

# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

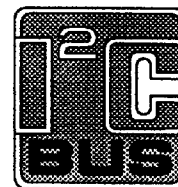
TDA9855

## FEATURES

- Quasi alignment-free BTSC stereo decoder due to auto adjustment of channel separation via I<sup>2</sup>C-bus
- High integration level with automatically tuned integrated filters
- Input level adjustment I<sup>2</sup>C-bus controlled
- Alignment-free SAP processing
- dbx noise reduction circuit
- Audio processor
  - Selector for internal and external signals (line in)
  - Automatic volume level control
  - Subwoofer or surround output with separate volume control
  - Volume control
  - Special loudness characteristic automatically controlled in combination with volume setting
  - Bass and treble control
  - Audio signal zero crossing detection between any volume step switching
- Mute control at audio signal zero crossing
- I<sup>2</sup>C-bus transceiver.

## GENERAL DESCRIPTION

The TDA9855 is a bipolar-integrated BTSC stereo / SAP decoder with hi-fi audio processor (I<sup>2</sup>C-bus controlled) for application in TV sets.



## ORDERING INFORMATION

EXTENDED TYPE NUMBER	PACKAGE			
	PINS	PIN POSITION	MATERIAL	CODE
TDA9855	52	SHDIL	plastic	SOT247AH
TDA9855WP	68	PLCC	plastic	SOT188CG

A license is required for the use of this product. For further information, please contact

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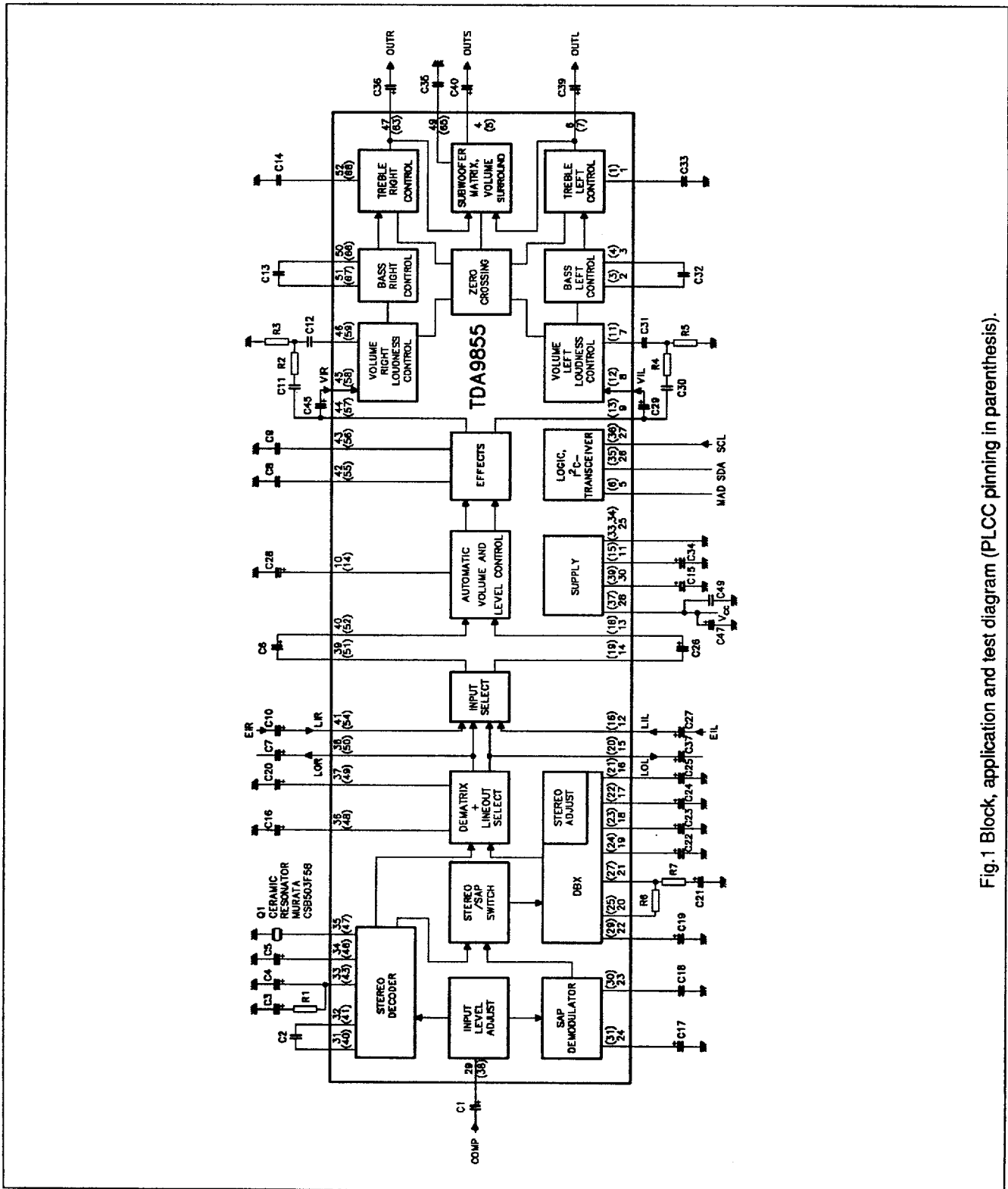


