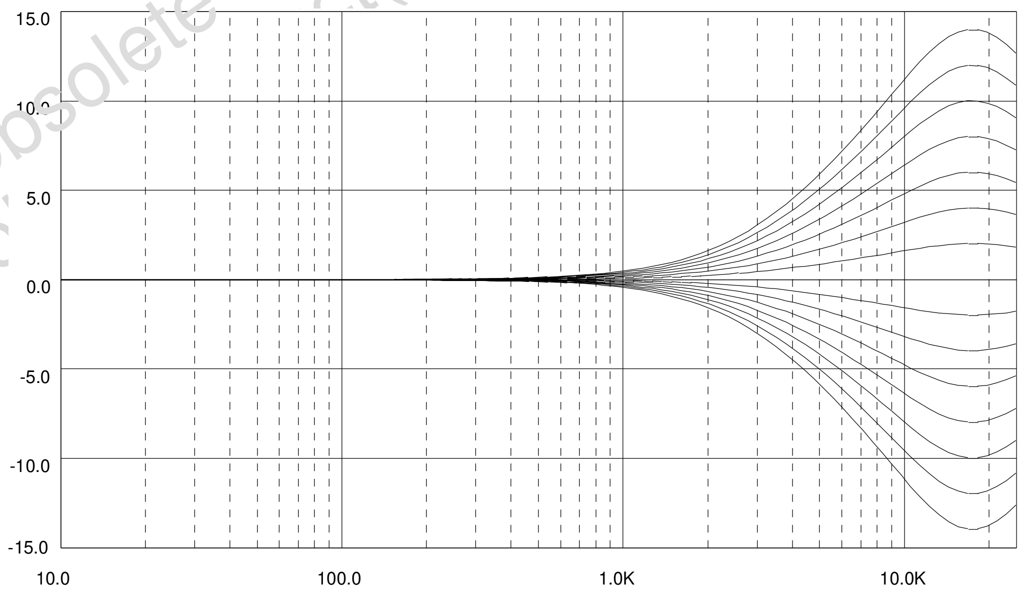
5.8 Treble

There are two parameters programmable in the treble stage:

5.8.1 Attenuation

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

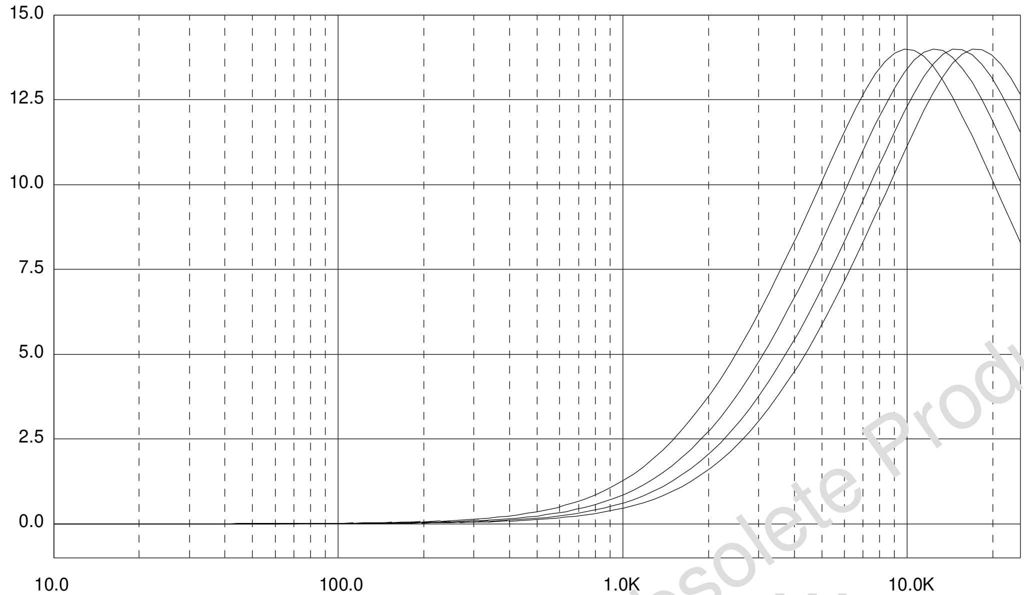
Figure 15. Treble Control @ fC = 17.5kHz



5.8.2 Center Frequency

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

Figure 16. Treble Center Frequencies @ Gain = 14dB



5.9 EQ-Filter

There are two EQ-Filters present in the A631: one for the High-Frequency-Range and one for the Low-Frequency-Range with a certain overlap. They are programmable in center-frequeny (4 frequencies/octave), in Q(4 settings) and in Attenuation (1dB-steps). In addition several configurations are possible to use the filters in the front- or rear-path.

