# SIEMENS

Audioprocessor   **TDA 4350X**

1 Overview

1.1 Features

Stereo-Soundprocessing

- Three stereo AF inputs, one of the inputs is equipped with floating ground.
- Input level control for individual level setting of the several AF sources in addition with a clipping detector.
- Volume control with software controlled switchable loudness function. Frequency response fixed by external components.
- Bass- and treble control with clipping detector.
- Four independent settable output attenuators for balance/fader function.
- Fan-out of the AF outputs software controlled.
- AF outputs switchable for driving bride power amplifiers.
- I²C Bus controlled immediately, or zero cross detector dependent mute, or immediately mute via extra pin.
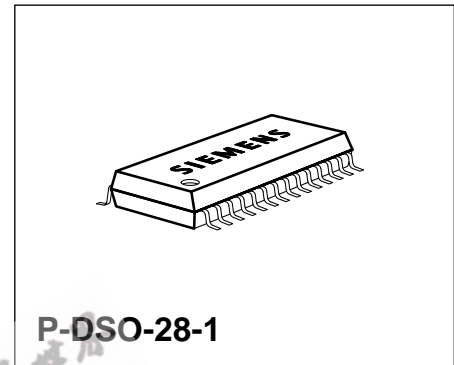
P-DSO-28-1

Control Part

- I²C Bus interface
- Control of sound processing
- Read out of the clipping detector status.

Type	Ordering Code	Package
TDA 4350X	Q67000-A5060	P-DSO-28-1

1.2 Application

The TDA 4350X is a single-chip audio-soundsystem. The circuit can be partitioned into two functional blocks: stereo-soundprocessing and control part.

1.3 Pin Configuration
(top view)

P-DSO-28-1
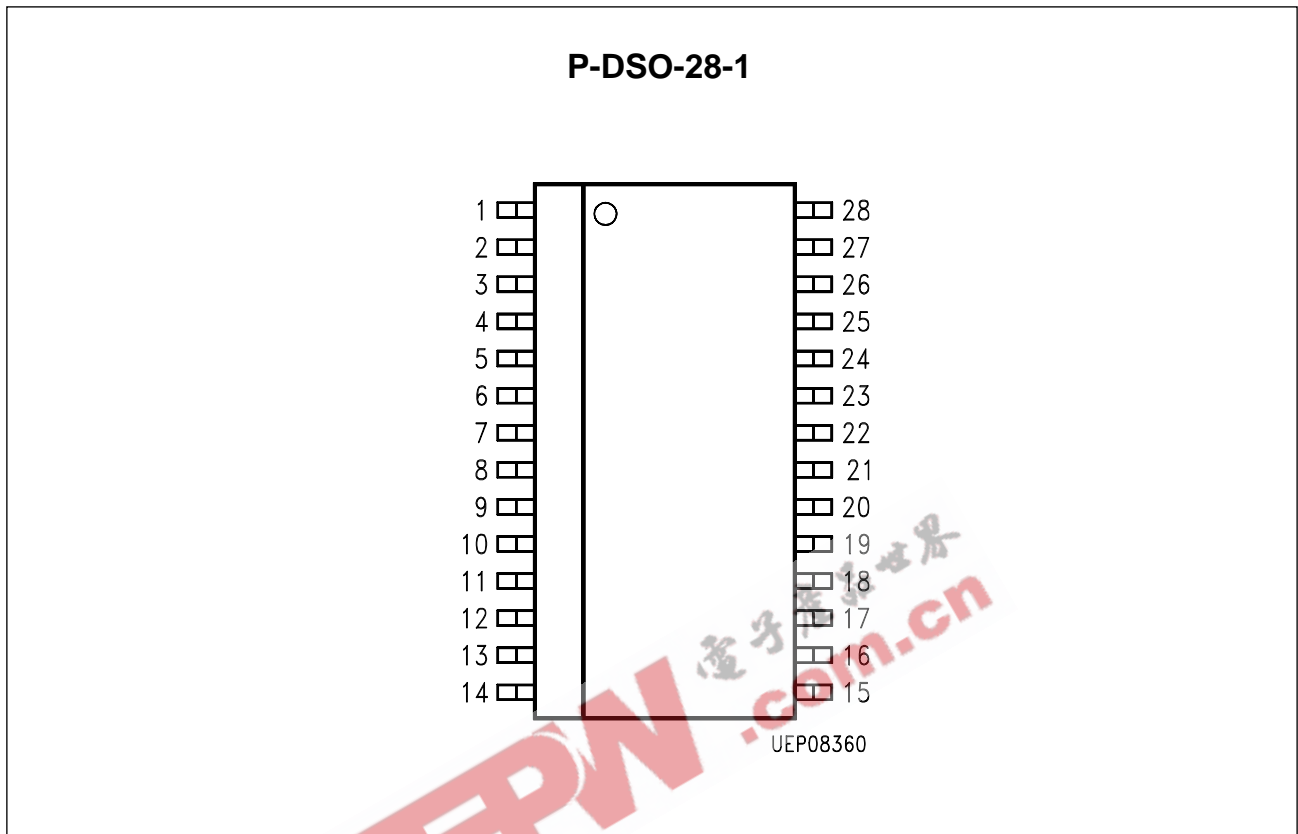
Figure 1

1.4   Pin Definitions and Functions

| Pin No.	Function
1	CD input right
2	Input 2 right
3	Input 3 right
4	Loudness output right
5	Loudness input right
6	Digital ground
7	Mute
8	I²C Bus SCL
9	I²C Bus SDA
10	+ V_S supply voltage
11	Corner frequency treble left
12	Corner frequency treble right
13	AF output right front
14	AF output right rear
15	AF output left rear
16	AF output left front
17	RC network bass right
18	RC network bass right
19	RC network bass left
20	RC network bass left
21	Analog ground
22	Bias for AF operation point
23	Loudness output left
24	Loudness input left
25	Input 3 left
26	Input 2 left
27	CD ground
28	CD input left

1.5   Functional Block Diagram
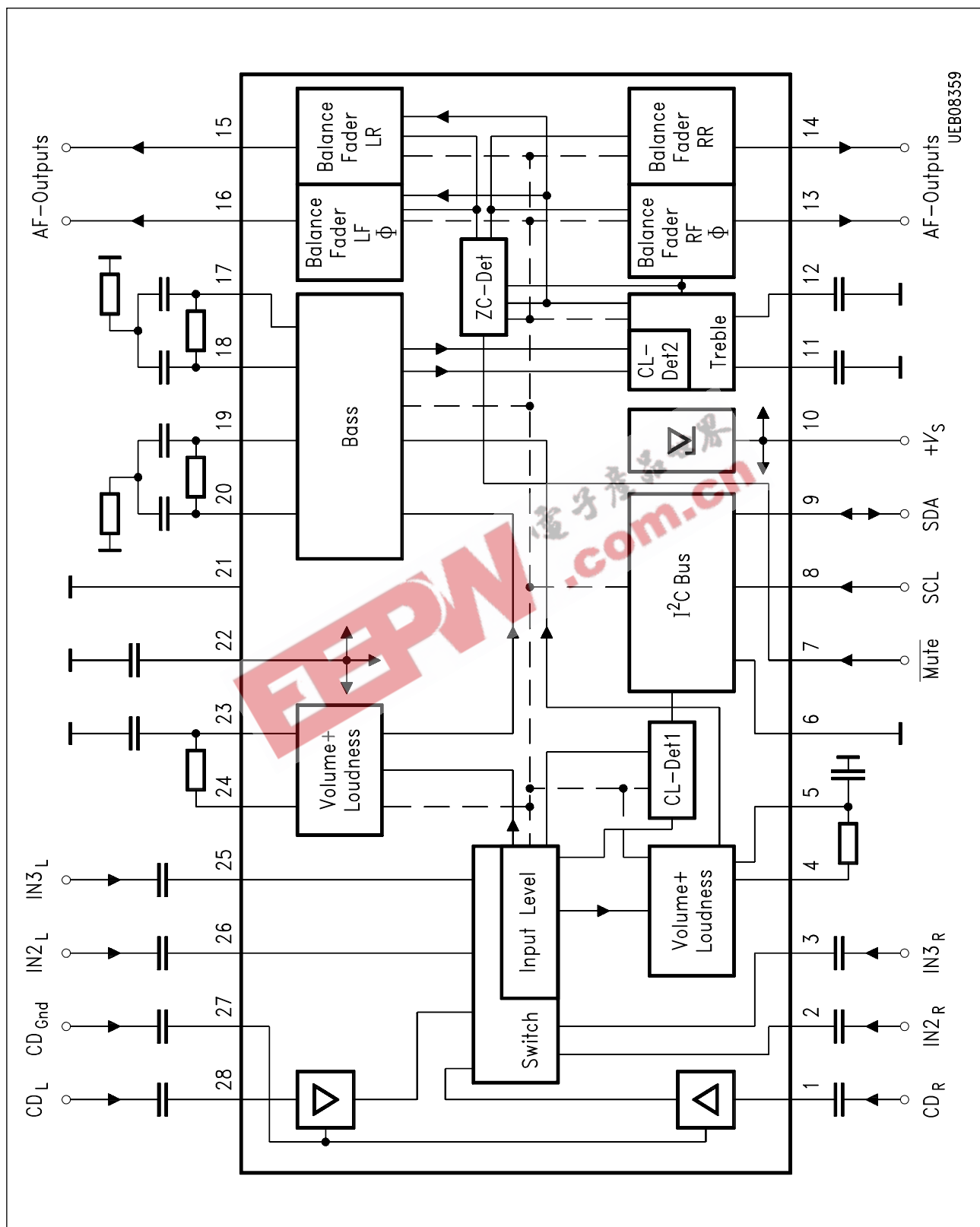
Figure 2
Block Diagram

2 Circuit Description

2.1 Signalprocessing

1. The selection of the AF inputs happens in the input switch. There are three stereo-inputs available. One of the input pairs is equipped with a separate floating ground connection especially provided for external signal sources. Crosstalk to this input is suppressed by common mode rejection. An input level control circuitry behind input switch realizes the adaption of different signal source levels. The circuit offers a control range from 0 dB to + 25 dB with a stepwidth of 2.5 dB. An I²C Bus controlled first clipping detector allows a software controlled level adaption.