Fig.1 Block, application and test diagram (PLCC pinning in parenthesis).

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**COMPONENT LIST**elco  $\pm 20\%$ ; foil or ceramic  $\pm 10\%$ ; resistors  $\pm 5\%$  unless otherwise specified.

COMPONENT	VALUE	TYPE	REMARK
C1	10 $\mu$ F	elco	63 V
C2	470 nF	foil	
C3	4.7 $\mu$ F	elco	63 V
C4	220 nF	foil	
C5	10 $\mu$ F	elco	63 V; $I_{leak} < 1.5 \mu$ A
C6	2.2 $\mu$ F	elco	16 V
C7	4.7 $\mu$ F	elco	16 V
C8	15 nF	foil	$\pm 5\%$
C9	15 nF	foil	$\pm 5\%$
C10	2.2 $\mu$ F	elco	63 V
C11	8.2 nF	foil or ceramic	$\pm 5\%$ SMD 2220/1206
C12	150 nF	foil	$\pm 5\%$
C13	33 nF	foil	$\pm 5\%$
C14	5.6 nF	foil or ceramic	$\pm 5\%$ SMD 2220/1206
C15	100 $\mu$ F	elco	16 V
C16	4.7 $\mu$ F	elco	63 V
C17	4.7 $\mu$ F	elco	63 V
C18	100 nF	foil	
C19	10 $\mu$ F	elco	63 V
C20	4.7 $\mu$ F	elco	63 V
C21	47 nF	foil	$\pm 5\%$
C22	1 $\mu$ F	elco	63 V
C23	1 $\mu$ F	elco	63 V
C24	10 $\mu$ F	elco	63 V $\pm 10\%$
C25	10 $\mu$ F	elco	63 V $\pm 10\%$
C26	2.2 $\mu$ F	elco	16 V
C27	2.2 $\mu$ F	elco	63 V
C28	4.7 $\mu$ F	elco	63 V $\pm 10\%$
C29	2.2 $\mu$ F	elco	16 V
C30	8.2 nF	foil or ceramic	$\pm 5\%$ SMD 2220/1206
C31	150 nF	foil	$\pm 5\%$
C32	33 nF	foil	$\pm 5\%$
C33	5.6 nF	foil or ceramic	$\pm 5\%$ SMD 2220/1206
C34	100 $\mu$ F	elco	16 V
C35	150 nF	foil	$\pm 5\%$
C36	4.7 $\mu$ F	elco	16 V
C37	4.7 $\mu$ F	elco	16 V
C39	4.7 $\mu$ F	elco	16 V
C40	4.7 $\mu$ F	elco	16 V
C45	2.2 $\mu$ F	elco	16 V
C47	220 $\mu$ F	elco	25 V
C49	100 nF	foil or ceramic	SMD 1206