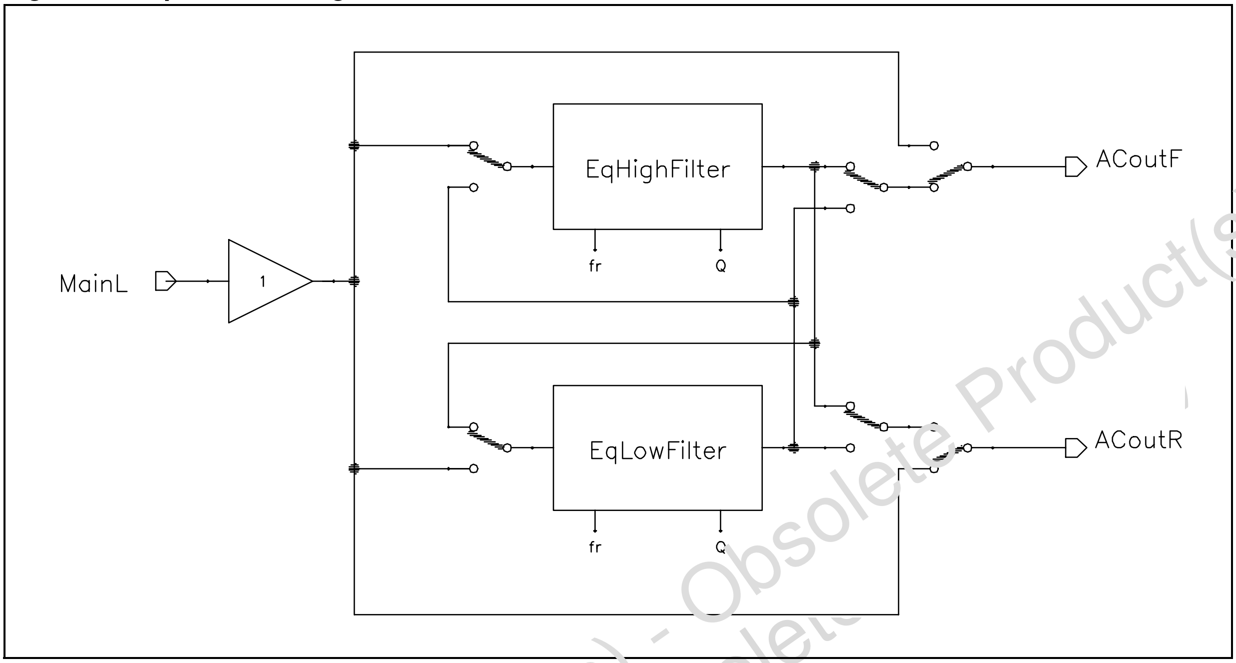
Table 6. Gain, Center Frequency and Quality Factor of Equalizer Filters

Parameter	Min	Max	Unit
Gain	-15	15	dB
Center Frequency Filter 1	63	840	Hz
Center Frequency Filter 2	300	4000	Hz
Quality Factor	1	4	

5.9.1 Equalizer-Setup

The two Filters can be configured in multiple ways in order to cover as most as possible applications. Both filters can be programmed to be either in the front- or in the rear-path, respectively. This feature enables to have e.g. the High-Filter in the front- and both filters in the rear-path.