2. Next stage in signal path is volume control, with common setting for both channels, a control range of 0 dB to – 78.75 dB and a stepwidth of 1.25 dB. In this stage a loudness function is realized. A loudness control circuit, in fact a second volume control circuit with identical structure, is to be set to a higher level as volume control. The resulting level difference fixes the maximum amplitude response of the loudness function. The frequency response, only bass boost or combined bass and treble boost is fixed by external components. Because the volume and loudness control are strictly independent of each other, the frequency response and threshold of the loudness function is programmable via software. A switch bit allows to enable the loudness function easily. Some possible loudness setups:

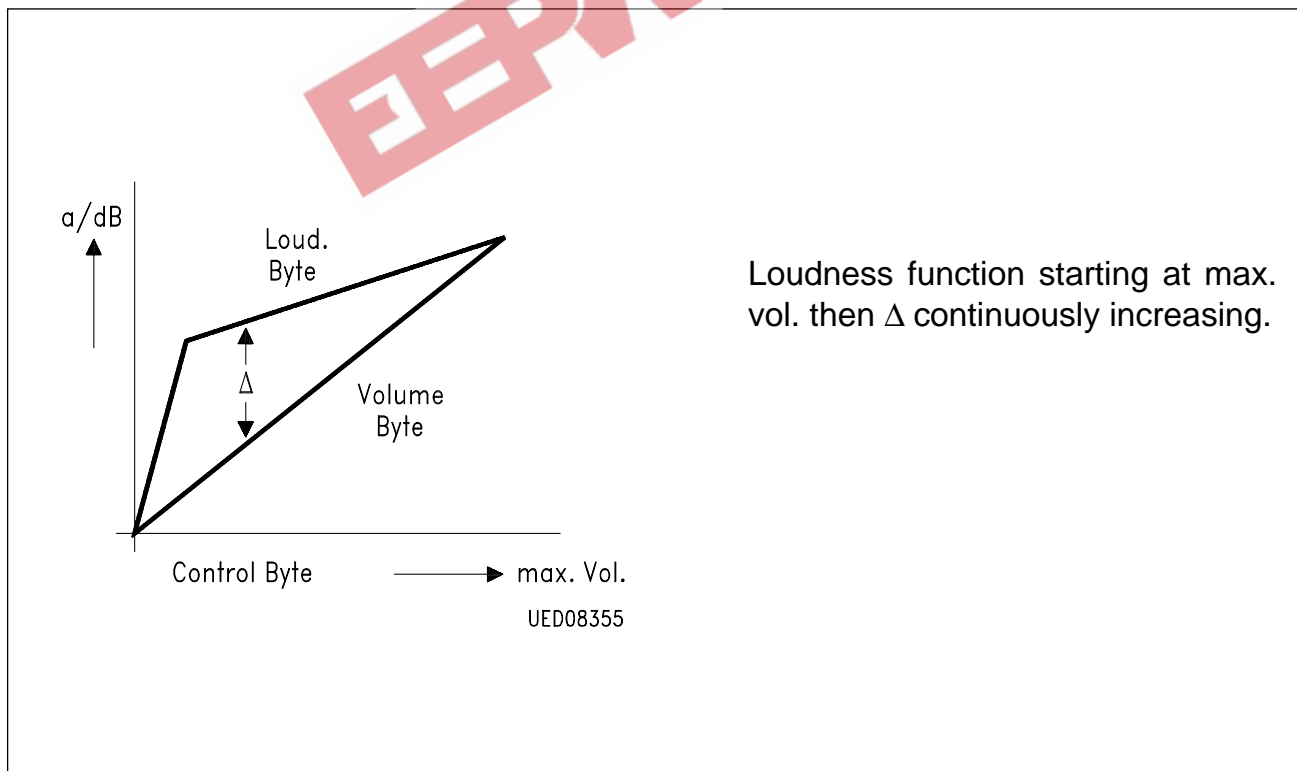Loudness function starting at max. vol. then Δ continuously increasing.

Figure 3

Loudness function starting at vol. a then Δ continuously increasing.

Figure 4

Loudness function starting at max. vol. increasing to Δ, following constant Δ.

Figure 5

Loudness function starting at vol. a increasing to Δ, following constant Δ.

UED08358
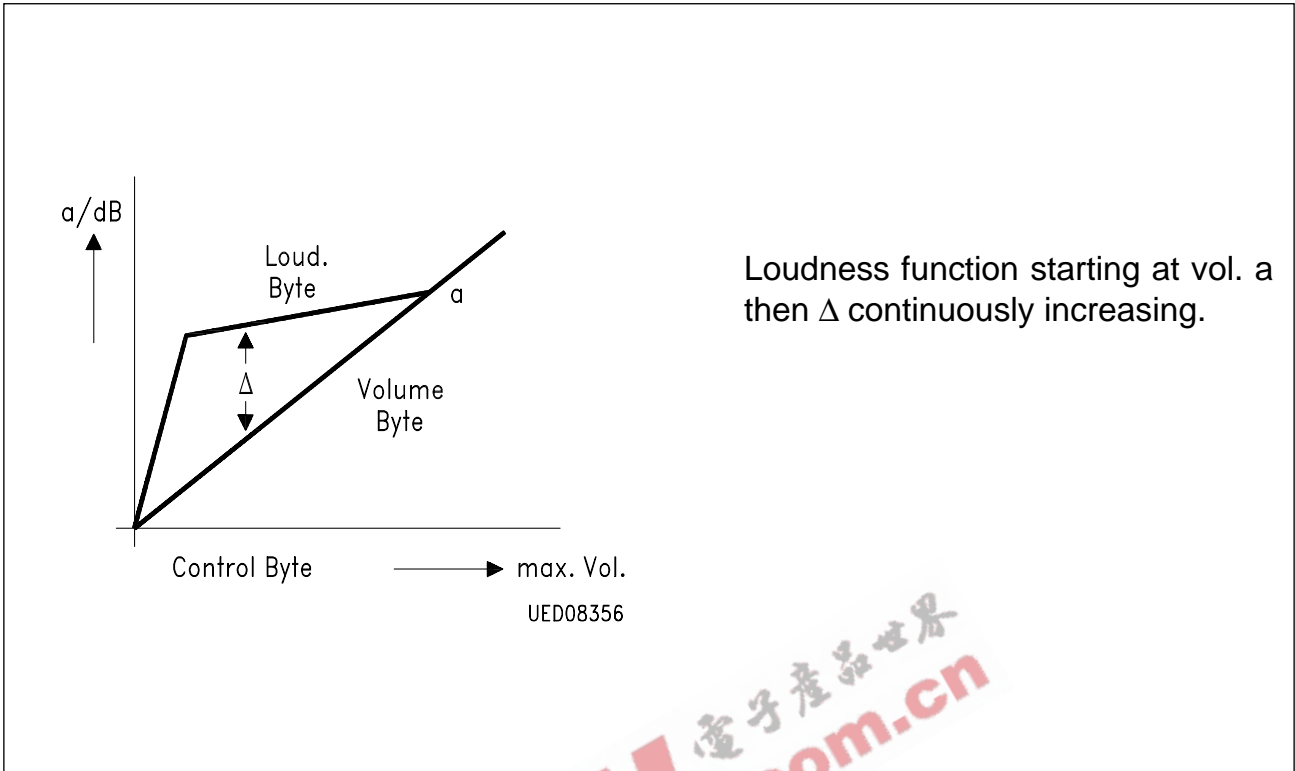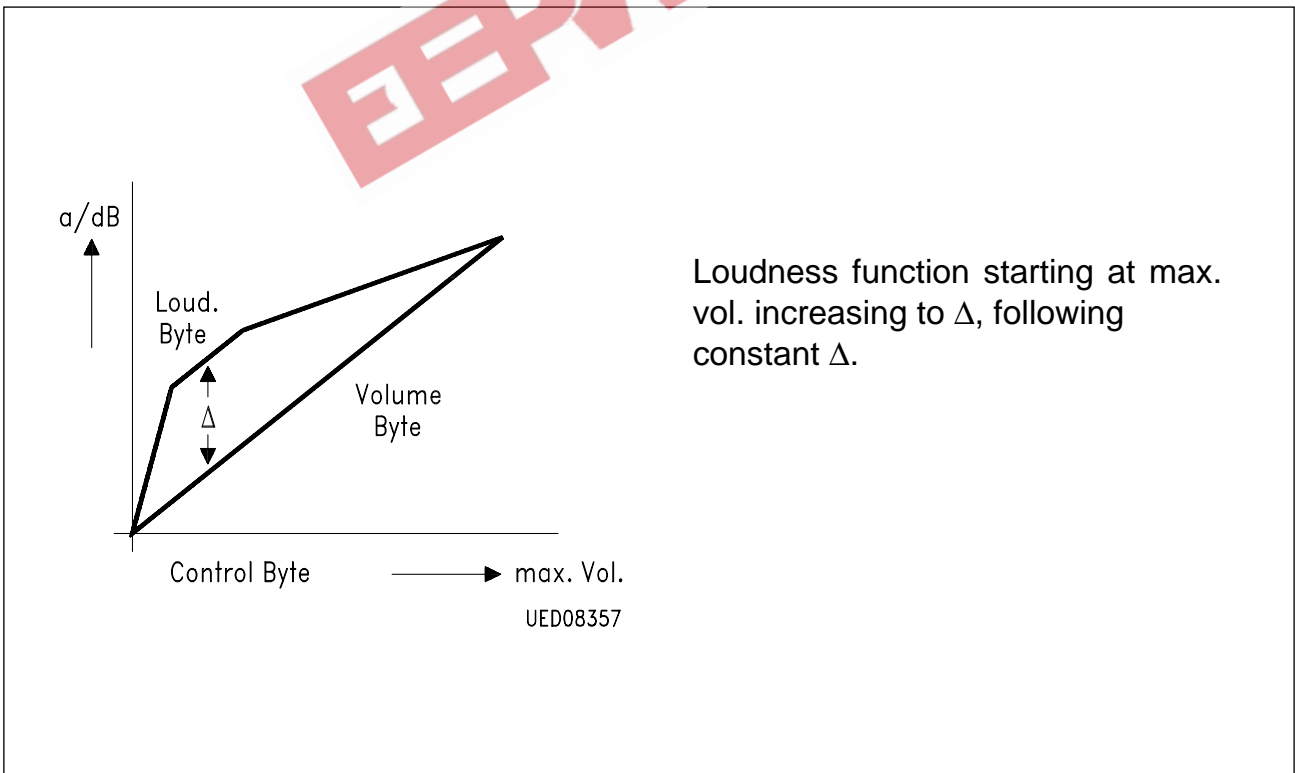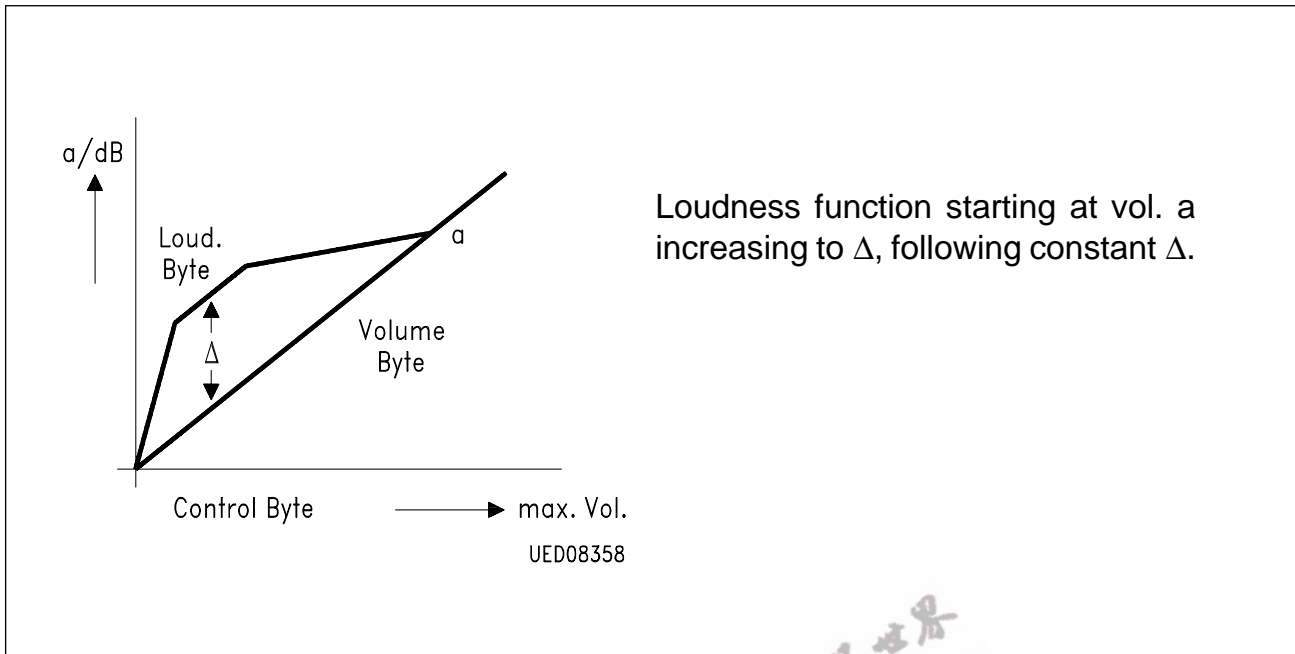
Figure 6