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COMPONENT	VALUE	REMARK
R1	2.2 k $\Omega$	
R2	20 k $\Omega$	
R3	2.2 k $\Omega$	
R4	20 k $\Omega$	
R5	2.2 k $\Omega$	
R6	8.2 k $\Omega$	$\pm 2\%$
R7	160 $\Omega$	$\pm 2\%$
Q1	503.5 kHz	MURATA CSB503F58

## QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V <sub>CC</sub>	supply voltage		8.0	8.5	9.0	V
I <sub>CC</sub>	supply current		50	75	95	mA
V <sub>comp</sub>	input signal (RMS value)	100% modulation L + R; f = 300 Hz	-	250	-	mV
V <sub>LOR</sub> , V <sub>LOL</sub>	output signal (RMS value)		-	500	-	mV
G <sub>LA</sub>	input level adjustment control range		-3.5	-	+4.0	dB
$\alpha_{st}$	stereo channel separation	f <sub>L</sub> = 300 Hz; f <sub>R</sub> = 3 kHz	25	35	-	dB
THD <sub>L,R</sub>	total harmonic distortion	f = 1 kHz	-	0.2	-	%
V <sub>I,O</sub>	signal handling (RMS value)	THD < 0.5%	2	-	-	V
AVL	control range		-15	-	+6	dB
G <sub>c</sub>	volume control range		-71	-	+16	dB
L <sub>B</sub>	maximum loudness boost	f = 40 Hz	-	17	-	dB
G <sub>b</sub>	bass control range	f = 40 Hz	-12	-	+16.5	dB
G <sub>t</sub>	treble control range	f = 15 kHz	-12	-	+12	dB
G <sub>v</sub>	subwoofer control range	f = 40 Hz	-14	-	+14	dB
S/N	signal-to-noise ratio	line out (mono); V <sub>O</sub> = 0.5 V (RMS)	-	60	-	dB
	CCIR noise weighting filter (peak value)					
S/N	signal-to-noise ratio	audio section; V <sub>O</sub> = 2 V (RMS); gain = 0 dB	-	94	-	dB
	CCIR noise weighting filter (peak value)					
	DIN noise weighting filter (RMS value)					dBA
	DIN noise weighting filter (RMS value)			107		dBA

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## PINNING

SYMBOL	SOT188	SOT247	DESCRIPTION
TL	1	1	treble control capacitor, left channel
n.c.	2	–	not connected
B1L	3	2	bass control capacitor, left channel
B2L	4	3	bass control capacitor, left channel
OUTS	5	4	output subwoofer or output surround sound
MAD	6	5	programmable address bit (module address)
OUTL	7	6	output, left channel
n.c.	8 to 10	–	not connected
LDL	11	7	input loudness, left channel
VIL	12	8	input volume control, left channel
EOL	13	9	output effects, left channel
CAV	14	10	automatic volume control capacitor
V <sub>REF</sub>	15	11	reference voltage 0.5V <sub>CC</sub>
LIL	16	12	line input, left channel
n.c.	17	–	not connected
AVL	18	13	input automatic volume control, left channel
SOL	19	14	output selector, left channel
LOL	20	15	line output, left channel
TW	21	16	capacitor timing wideband for dbx
TS	22	17	capacitor timing spectral for dbx
CW	23	18	capacitor wideband for dbx
CS	24	19	capacitor spectral for dbx
VEO	25	20	variable emphasis out for dbx
n.c.	26	–	not connected
VEI	27	21	variable emphasis in for dbx
n.c.	28	–	not connected
CNR	29	22	capacitor noise reduction for dbx
CM	30	23	capacitor mute for SAP
CD	31	24	capacitor DC decoupling for SAP
n.c.	32	–	not connected
GND	33	–	analog ground
GND	34	–	digital ground
GND	–	25	common ground
SDA	35	26	serial data input/output
SCL	36	27	serial clock input
V <sub>CC</sub>	37	28	supply voltage
COMP	38	29	input composite signal
VCAP	39	30	capacitor for electronic filtering of supply
CP1	40	31	capacitor for pilot detector
CP2	41	32	capacitor for pilot detector
n.c.	42	–	not connected
CPH	43	33	capacitor for phase detector
n.c.	44, 45	–	not connected