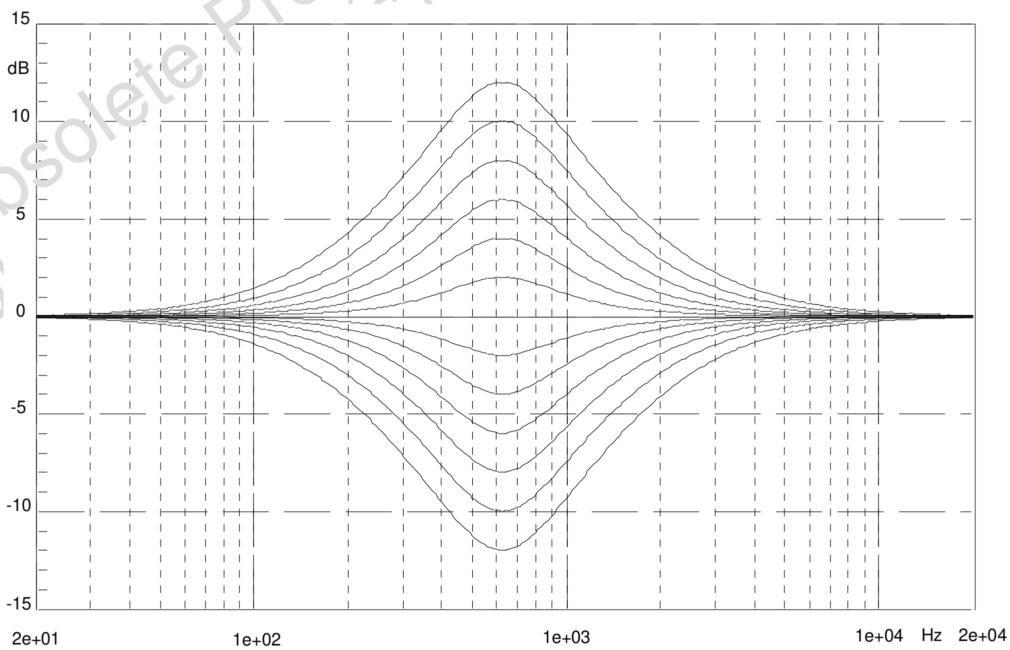
Figure 17. Equalizer Configuration



5.9.2 Attenuation

Figure 18 shows the attenuation as a function of frequency at a center frequency of 625 Hz.

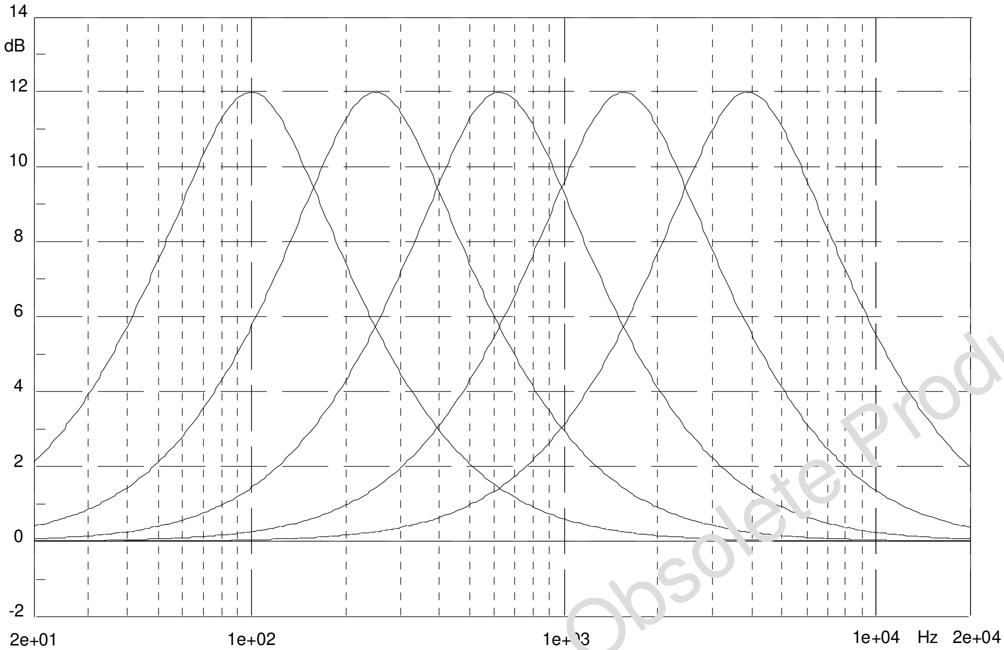
Figure 18. Gain/Attenuation of EQ-Filter