3. In the following signalpath there is tone control, consisting of bass and treble control. Bass control offers a control range of + 16 dB to − 14 dB with a stepwidth of 2 dB. Frequency characteristic, 1st order or 2nd order (resonance type) is fixed by external components. Treble control also offers a control range of + 16 dB to − 14 dB with a stepwidth of 2 dB. The treble control corner frequency is determined by an external capacitor.
A second clipping detector allows to detect clipping in tone control part.

4. Last stages in signal path are four strictly independent controllable output attenuators to realize balance and fader function. Each unit offers a control range of 0 dB to − 38.75 dB in steps of 1.25 dB. The AF outputs are of a class A-type to avoid distortion via software, the output fan-out can be increased to drive loads up to > 1.5 kΩ.
One output of each stereo channel can be inverted software controlled, to drive easily bridge power amplifiers.

5. Mute control may be either done via the volume control setting, or directly for all outputs by setting the IM (immediately mute) bit via I²C Bus. The second bus controlled mute mode is mute after signal zero crossing (ZCM). Two zero cross detectors are built-in, therefore this mute control works independent for left and right channel. Signal off- and on-switching is performed under zero cross detector control. The ZCM status can be read out via I²C Bus (ZCS). After activating ZCM, the ZCS (zero crossing status) bit is set to '1', when all outputs are muted after zero crossing. After deactivating ZCM, the ZCS bit is set to '0' when all outputs are switched on after zero crossing. The IM mute overwrites ZCM mute. Third mute control is hardware mute via a mute pin. If the mute pin is switched to ground all outputs are muted immediately. Hardware mute overwrites all other mute modes.

2.2 Controlpart

All functions are controlled via an I²C Bus interface. All data are stored into a latch circuit. The telegram structure is built as follows:

Startcondition – chipaddress – any number of databytes – stopcondition.

For the databytes the following conditions must be fulfilled:
Before transmitting a databyte a subaddress byte must first be placed in the data telegram.

2.2.1 Chipaddress

MSB							LSB
1	0	0	0	0	1	1	R/W

R/W = '0' → Read   R/W = '1' → Write

2.2.2 Subaddress Bytes

	MSB							LSB
Switchbyte	0	0	0	0	0	0	0	0
Inputlevel	0	0	0	0	0	0	0	1
Volume	0	0	0	0	0	0	1	0
Loudness	0	0	0	0	0	0	1	1
Bass/Treble	0	0	0	0	0	1	0	0
Out rear left	0	0	0	0	0	1	0	1
Out front left	0	0	0	0	0	1	1	0
Out rear right	0	0	0	0	0	1	1	1
Out front right	0	0	0	0	1	0	0	0

2.2.3 Control Bytes

a) Switch Control Byte

MSB   LSB

ZCM	IM	Fan	Ph	IN-3	IN-2	IN-CD	X

IN-CD = '0'   CD input OFF; power ON
IN-CD = '1'   CD input ON

IN-2 = '0'   Input 2 OFF; power ON
IN-2 = '1'   Input 2 ON

IN-3 = '0'   Input 3 OFF; power ON
IN-3 = '1'   Input 3 ON

If no input is selected, mute function is active.
If no protection against multiple selection implemented!

Ph = '0'   Bridgepower amplifier operation ON; power ON
Ph = '1'   Normal operation

Fan = '0'   Normal operation; power ON
Fan = '1'   Increased Fan out ON

IM = '0'   Normal operation; power ON
IM = '1'   Immediate mute for all AF outputs

ZCM = '0'   Normal operation; power ON
ZCM = '1'   Mute after signal zero crossing

IM overwrites ZCM, handware mute overwrites all other mute modes.

b) Input Level Control Byte

       MSB   LSB

	MSB							LSB	
Min. gain	X	X	X	X	0	0	0	0	
Min. gain + 1	X	X	X	X	0	0	0	1	power ON
Max. gain – 1	X	X	X	X	1	0	0	1	
Max. gain	X	X	X	X	1	0	1	0	
				to					
Max. gain	X	X	X	X	1	1	1	1	

c) Volume Level Control Byte

	MSB						LSB	
Min. gain	X	0	0	0	0	0	0	0	
Min. gain + 1	X	0	0	0	0	0	0	1	power ON
Max. gain − 1	X	0	1	1	1	1	1	0	
Max. gain	X	0	1	1	1	1	1	1	

d) Loudness Control Byte

	MSB						LSB	
Min. gain	X	Ld	0	0	0	0	0	0	
Min. gain + 1	X	Ld	0	0	0	0	0	1	power ON
Max. gain − 1	X	Ld	1	1	1	1	1	0	
Max. gain	X	Ld	1	1	1	1	1	1	

Ld = '0' Loudness OFF; power ON
(loudness attenuator has the same setting
as volume attenuator)

Ld = '1' Loudness ON

e) Treble/Bass Control Byte

	MSB							LSB
linear	1	0	0	0	1	0	0	0
max. treble, lin. bass	0	0	0	0	1	0	0	0
min. treble, lin. bass	1	1	1	1	1	0	0	0
lin. treble, max. bass	1	0	0	0	0	0	0	0
lin. treble, min. bass	1	0	0	0	1	1	1	1
max. treble, max. bass	0	0	0	0	0	0	0	0
min. treble, min. bass	1	1	1	1	1	1	1	1
power ON	0	0	0	0	0	0	0	1
	treble				bass			

f) Output Control Bytes

	MSB							LSB	
Min. gain	X	X	X	X	0	0	0	0	
Min. gain + 1	X	X	X	X	0	0	0	1	power ON
Max. gain – 1	X	X	X	X	1	1	1	0	
Max. gain	X	X	X	X	1	1	1	1	

2.2.4   Talkmode

MSB   LSB

CI1	CI2	ZCS	X	X	X	X	X

CI1 = '0'   Normal operation
CI1 = '1'   Input level control output at clipping level
CL 2 = '0'   Normal operation
CL2 = '1'   Tone control output at clipping level
ZCS = '0'   All AF outputs are ON after ZCS set to '0'
ZCS = '1'   All AF outputs are muted after ZCM set to '1'
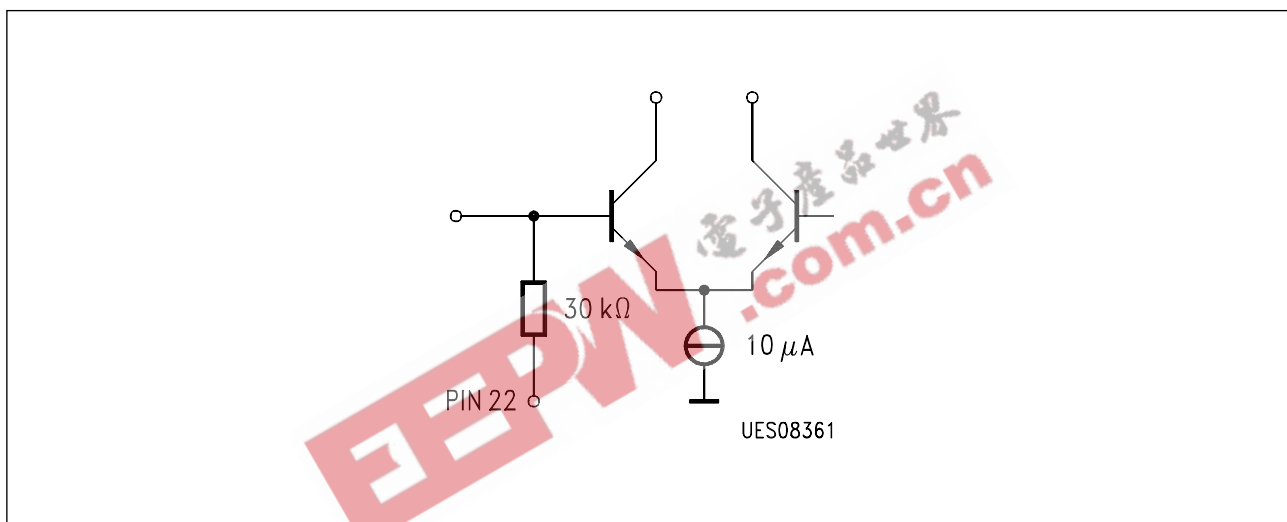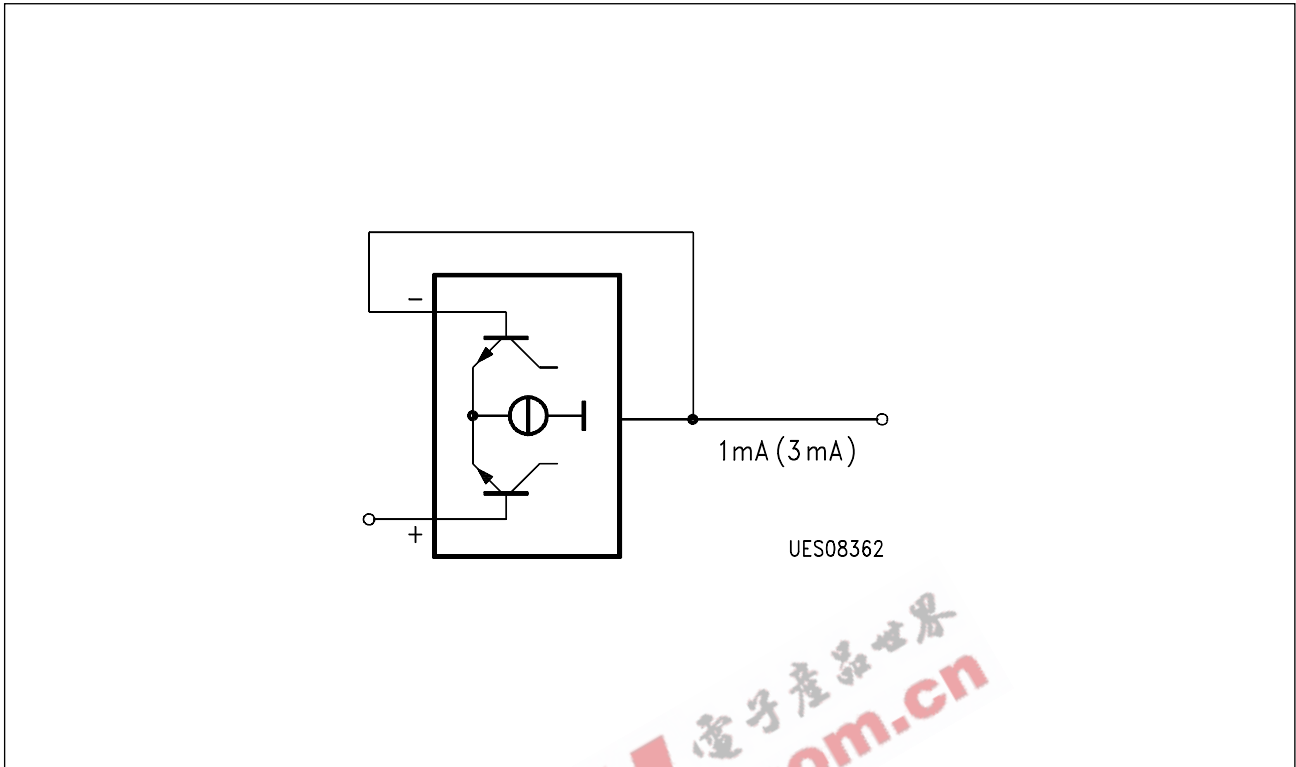