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SYMBOL	SOT188	SOT247	DESCRIPTION
CA	46	34	capacitor for filter adjust
CER	47	35	ceramic resonator
CMO	48	36	capacitor DC decoupling mono
CSS	49	37	capacitor DC decoupling stereo/SAP
LOR	50	38	line output, right channel
SOR	51	39	output selector, right channel
AVR	52	40	input automatic volume control, right channel
n.c.	53	–	not connected
LIR	54	41	line input, right channel
PS2	55	42	capacitor 2 pseudo function
PS1	56	43	capacitor 1 pseudo function
EOR	57	44	output effects, right channel
VIR	58	45	input volume control, right channel
LDR	59	46	input loudness, right channel
n.c.	60 to 62	–	not connected
OUTR	63	47	output, right channel
n.c.	64	48	not connected
SW	65	49	filter capacitor for subwoofer
B2R	66	50	bass control capacitor, right channel
B1R	67	51	bass control capacitor, right channel
TR	68	52	treble control capacitor

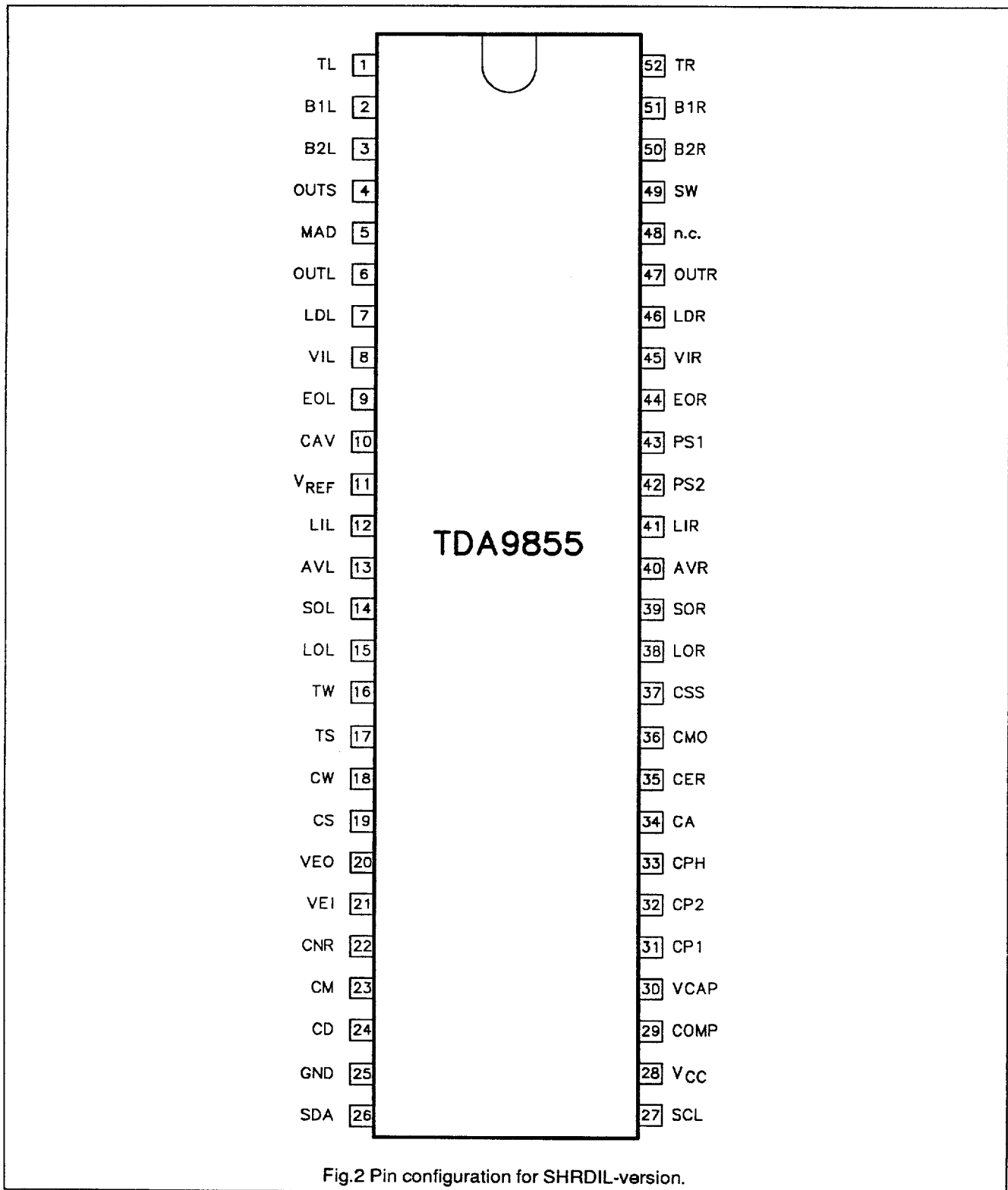
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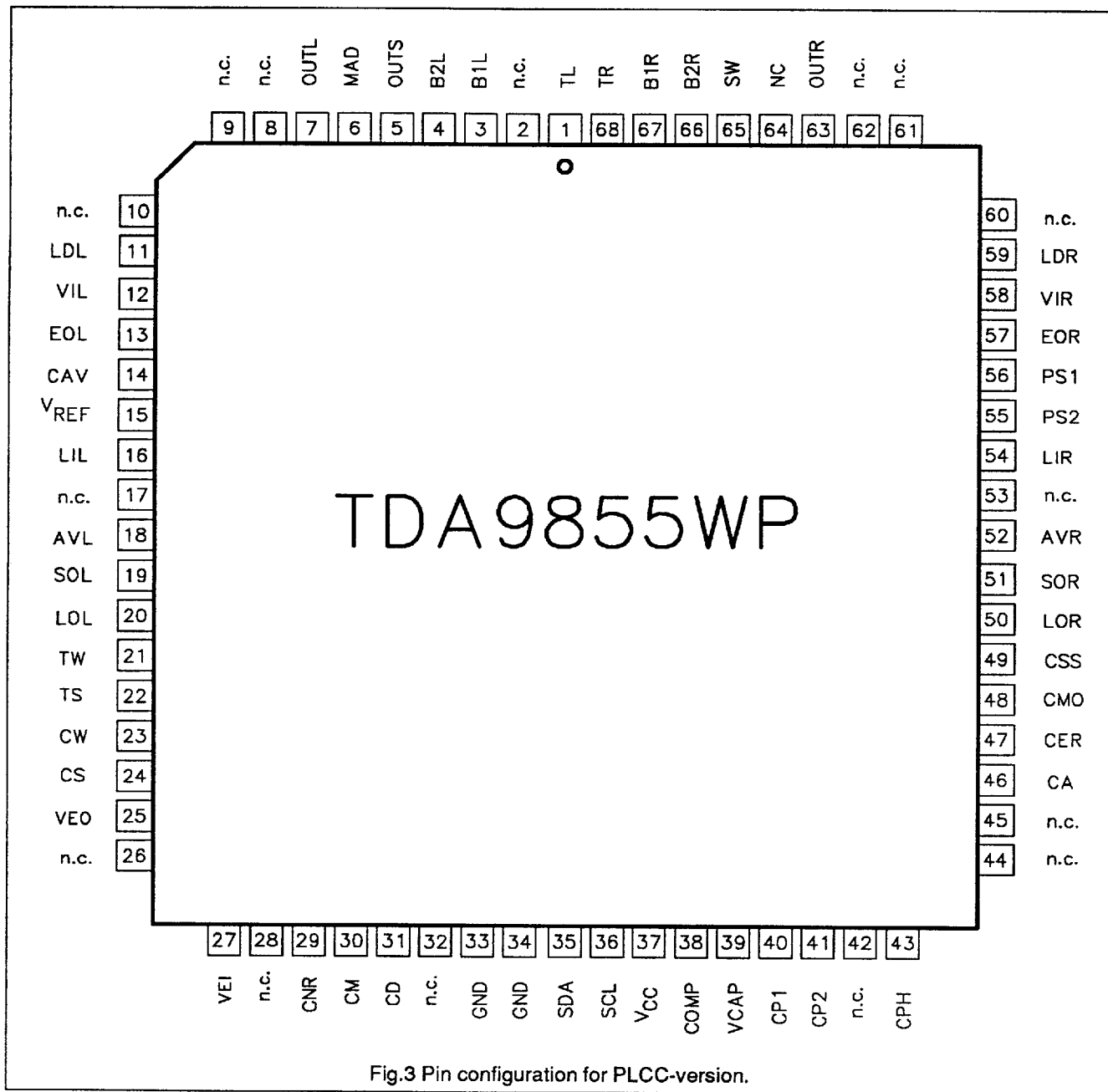
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## FUNCTIONAL DESCRIPTION