5.9.3 Frequencies

Figure 19 shows the different center frequencies of the EQ-Filter at 12 dB gain

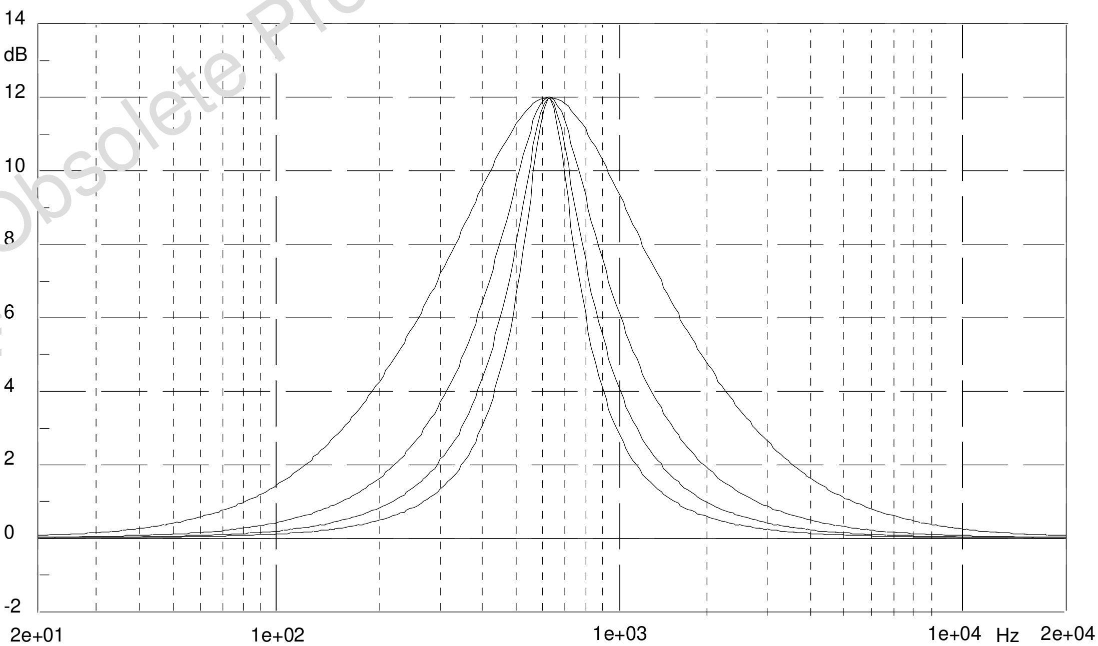
Figure 19. Center-Frequencies of EQ-Filter



5.9.4 Q-Factor

Figure 20 shows the four possible quality factors 1, 2, 3 and 4.