Figure 7
AF Inputs Pin 1/2/3/25/26/27/28

Figure 8
AF Outputs Pin 13/14/15/16
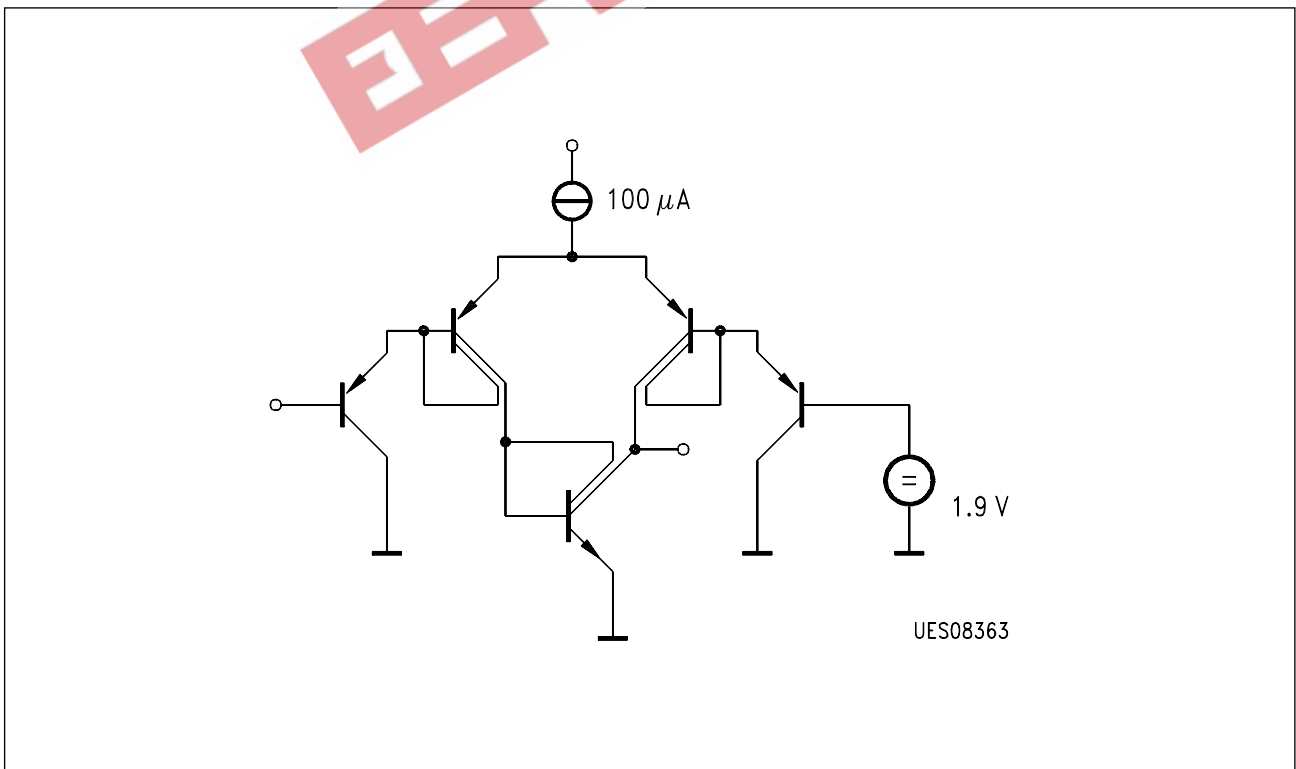
Figure 9
Mute Pin 7, I²C Bus SCL Pin 8
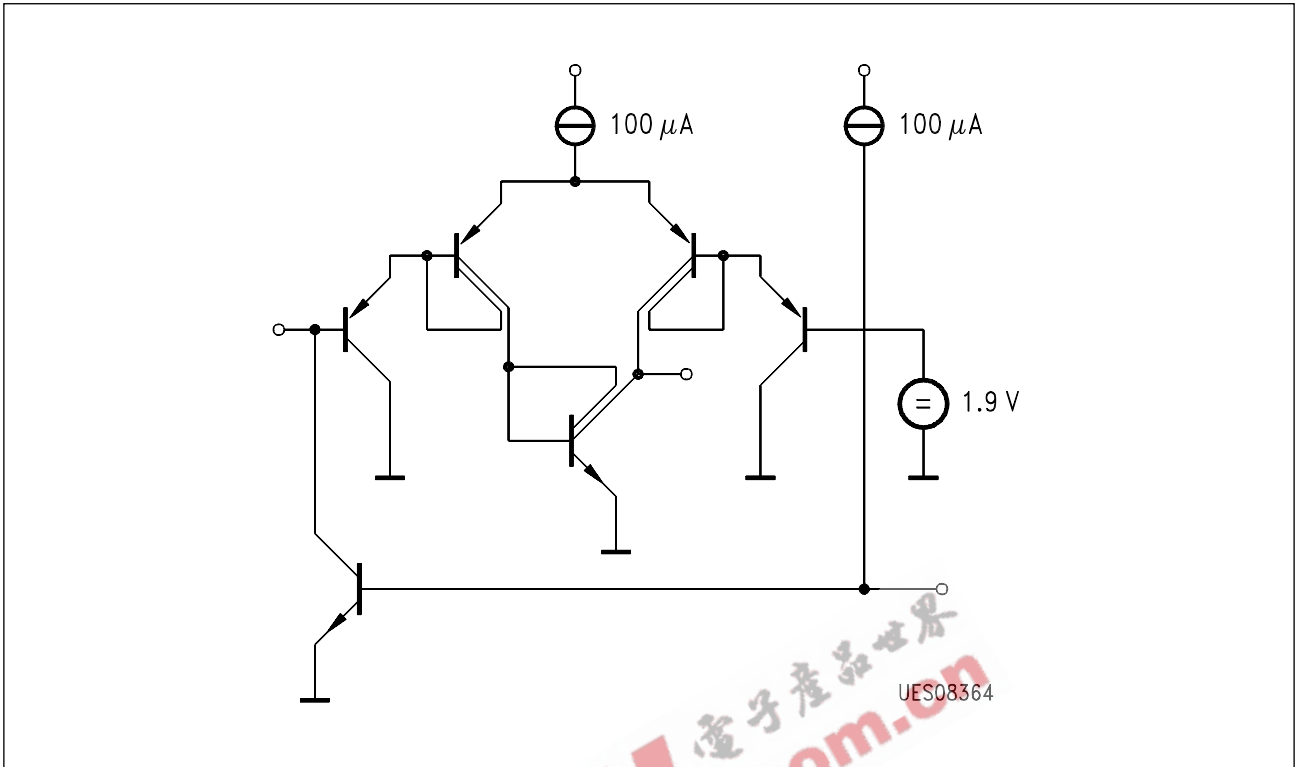
Figure 10
I²C Bus SDA Pin 9
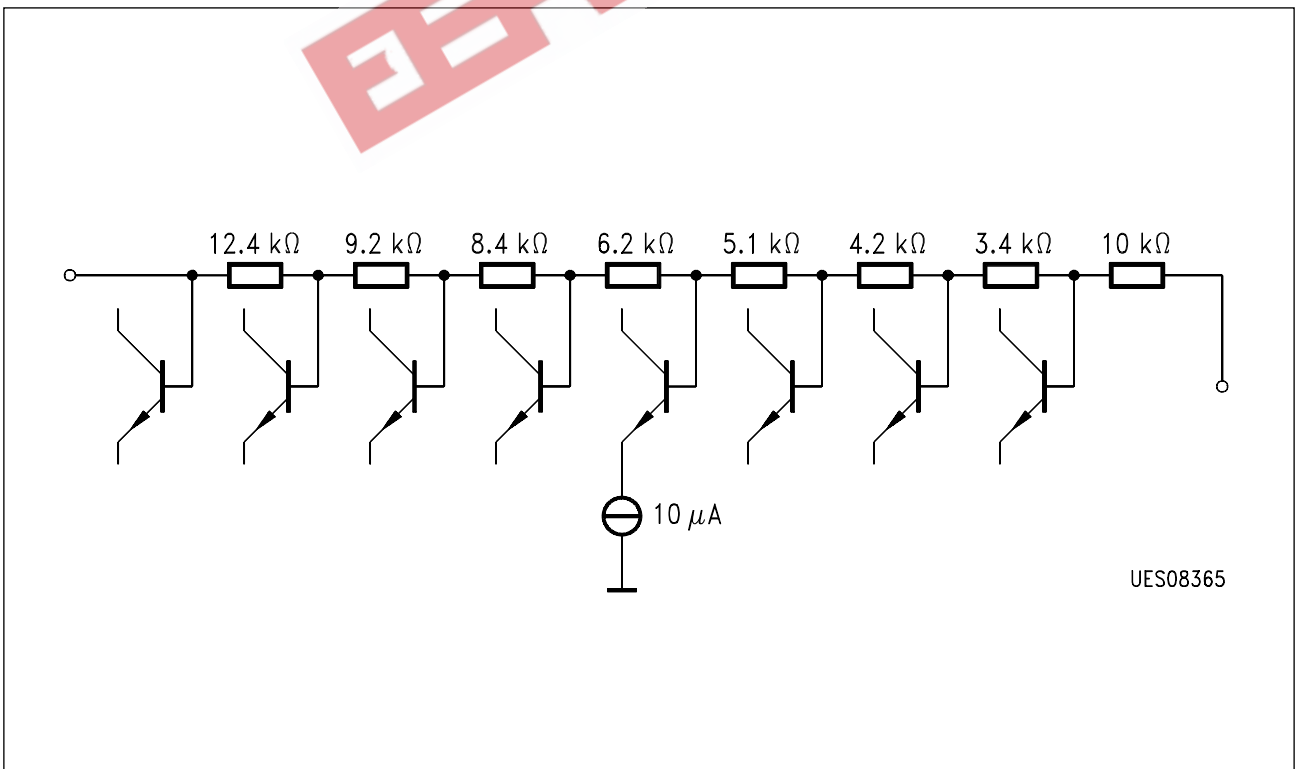
Figure 11
Corner Frequency Treble Pin 11/12
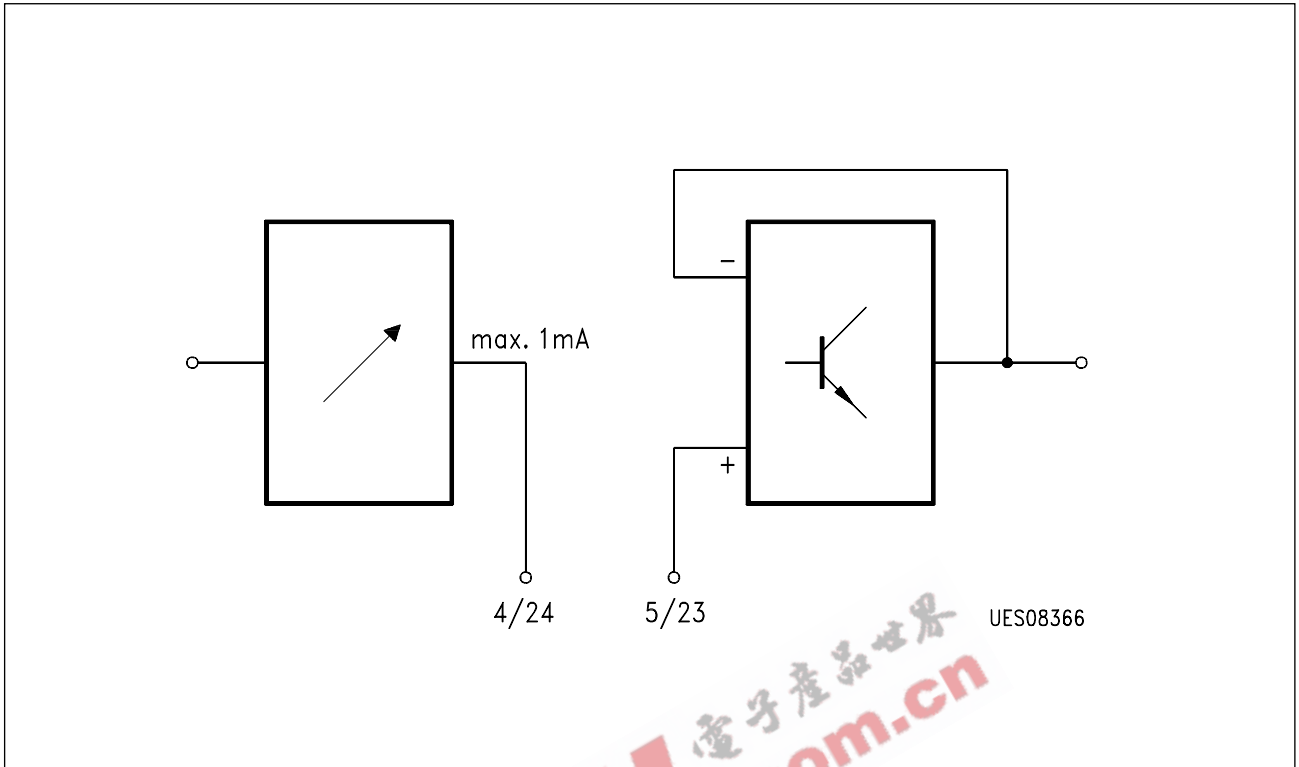
Figure 12
Loudness Pin 4/5/23/24