### Decoder

#### Input level adjustment

The composite input signal is fed to the input level adjustment stage. In order to compensate tolerances of the FM demodulator which supplied the composite input signal, the TDA9855 provides an input level adjustment stage. The control range is between  $-3.5$  dB and  $+4.0$  dB in steps of  $0.5$  dB. The subaddress control 3 of Tables 2 and 3 and the level adjust setting of Table 16 allows an optimal signal adjustment during the set alignment in the production line. This value has to be stored in a non-volatile memory. The maximum input signal voltage is  $2$  V (RMS).

#### Stereo decoder

The output signal of the level adjustment stage is coupled to a low-pass filter which suppresses the baseband noise above  $125$  kHz. The composite signal is then fed into a pilot detector/pilot cancellation circuit and into the MPX demodulator. The main L + R signal passes a  $75$   $\mu$ s fixed de-emphasis filter and is fed into the dematrix circuit. The decoded subsignal L - R is sent to the stereo/SAP switch. To generate the pilot signal the stereo demodulator uses a PLL circuit including a ceramic resonator. The stereo channel separation can be adjusted by an automatic procedure or manually. A detailed description of this alignment is provided in the ADJUSTMENT PROCEDURE. The stereo identification can be read by the I<sup>2</sup>C-bus (see Table 1). Two different pilot thresholds can be selected via I<sup>2</sup>C-bus (see Table 18).

#### SAP demodulator

The composite signal is fed from the output of the input level adjustment stage to the SAP demodulator circuit

through a  $5$ Hz band-pass filter. The demodulator level is automatically controlled. The SAP demodulator includes internal noise and field strength detectors that mute the SAP output in case of insufficient signal conditions. The SAP identification signal can be read by the I<sup>2</sup>C-bus (see Table 1).

#### Switch

The stereo/SAP switch feeds either the L - R signal or the SAP demodulator output signal via the internal dbx noise reduction circuit to the dematrix/line out select circuit. Table 15 shows the different switch modes provided at the output pins LOR and LOL.

#### dbx decoder

The dbx circuit includes all blocks required for the noise reduction system according to the BTSC system specification. The output signal is fed through a  $73$   $\mu$ s fixed de-emphasis circuit to the dematrix block.

#### Integrated filters

The filter functions necessary for stereo and SAP demodulation and part of the dbx filter circuits are provided on chip using transistor circuits. The required filter accuracy is attained by an automatic filter alignment circuit.

#### Audio processor

##### Selector

The selector allows selecting either the internal line out signals LOR or LOL (dematrix out) or the external line in signals LIR and LIL and combines the left and right signals in several modes (see Table 8). The input signal capability of the line inputs (LIR/LIL) is  $2$  V (RMS). The output of the selector is AC coupled to the automatic volume level control

circuit via pins SOR/SOL and AVR/AVL to avoid offset voltages.

#### Automatic volume level control

The automatic volume level stage controls its output voltage to a constant level of typically  $200$  mV (RMS) from an input voltage range between  $0.1$  and  $1.1$  V (RMS). The circuit adjusts variations in modulation during broadcasting and due to changes in the programme material. The function can be switched off. To avoid audible 'plops' during the permanent operation of the AVL circuit a soft blending scheme has been applied between the different gain stages. A capacitor at pin CAV determines the attack and decay time constants. In addition the ratio of attack and decay time can be changed via I<sup>2</sup>C-bus (see notes 3 and 4 of the CHARACTERISTICS).