Figure 20. Different Q-factors of Equalizer-Filter

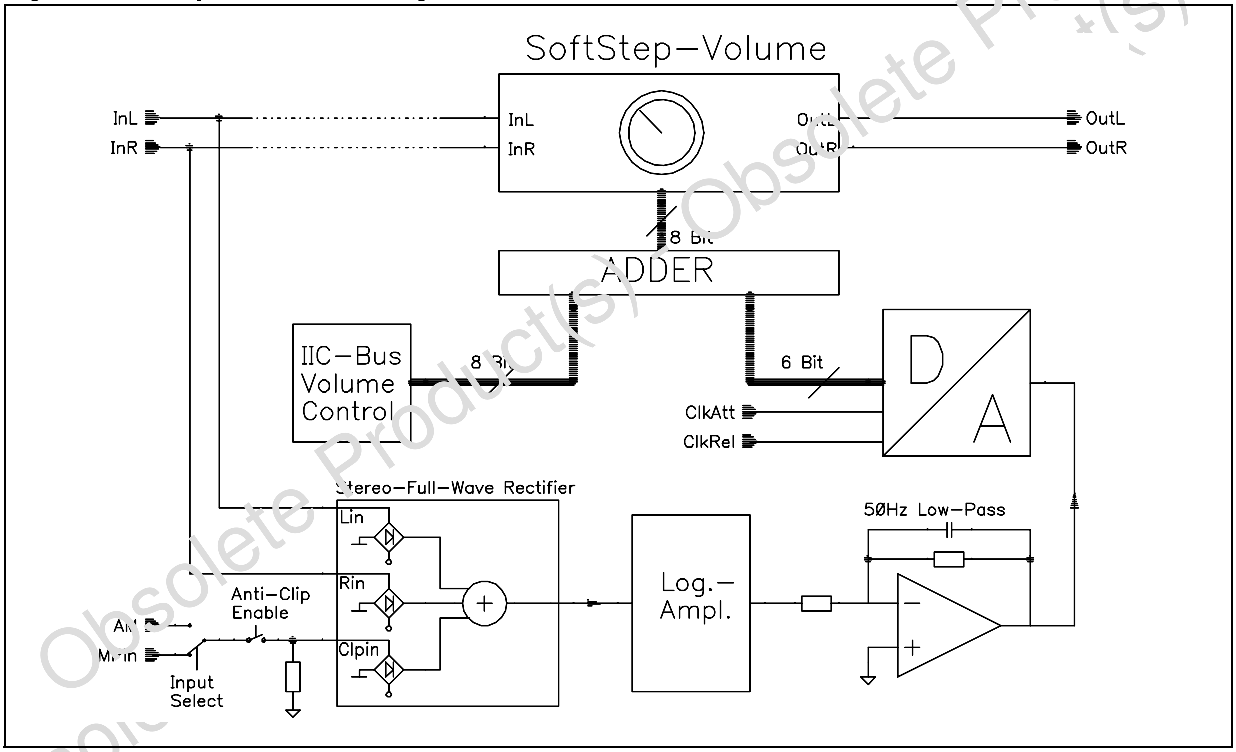


5.10 Compander

5.10.1 Signal-Compression

A fully integrated signal-compressor with programmable Attack- and Decay-times is present in the A631 (see Figure 20). The compander consists of a signal-level detection, an A/D-Converter plus adder and the normal SoftStep-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 IIC-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 1 Bit/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 21. Compander Block Diagram



5.10.2 Anti-Clipping

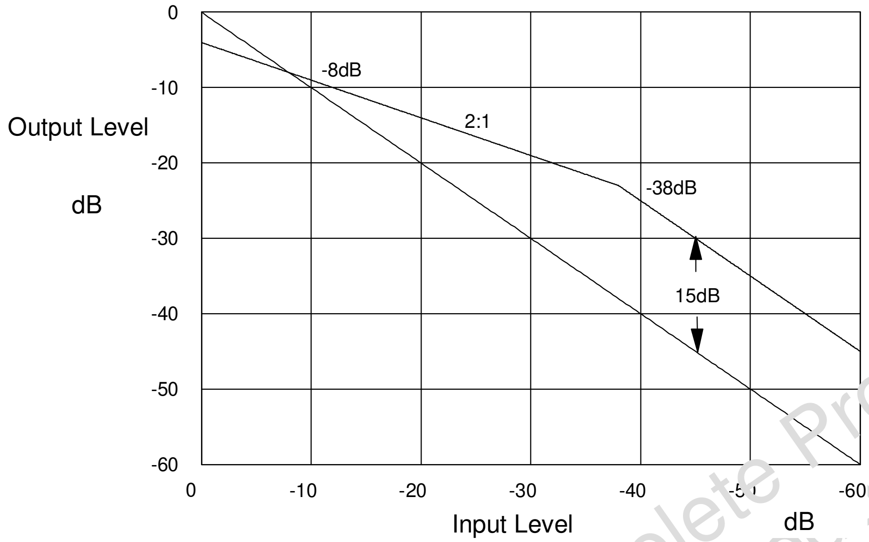
In a second application the compander-circuit can be used for a Anti-Clipping or Limiting function. In this case one of the dedicated inputs (AM or MPin) is connected directly to the Clip-Detector of the Power-Amplifier. If no clipping is detected, the open-collector output of the Power-Amplifier is 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 volume with the same value in order to get the desired output-level. In clipping situation the open-collector-current generates a voltage-drop at the rectifier-input, which forces the compander to decrease the gain until the clipping disappears.

It is even possible to run the compression-mode and the Anti-Clipping mode in parallel. In this case the maximum compander-Gain should be set to 29 dB.

5.10.3 Characteristic

To achieve the desired compression characteristic like shown below the volume has to be decreased by 4dB.