max. 1mA

4/24   5/23   UES08366
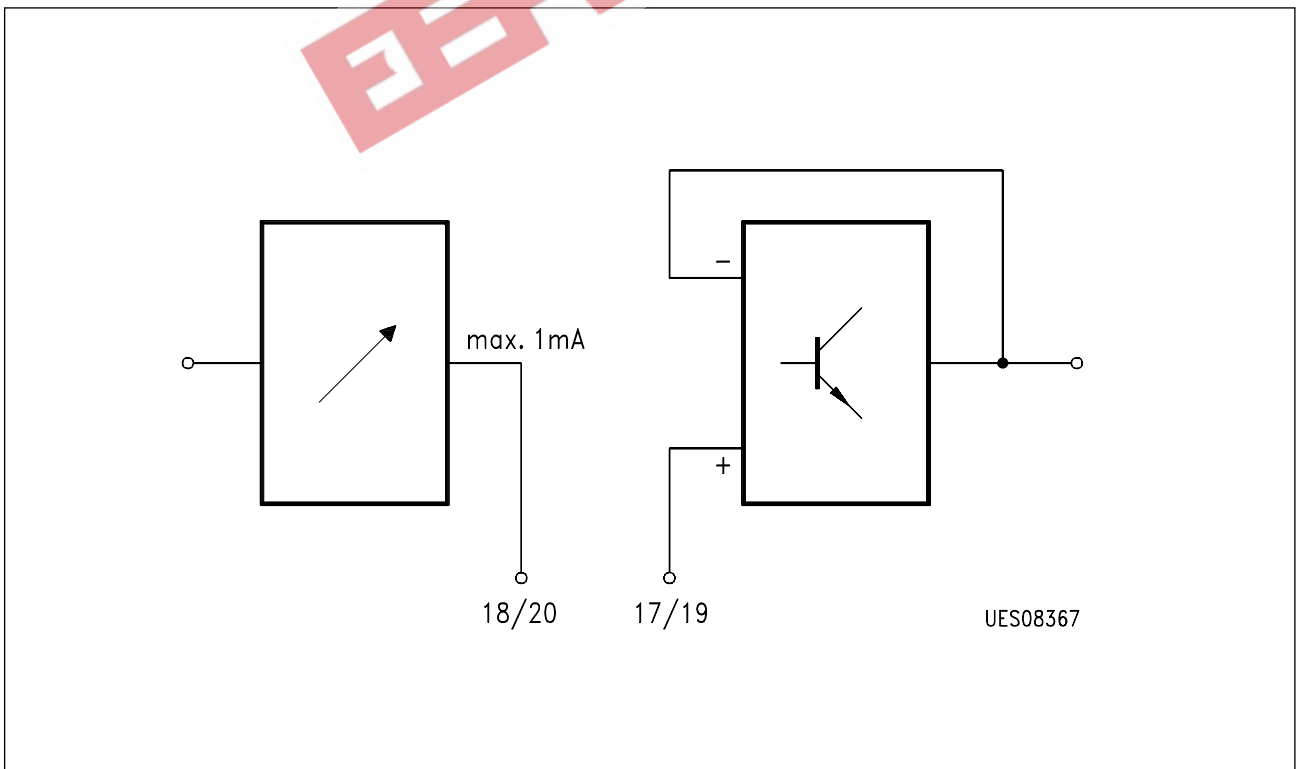
Figure 13
RC Network Bass Pin 17/18/19/20

max. 1mA

18/20   17/19   UES08367

PIN 10

10 kΩ

22

10 kΩ

UES08368

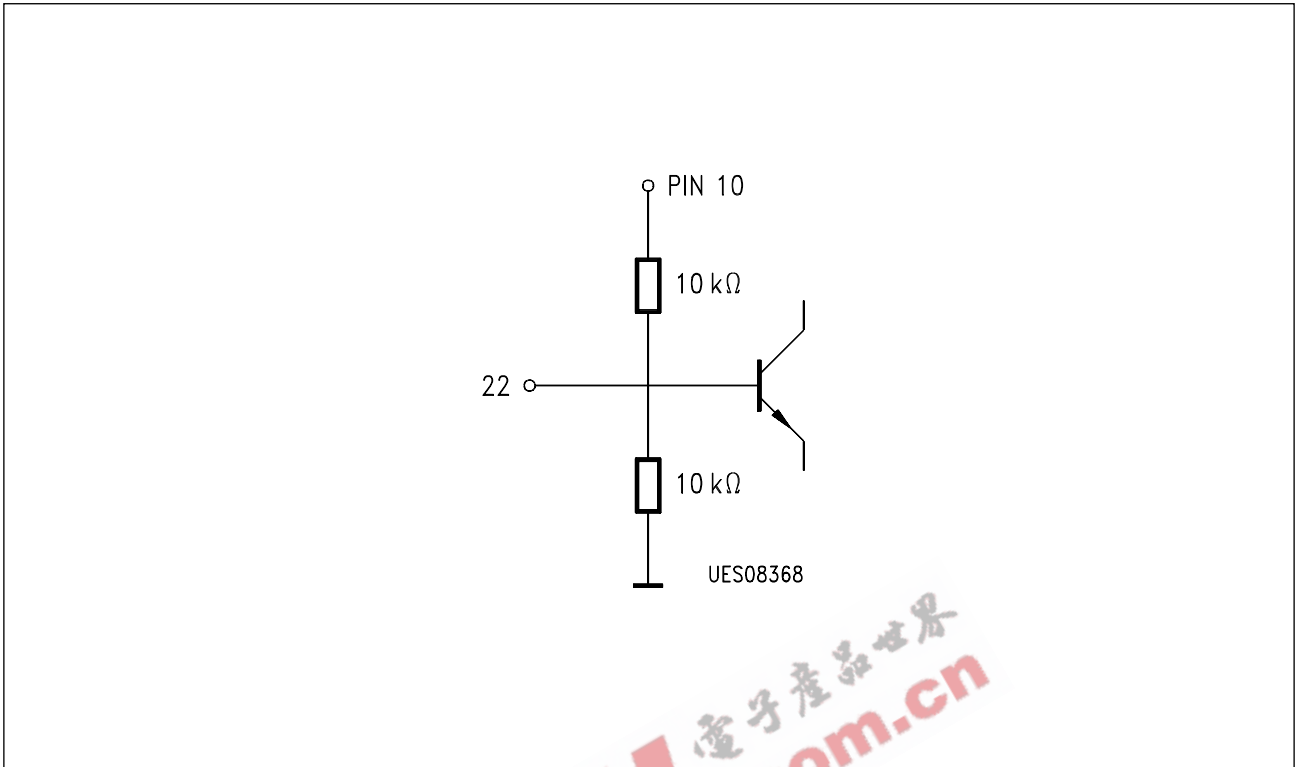**Figure 14**
Bias for AF Operation Point Pin 22