Figure 22. Compander Characteristic



5.10.4 I²C -BUS-Timing

When the Compander is active a volume- word coming from this stage is added to the I2C-Bus volume-word and the volume is changed with a soft slope between adjacent steps (SoftStep-stage). As mentioned in the description of this stage it is not recommended to change the volume during this slope. To avoid this behaviour-while the Compander is working, and the volume has to be changed, the compander-hold-bit is implemented (Bit 7 in the subaddress-byte). The recommended timing for changing the volume during compander-ON is the following:

1. Set the compander-hold-bit
2. Wait the actual SoftStep-time
3. Change the volume
4. Reset the compander-hold-bit

The SoftStep-times are in compander-ON condition automatically adapted to the attack-time of the Compander. In the following table the related SoftStep-times are shown:

Attack-Time	SoftStep-Time
6ms	0.16ms
12ms	0.32ms
24ms	0.64ms
48ms	1.28ms

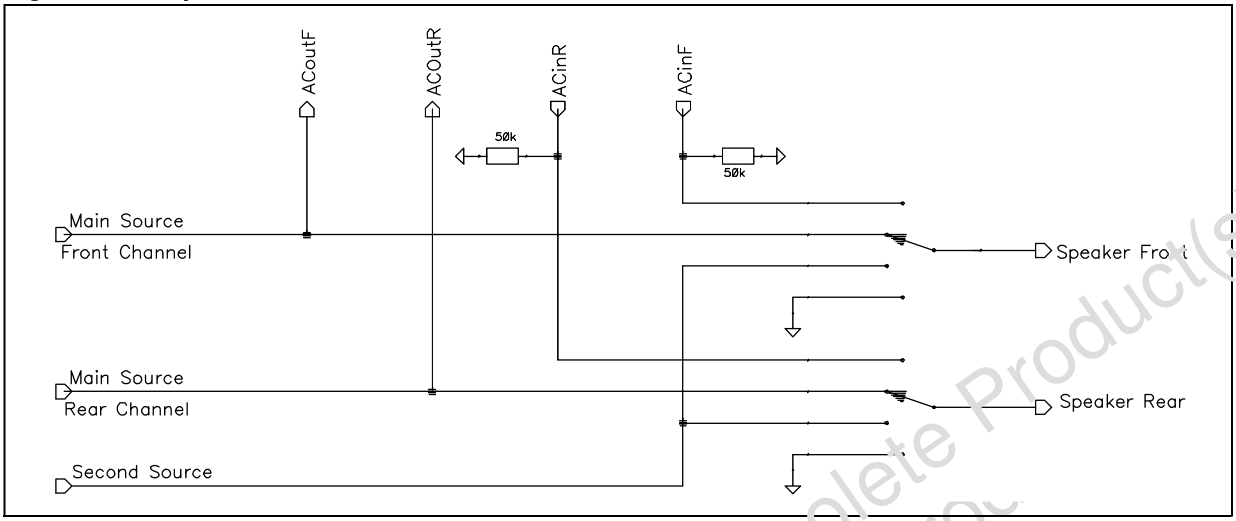
5.10.5 AC-Coupling

In some applications additional signal manipulations are desired, for example surround-sound or more-band-equalizing. For this purpose an AC-Coupling is placed before the speaker-attenuators, which can be activated or internally shorted by I²C-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 50kΩ.

5.10.6 Output Selector

The output-selector allows to connect the main- or the second-source to the Front-, Rear-speaker-attenuator, respectively. As an example of this programming the device is able to connect via software the main-source to the back (rear) and the second-source to the front (see Figure 23).

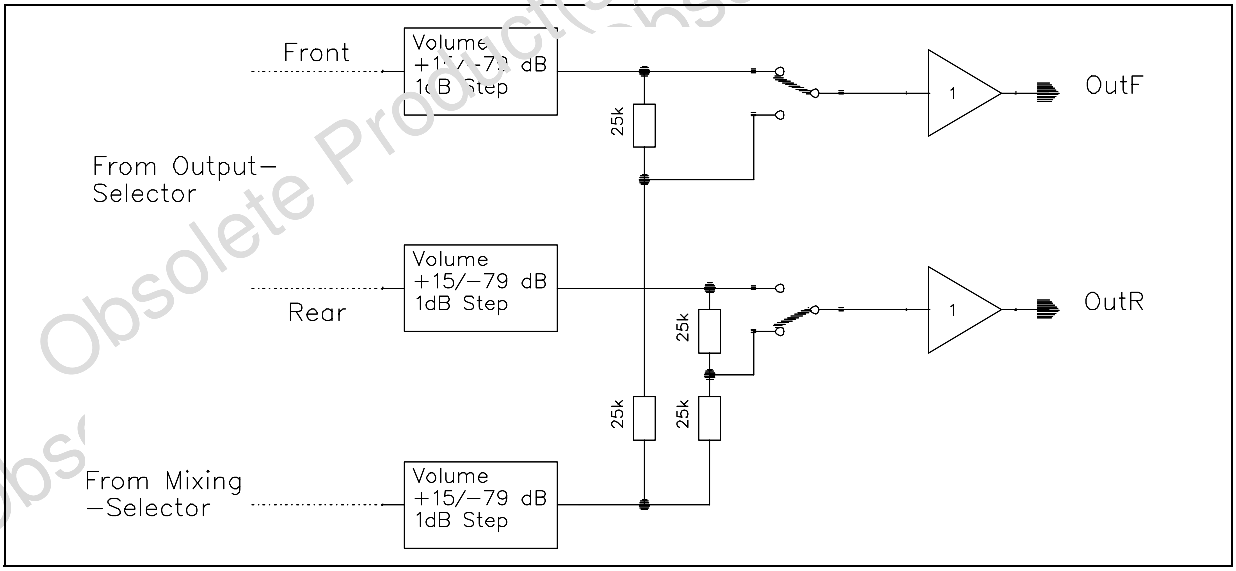
Figure 23. Output Selector



5.10.7 Speaker-Attenuator and Mixing

A Mixing-stage is placed after each 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 24. Mixing Configuration



5.10.8 Audioprocessor Testing

During the Testmode, which can be activated by setting bit D_0 of the stereodecoder testing-byte and the audio-processor testing byte, several internal signals are available at the FD2R- pin. During this mode the input resistance of 100kOhm is disconnected from the pin. The internal signals available are shown in the Data-byte specification.

6 STEREODECODER-PART

6.1 Features:

- no external components necessary
- PLL with adjustment free, fully integrated VCO
- automatic pilot dependent MONO/STEREO switching
- very high suppression of intermodulation and interference
- programmable Roll-Off compensation
- dedicated RDS-Softmute
- Highcut- and Stereoblend-characterisctics programmable in a wide range
- FM/AMNoiseblanker with several threshold controls
- Multipath-detector with programmable internal/external influence
- I^2C-bus control of all necessary functions

Table 7. ELECTRICAL CHARACTERISTICS

V_S = 9V, deemphasis time constant = 50µs, MPX input voltage V_{MPX} = 500mV (75kHz deviation), modulation frequency = 1kHz, input gain = 6dB, T_{amb} = 27°C, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{in}	MPX Input Level	Input Gain = 3.5dB		0.5	1.25	V_{rms}
R_{in}	Input Resistance		70	100	130	kΩ
G_{min}	Min. Input Gain		1.5	3.5	4.5	dB
G_{max}	Max. Input Gain		8.5	11	12.5	dB
G_{step}	Step Resolution		1.75	2.5	3.25	dB
SVRR	Supply Voltage Ripple Rejection	V_{ripple} = 100mV, f = 1kHz		55		dB
α	Max. Channel Separation		30	50		dB
THD	Total Harmonic Distortion	f_{in}=1kHz, mono		0.02	0.3	%
$\frac{S+N}{N}$	Signal plus Noise to Noise Ratio	A-weighted, S = $2V_{rms}$	80	91		dB
MONO/STEREO-SWITCH						
V_{PTHST1}	Pilot Threshold Voltage	for Stereo, PTH = 1	10	15	25	mV
V_{PTHST0}	Pilot Threshold Voltage	for Stereo, PTH = 0	15	25	35	mV
V_{PTHMO1}	Pilot Threshold Voltage	for Mono, PTH = 1	7	12	17	mV
V_{PTHMO0}	Pilot Threshold Voltage	for Mono, PTH = 0	10	19	25	mV
PLL						
Δf/f	Capture Range		0.5			%
DEEMPHASIS and HIGHCUT						

Table 7. ELECTRICAL CHARACTERISTICS (continued)