3   Electrical Characteristics

3.1   Absolute Maximum Ratings

$T_A = -40\ °C$ to $85\ °C$

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		
Supply voltage	V_{10}	0	14	V	
Max. DC voltage	V_1	0	V_{10}	V	
Max. DC voltage	V_2	0	V_{10}	V	
Max. DC voltage	V_3	0	V_{10}	V	
Max. DC voltage	V_5	0	V_{10}	V	
Max. DC voltage	V_7	0	V_{10}	V	
Max. DC voltage	V_8	0	V_{10}	V	
Max. DC voltage	V_9	0	V_{10}	V	
Max. DC voltage	V_{11}	0	V_{10}	V	
Max. DC voltage	V_{12}	0	V_{10}	V	
Max. DC voltage	V_{17}	0	V_{10}	V	
Max. DC voltage	V_{19}	0	V_{10}	V	
Max. DC voltage	V_{22}	0	V_{10}	V	
Max. DC voltage	V_{23}	0	V_{10}	V	
Max. DC voltage	V_{25}	0	V_{10}	V	
Max. DC voltage	V_{26}	0	V_{10}	V	
Max. DC voltage	V_{27}	0	V_{10}	V	
Max. DC voltage	V_{28}	0	V_{10}	V	
Max. DC current	I_4	0	2	mA	
Max. DC current	I_{13}	0	5	mA	
Max. DC current	I_{14}	0	5	mA	
Max. DC current	I_{15}	0	5	mA	
Max. DC current	I_{16}	0	5	mA	
Max. DC current	I_{18}	0	2	mA	
Max. DC current	I_{20}	0	2	mA	
Max. DC current	I_{24}	0	2	mA	

3.1 Absolute Maximum Ratings (cont'd)

$T_A = -40\ °C$ to $85\ °C$

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	**max.**		
Junction temperature	T_j		150	°C	
Storage temperature	T_g		125	°C	
Thermal resistance	R_{thSA}		76	K/W	
ESD voltage, HBM	V_{ESD1}	− 4	4	kV	1.5 kΩ, 100 pF
ESD voltage, AF outputs	V_{ESD2}	− 6	6	kV	1.5 kΩ, 100 pF

Note: Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

3.2 Operational Range

Parameter	Symbol	Limit Values		Unit
		min.	**max.**	
Supply voltage	V_S	7.5	13.2	V
Ambient temperature range	T_A	− 40	85	°C
Input frequency range	f_I	0.01	20	kHz

Note: In the operating range the functions given in the circuit description are fulfilled.

3.3 AC/DC Characteristics

V_{10} = 10 V; T_A = 25 °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Current consumption	I_{10}		45		mA		1

Signal Section

Gain	$G_{13\text{-}1}$		0		dB		1
Gain	$G_{14\text{-}1}$		0		dB		1
Analogous values are apply for feeding in on pins 2 and 3.							
Gain	$G_{15\text{-}28}$		0		dB		1
Gain	$G_{16\text{-}28}$		0		dB		1
Analogous values are apply for feeding in on pins 25 and 26.							

Input Level Control

Min. gain	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		0		dB		1
Max. gain	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		25		dB	01,0A V_{inp} 10	1
Stepwidth	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		2.5		dB	01,X-01, X ± 1 V_{inp} X-V_{inp} (X ± 1)	1
Analogous values are apply for feeding in on pins 2, 3, 25 and 26.							
Threshold Clipping detector 1	$V_{1\ Cl1}$ $V_{28\ Cl1}$		1.9		Vrms		1

3.3 AC/DC Characteristics (cont'd)

$V_{10} = 10$ V; $T_A = 25$ °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

Volume Control

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Max. gain	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		0		dB		1
Min. gain	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		-78.25		dB	02,00; 03,00 *Vol. 0; Loud. OFF*	1
Tracking error	$\Delta G_{13\text{-}14}$ $\Delta G_{15\text{-}16}$ $\Delta G_{13\text{-}16}$ $\Delta G_{14\text{-}15}$			± 2	dB	02,3F-02,24; 03,3F *Vol. 63-36; Loud. OFF*	1
Stepwidth	ΔG_{13} ΔG_{14} ΔG_{15} ΔG_{16}		1.25		dB	02,X-02, (X $\pm$ 1) *Vol. X-Vol. (X $\pm$ 1)*	1

Loudness Control

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Max. gain	$G_{4\text{-}1}$ $G_{24\text{-}28}$		-6		dB	03,7F; 02,00 Loud. ON	1
Min. gain	$G_{4\text{-}1}$ $G_{24\text{-}28}$		-84.75		dB	03,40; 02,00 Loud. 0	1
Tracking error	$\Delta G_{5\text{-}24}$			± 2	dB	03,7F-03,64; 02,00 Loud. 63-36; Loud. ON	1
Stepwidth	ΔG_4 ΔG_{24}		1.25		dB	03,X-03, (X $\pm$ 1) *Loud. X-Loud. (X $\pm$ 1)*	1

3.3   **AC/DC Characteristics** (cont'd)

V_{10} = 10 V; T_A = 25 °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

Output Control

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Max. gain	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		0		dB		1
Min. gain	$G_{13\text{-}1}$ $G_{14\text{-}1}$ $G_{15\text{-}28}$ $G_{16\text{-}28}$		− 38.75		dB	*08,00; Out 0* *07,00; Out 0* *05,00; Out 0* *06,00; Out 0*	1
Stepwidth	ΔG_{13} ΔG_{14} ΔG_{15} ΔG_{16}		1.25		dB	*08,X-08, (X ± 1)* *OutX-Out (X ± 1)* *07,X-07, (X ± 1)* *OutX-Out (X ± 1)* *05,X-05, (X ± 1)* *OutX-Out (X ± 1)* *06,X-06, (X ± 1)* *OutX-Out (X ± 1)*	1

3.3 AC/DC Characteristics (cont'd)

$V_{10} = 10$ V; $T_A = 25$ °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

Bass Control

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
Bass boost	G_{13-1} G_{14-1} G_{15-28} G_{16-28}	14	16		dB	04,80; $f_1 = 40$ Hz *Bass min, Treble lin*	1
Bass cut	G_{13-1} G_{14-1} G_{15-28} G_{16-28}		− 14		dB	04,8F; $f_1 = 40$ Hz *Bass min, Treble lin*	1
Bass stepwidth	ΔG_{13} ΔG_{14} ΔG_{15} ΔG_{16}	1	2	3	dB	04,8X (X ± 1) *BassX-Bass (X ± 1)*	1

Treble Control

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
Treble boost	G_{13-1} G_{14-1} G_{15-28} G_{16-28}	14	16		dB	04,80; $f_1 = 15$ kHz *Treble max, Bass lin*	1
Treble cut	G_{13-1} G_{14-1} G_{15-28} G_{16-28}		− 14		dB	04,8F; $f_1 = 15$ kHz *Treble min, Bass lin*	1
Treble stepwidth	ΔG_{13} ΔG_{14} ΔG_{15} ΔG_{16}	1	2	3	dB	04,8X-04, (X ± 1) 8 *TrebleX-Treble (X ± 1)*	1
Tone linearity	ΔG_{13} ΔG_{14} ΔG_{15} ΔG_{16}	1	2	3	dB	04, 88-04, $f_1 = 40$ Hz … 15 kHz *Treble, Bass lin*	1
Threshold clipping detector 2	$V_{1\ Cl2}$ $V_{28\ Cl2}$		380		mVrms	04,00 $f_1 = 40$ Hz or 15 kHz *Treble max, Bass max*	1

3.3   AC/DC Characteristics (cont'd)

$V_{10} = 10$ V; $T_A = 25$ °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Channel separation	$\Delta G_{14\text{-}15}$ $\Delta G_{13\text{-}16}$	80			dB	V_1 or $V_{28} = 300$ mVrms	1
Analogous values apply for feeding on pins 2, 3, 25 and 26.							
Crosstalk attenuation input switch	$a_{\text{in use/out interf.}}$	80			dB	$V_{i\,use.} = 0$ $V_{i\,interf.} = 300$ mVrms	1
Feed on pins 1-3 and 25, 26, 28, measured on pins 13-16.							
Attenuation mute	$a_{1\text{-}13}$ $a_{1\text{-}14}$ $a_{28\text{-}15}$ $a_{28\text{-}16}$	80			dB	02,7F; $V_1 = 300$ mVrms *mute active* 00,20; $V_1 = 300$ mVrms *notselect* 02,7F; $V_{28} = 300$ mVrms *mute active* 00,20; $V_{28} = 300$ mVrms *notselect*	1
Max. input voltage	V_1 V_{28}	2 2			Vrms Vrms	$THD_{13} < 1$ % $THD_{14} < 1$ % $THD_{15} < 1$ % $THD_{16} < 1$ %	1 1
Max. output voltage	V_{13} V_{14} V_{15} V_{16}	2.2			Vrms	$THD_{13} < 1$ % 01,07; $V_{inp.}7$ $THD_{14} < 1$ % 01,07; $V_{inp.}7$ $THD_{15} < 1$ % 01,07; $V_{inp.}7$ $THD_{16} < 1$ % 01,07; $V_{inp.}7$	1
Distortion	THD_{13} THD_{14} THD_{15} THD_{16}		0.01	0.05	%	$V_1 = 300$ mVrms $V_{28} = 300$ mVrms	1

3.3 AC/DC Characteristics (cont'd)

$V_{10} = 10$ V; $T_A = 25$ °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Analog values apply for feeding in on pins 2, 3, 25 and 26.							
Distortion	THD_{13} THD_{14} THD_{15} THD_{16}		0.01	0.1	%	$V_1 = 300$ mVrms 02,2F; 03,6F; *Vol. 47* $V_{28} = 300$ mVrms 02,2F; 03,6F; *Vol. 47*	1
Distortion	THD_{13} THD_{14} THD_{15} THD_{16}		0.05	0.2	%	$V_1 = 150$ mVrms 04,XX *any tone setting* $V_{28} = 150$ mVrms 04,XX *any tone setting*	1
Unweighted signal/noise ratio	a_S/N_{13} a_S/N_{14} a_S/N_{15} a_S/N_{16}		105		dB	$V_{Nrms\ 20\ Hz\ ...\ 20\ kHz}$ $V_1 = 2$ Vrms $V_{Nrms\ 20\ Hz\ ...\ 20\ kHz}$ $V_{28} = 2$ Vrms	1
Unweighted signal/noise ratio	a_S/N_{13} a_S/N_{14} a_S/N_{15} a_S/N_{16}		60		dB	$V_{Nrms\ 20\ Hz\ ...\ 20\ kHz}$ $V_1 = 0.3$ Vrms 02,27; 03,67 *Vol. 39* $V_{Nrms\ 20\ Hz\ ...\ 20\ kHz}$ $V_{28} = 0.3$ Vrms 02,27; 03,67 *Vol. 39*	1
Unweighted noise voltage	V_{N13} V_{N14} V_{N15} V_{N16}			20	µVrms	$V_{Nrms\ 20\ Hz\ ...\ 20\ kHz}$ 02,00; 03,00 *Vol. 0*	1
Bridge power-amp	Φ_{13-14}		180			Bit Ph = '0'	1
Modus	Φ_{15-16}		180			Bit Ph = '0'	1
Load resistor	$R_{L13,\ 14}$ $R_{L15,\ 16}$	4.5			kΩ	$V_{13,\ 14} = 2.5$ V; *THD* < 1 % $V_{15,\ 16} = 2.5$ V; *THD* < 1 %	1
	$R_{L13,\ 14}$ $R_{L15,\ 16}$	1.5			kΩ	Bit fan = '1' $V_{13,\ 14} = 2.5$ V; *THD* < 1 % Bit fan = '1' $V_{15,\ 16} = 2.5$ V; *THD* < 1 %	1
DC jump Δ1 bit	ΔV_{13}			± 4	mV	Sub, X-Sub, X ± 1	1

3.3 AC/DC Characteristics (cont'd)

$V_{10} = 10$ V; $T_A = 25$ °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Analog values apply for measuring on pins 14, 15 and 16.							
DC jump Δ1 bit	ΔV_{13}			± 6	mV	01, 03-01, 04-01, 05-01, 06-01, 07 *Input level control*	1
DC jump Δ1 bit	ΔV_{13}			± 10	mV	01, 07-01, 08-01, 09-01, 0A-01, 08 *Input level control*	1
PSRR Power supply Ripple rejection	a_{PSRR13} a_{PSRR14} a_{PSRR15} a_{PSRR16}		70 70 70 70		dB dB dB dB	$V_{i\,interf.}$ = 1 Vrms $f_{i\,interf.}$ = 100 Hz ... 20 kHz R_G = 220 Ω R_G = 220 Ω Measurement CCIR 651 Effective	1 1 1 1
Zero crossing detector window			± 30		mV		1
Mute active	V_{QML}	0.3		1.5	V		1
Mute inactive	V_{QMH}	3		5.5	V		1
Input current	I_{QH} I_{QL}			50 100	μA μA		1 1

Design Hints

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Input resistance	R_1 R_2 R_3 R_{25} R_{26} R_{28}	30			kΩ		
Output resistance	R_{13} R_{14} R_{15} R_{16}			70	Ω		

3.3 AC/DC Characteristics (cont'd)

$V_{10} = 10$ V; $T_A = 25$ °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

I²C Bus (SCL, SDA)

SCL, SDA Edges

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Rise time	t_R			1	µs		
Fall time	t_F			300	ns		

Shift Register Clock Pulse SCL

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Frequency	f_{SCL}	0		100	kHz		
H pulse width	t_{High}	4			µs		
L pulse width	t_{Low}	4			µs		

Start

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Set-up time	t_{SUSTA}	4			µs		
Hold time	t_{HDSTA}	4			µs		

Stop

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Set-up time	t_{SUSTO}	4			µs		
Bus free time	t_{BUF}	4			µs		

Data Transfer

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Set-up time	t_{SUDAT}	250			ns		
Hold time	t_{HDDAT}	1			µs		

Input SCL, SDA

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Input voltage	V_{QH} V_{QL}	3		5.5 1.5	V		1
Input current	I_{QH} I_{QL}	3		50 100	µA µA		1

3.3 **AC/DC Characteristics** (cont'd)

V_{10} = 10 V; T_A = 25 °C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

Output SDA (open collector)

Parameter	Symbol	min.	typ.	max.	Unit	Test Condition	Test Circuit
Output voltage	V_{QH}	5.5			V	R_L = 2.5 kΩ	1
	V_{QL}			0.4		I_{QL} = 3 mA	

Note: The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at $T_A = 25°C$ and the given supply voltage.
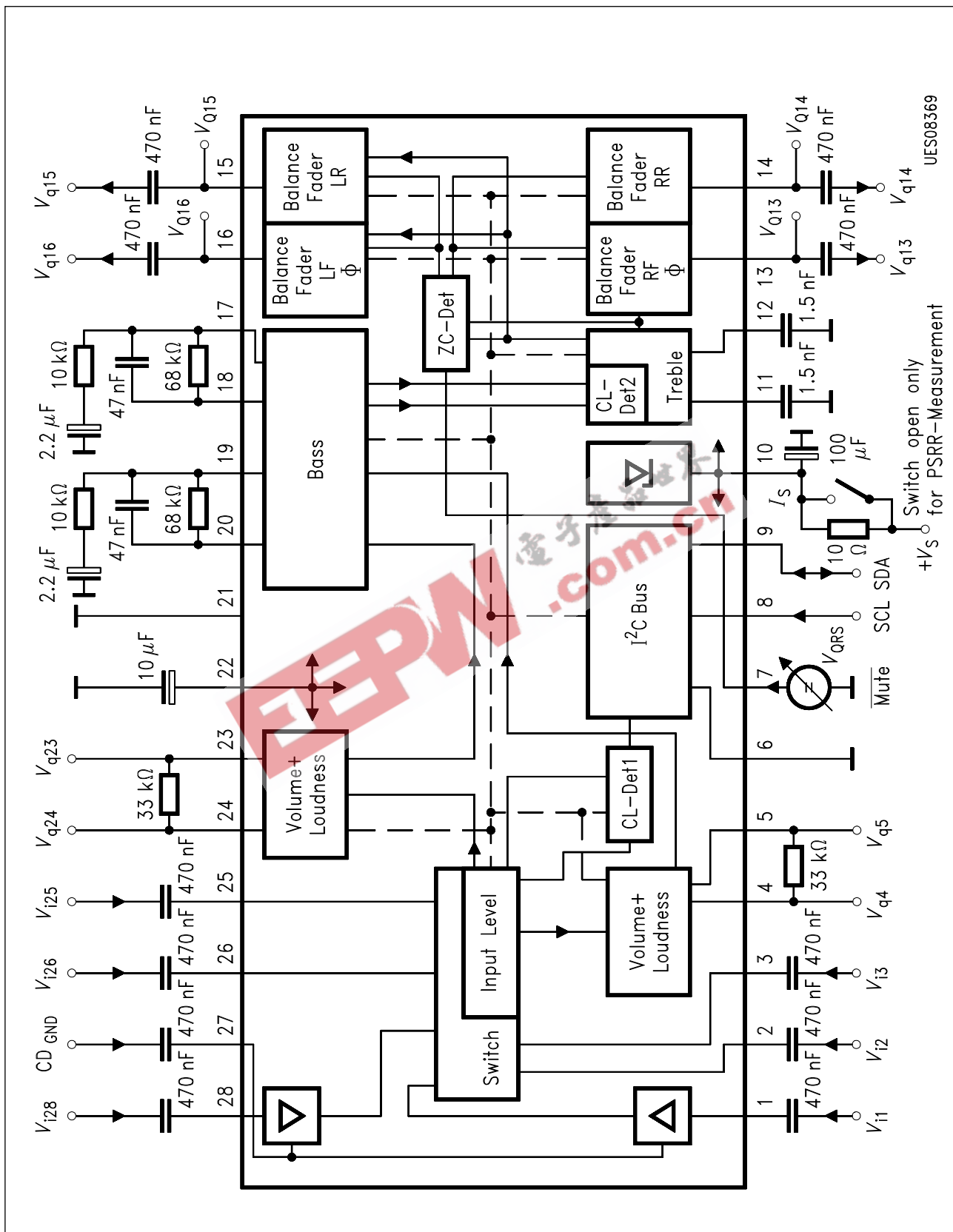
Figure 15
Test Circuit