V_S = 9V, deemphasis time constant = 50µs, MPX input voltage V_{MPX} = 500mV (75kHz deviation), modulation frequency = 1kHz, input gain = 6dB, T_{amb} = 27°C, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$\tau_{DeempFM}$	Deemphasis Timeconstants FM	$V_{LEVEL} >> V_{HCH}$	25	50	75	µs
		$V_{LEVEL} >> V_{HCH}$	44	62.5	80	µs
		$V_{LEVEL} >> V_{HCH}$	50	75	100	µs
		$V_{LEVEL} >> V_{HCH}$	70	100	130	µs
M_{FM}	Highcut Timeconstant Multiplier FM	$V_{LEVEL} << V_{HCL}$		3		
$\tau_{DeempAM}$	Deemphasis Timeconstants AM	$V_{LEVEL} >> V_{HCH}$		37.5		µs
		$V_{LEVEL} >> V_{HCH}$		47		µs
		$V_{LEVEL} >> V_{HCH}$		56		µs
		$V_{LEVEL} >> V_{HCH}$		75		µs
M_{AM}	Highcut Timeconstant Multiplier AM	$V_{LEVEL} << V_{HCL}$		3.7		
REF5V	Internal Reference Voltage		4.7	5	5.3	V
L_{min}	min. LEVEL Gain		-1	0	1	dB
L_{maxs}	max. LEVEL Gain		5	6	7	dB
L_{Gstep}	LEVEL Gain Step Resolution	see section 2.7	0.2	0.4	0.6	dB
$VSBL_{min}$	Min. Voltage for Mono	see section 2.8	17	20	23	%REF5V
$VSBL_{max}$	Max. Voltage for Mono	see section 2.8	62	70	78	%REF5V
$VSBL_{step}$	Step Resolution	see section 2.8	1.6	3.3	5.0	%REF5V
$VHCH_{min}$	Min. Voltage for NO Highcut	see section 2.9	37	42	47	%REF5V
$VHCH_{max}$	Max. Voltage for NO Highcut	see section 2.9	58	66	74	%REF5V
$VHCH_{step}$	Step Resolution	see section 2.9	4.2	8.4	12.6	%REF5V
$VHCL_{min}$	Min. Voltage for FULL High cut	see section 2.9	15	17	19	%VHCH
$VHCL_{max}$	Max. Voltage for FULL High cut	see section 2.9	29	33	37	%VHCH
$VHCL_{step}$	Step Resolution	see section 2.9	2.1	4.2	6.3	%REF5V
Carrier and harmonic suppression at the output						
$\alpha19$	Pilot Signalf=19kHz		40	50		dB
$\alpha38$	Subcarrier f=38kHz			75		dB
$\alpha57$	Subcarrier f=57kHz			62		dB
$\alpha76$	Subcarrier f=76kHz			90		dB
Intermodulation (Note 1)						

Table 7. ELECTRICAL CHARACTERISTICS (continued)
V_S = 9V, deemphasis time constant = 50µs, MPX input voltage V_{MPX} = 500mV (75kHz deviation), modulation frequency = 1kHz, input gain = 6dB, T_{amb} = 27°C, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
α2	f_{mod}=10kHz, f_{spur}=1kHz			65		dB
α3	f_{mod}=13kHz, f_{spur}=1kHz			75		dB
Traffic Radio (Note 2)						
α57	Signal f=57kHz			70		dB
SCA - Subsidiary Communications Authorization (Note 3)						
α67	Signal f=67kHz			75		dB
ACI - Adjacent Channel Interference (Note 4)						
α114	Signal f=114kHz			95		dB
α190	Signal f=190kHz			84		dB

7 NOTES TO THE CHARACTERISTICS

Note 1. Intermodulation Suppression

$$\alpha 2 = \frac{V_o(signal)(at1kHz)}{V_o(spurious)(at1kHz)}; f_s = (2 \cdot 10kHz) - 19kHz$$

$$\alpha 3 = \frac{V_o(signal)(at1kHz)}{V_o(spurious)(at1kHz)}; f_s = (3 \cdot 13kHz) - 38kHz$$

measured with: 91% pilot signal; fm = 10 kHz or 13 kHz.

Note 2. Traffic Radio (V.F.) Suppression
measured with: 91% stereo signal; 9% pilot signal; fm=1kHz; 5% subcarrier (f=57kHz, fm=23Hz AM, m=60%)

$$\alpha 57(V.W.F.) = \frac{V_o(signal)(at1kHz)}{V_o(spurious)(at1kHz \pm 23kHz)}$$

Note 3. SCA (Subsidiary Communications Authorization)

$$\alpha 67 = \frac{V_o(signal)(at1kHz)}{V_o(spurious)(at9kHz)}; f_s = (3 \cdot 38kHz) - 67kHz$$

measured with: 81% mono signal; 9% pilot signal; fm=1kHz; 10%SCA - subcarrier (fs = 67kHz, unmodulated).