Application Circuit 1
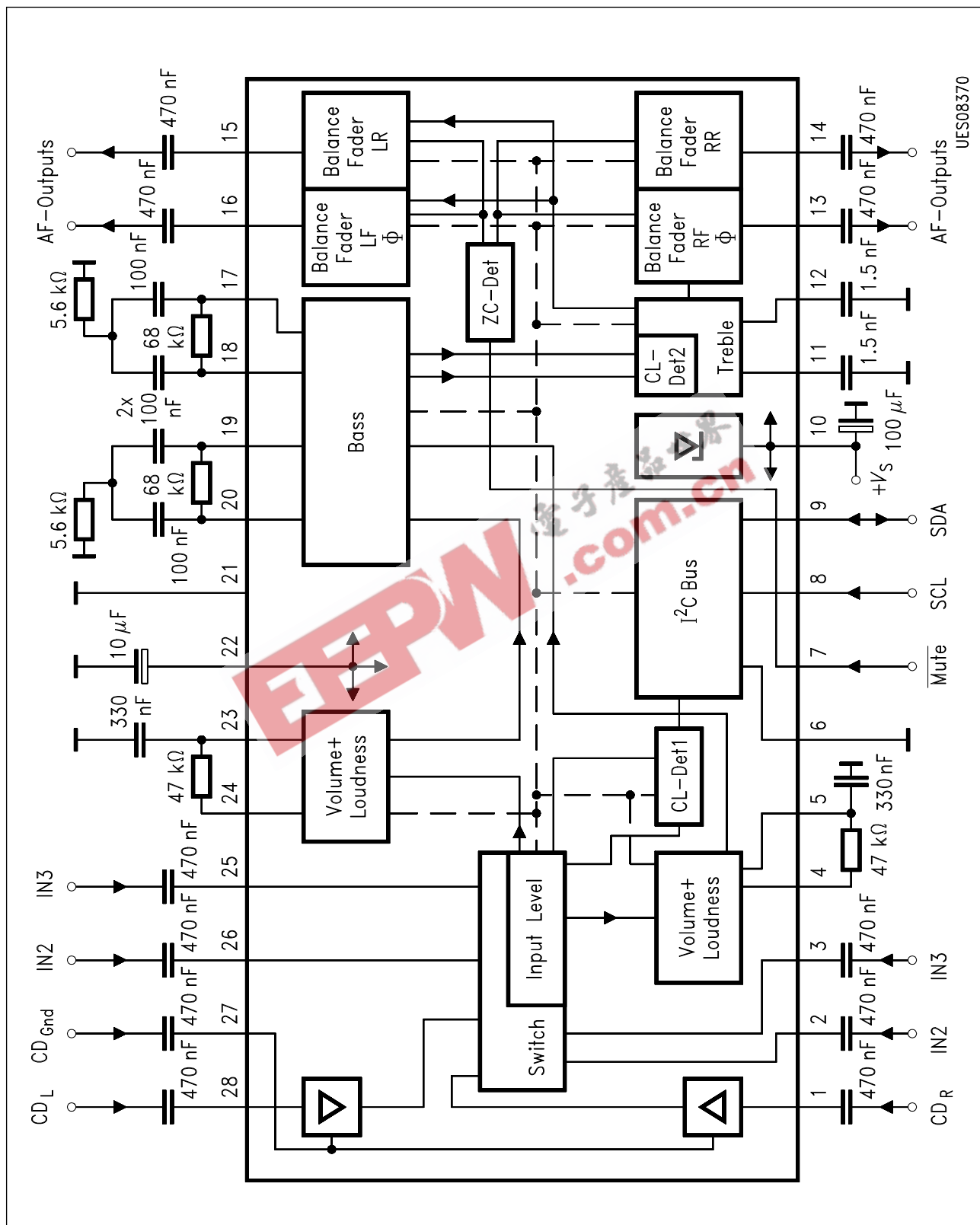

Figure 16
Bass Loudness Circuitry and Bass Control Resonance Characteristic
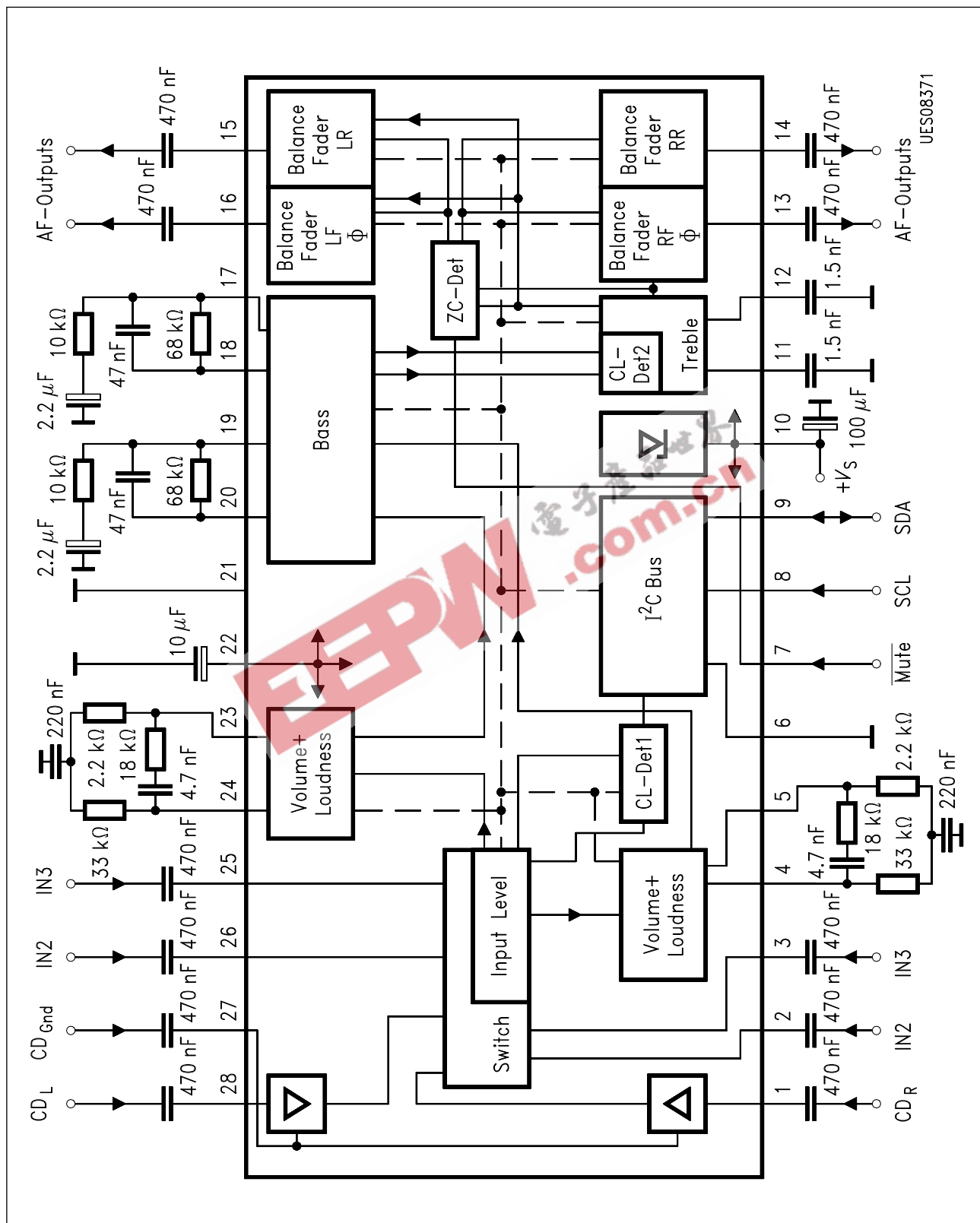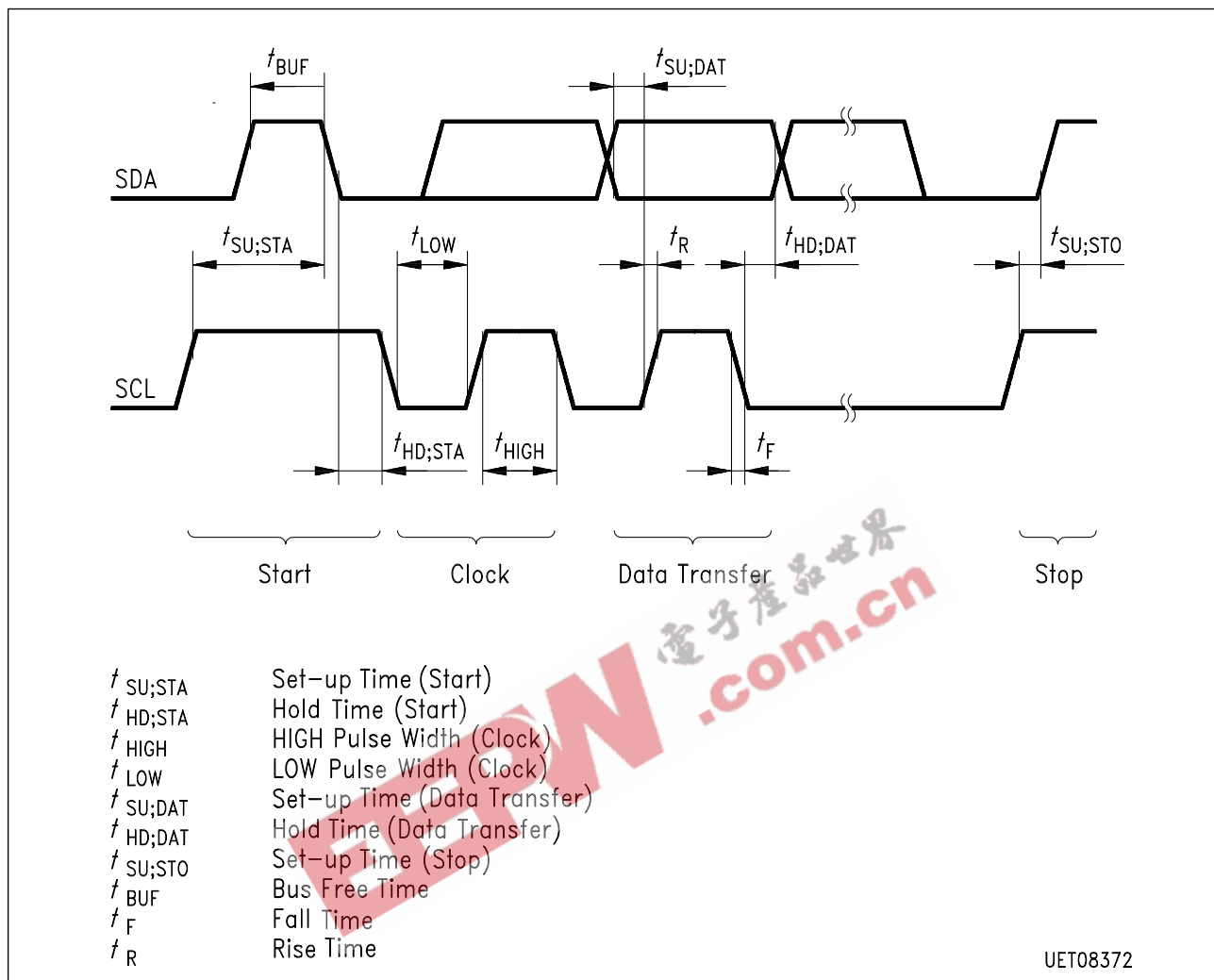
Application Circuit 2

Figure 17
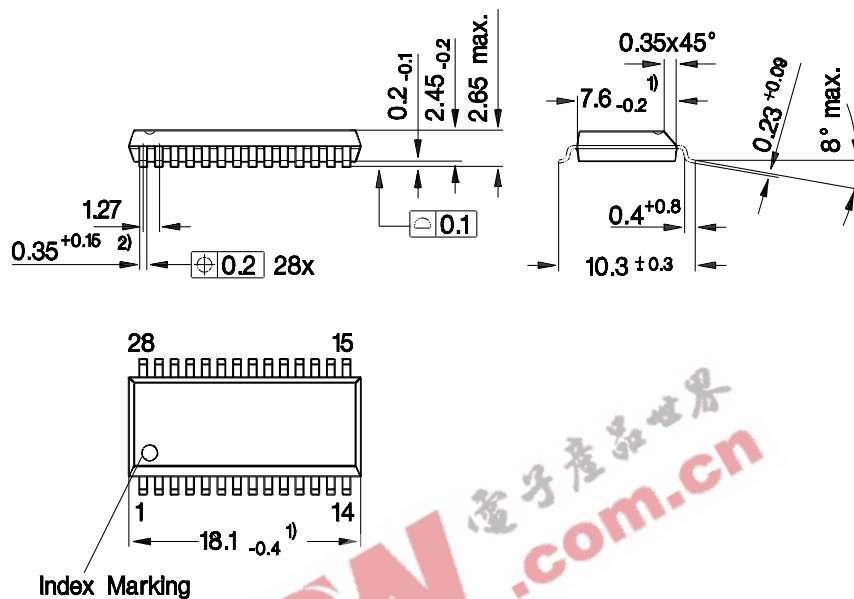**Bass/Treble Loudness Circuitry and 1. Order Bass Control Characteristic**

Diagram

Figure 18 timing diagram labels:

$t_{SU;STA}$ — Set-up Time (Start)
$t_{HD;STA}$ — Hold Time (Start)
t_{HIGH} — HIGH Pulse Width (Clock)
t_{LOW} — LOW Pulse Width (Clock)
$t_{SU;DAT}$ — Set-up Time (Data Transfer)
$t_{HD;DAT}$ — Hold Time (Data Transfer)
$t_{SU;STO}$ — Set-up Time (Stop)
t_{BUF} — Bus Free Time
t_F — Fall Time
t_R — Rise Time

UET08372

Figure 18
I²C Bus Timing

4   Package Outlines

P-DSO-28-1
(Plastic Dual Small Outline Package)

0.2 −0.1
2.45 −0.2
2.65 max.

0.35x45°
7.6 −0.2
0.23 +0.09
8° max.

1.27
0.35 +0.15 2)
0.1
0.2 28x

0.4 +0.8
10.3 ± 0.3

28   15
1   14
18.1 −0.4 1)

Index Marking

1) Does not include plastic or metal protrusion of 0.15 max. per side
2) Does not include dambar protrusion

GPS05123

Sorts of Packing
Package outlines for tubes, trays etc. are contained in our
Data Book "Package Information".
SMD = Surface Mounted Device

Dimensions in mm