#### Effects

The audio processor section offers the following mode selections: linear stereo, pseudo stereo, spatial stereo and forced mono. The spatial mode provides an antiphase crosstalk of  $30\%$  or  $52\%$  (switchable via I<sup>2</sup>C-bus; see Table 13).

#### Volume/loudness

The volume control range is between  $+16$  dB and  $-71$  dB in steps of  $1$  dB and ends with a mute step (see Table 4). Balance control is achieved by the independent volume control of each channel. The volume control blocks operate in combination with the loudness control. The filter is linear when maximum gain for volume control is selected. The filter characteristic changes automatically over a range of  $28$  dB down to a setting of  $-12$  dB. At  $-12$  dB volume control the maximum loudness boost is obtained. The filter characteristic is

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determined by external components. The proposed application provides a maximum boost of 17 dB for bass and 4.5 dB for treble. The loudness may be switched on or off via the I<sup>2</sup>C-bus control (see Table 10). The left and right volume control stages include two independent zero crossing detectors. In the zero cross mode a change in volume is automatically activated but not executed. The execution is enabled at the next zero crossing of the signal. If a new volume step is activated before the previous one has been processed, the previous value will be executed first, and then the new value will be activated. If no zero crossing occurs the next volume transmission will enforce the last activated volume setting. The zero crossing mode is realized between adjoining steps and between any steps, but not from any step to mute. In this case the GMU bit is needed to use. In case of need to mute only one channel, two steps are necessary. The first step is a transmission from any steps to -71 dB and the second is -71 dB step to mute. The step of -71 dB to mute has no zero crossing but it is not relevant. This procedure has to be provided by software.

## Bass control

A single external 33 nF capacitor for each channel in combination with a linear operational amplifier and internal resistors provides a bass control range of +16.5 dB to -12 dB in steps of 1.5 dB at low frequencies (40 Hz). Internally the basic step width is 3 dB, with intermediate steps are obtained by a toggle function that provides additional an 1.5 dB boost or attenuation (see Table 5). Please note that both loudness and bass control together result in a maximum bass boost of 34.5 dB for low volume steps.

## Treble control

The adjustable range of the treble control stage is between -12 dB and +12 dB in steps of 3 dB. The filter characteristic is determined by an external 5.6 nF capacitor for each channel. The logic circuitry is arranged in a way that the same data words (HEX 06 to 16) can be used for both tone controls if a bass control range from -12 dB to +12 dB and a treble control range from -12 dB to +12 dB with 3 dB steps are used (see Tables 5 and 6).

## Subwoofer; surround sound control

The subwoofer or the surround mode can be activated with the control bit SUR (see Table 3). A low bit provides an output signal  $(L + R)/2$  in subwoofer mode, a high bit selects surround mode and provides an output signal  $(L - R)/2$ . The signal is fed through a volume control stage with a range between +14 dB and -14 dB in 2 dB steps on top of the main channel control to the output pin OUTS. The last setting is the mute position (see Table 7). The capacitor C35 at pin SW provides a 230 Hz low-pass filter in subwoofer mode. In surround mode this capacitor should be disconnected. If balance is not in mid position the selected left and right output levels will be combined.

## Mute

The mute function can be activated independently with the last step of volume or subwoofer/surround control at the left, right or center output. By setting the general mute bit GMU via the I<sup>2</sup>C-bus all audio part outputs are muted. All channels include an independent zero cross detector. The zero crossing mute feature can be selected via bit TZCM:

TZCM = 0:

forced mute with direct execution,

TZCM = 1:

execution in time with signal zero crossing.

In the zero cross mode a change of the GMU bit is activated but not executed. The execution is enabled at the next zero crossing of the signal. To avoid a large delay of mute switching, when very low frequencies are processed, or the output signal amplitude is lower than the DC offset voltage, the following I<sup>2</sup>C-bus transmissions are needed:

- a first transmission for mute execution
- a second transmission about 100 ms later, which must switch the zero crossing mode to forced mute (TZCM = 0)
- a third transmission to reactivate the zero crossing mode (TZCM = 1). This transmission can take place immediately, but must follow before the next mute execution.

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## LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V <sub>CC</sub>	supply voltage		0	9.5	V
T <sub>amb</sub>	operating ambient temperature		-20	+70	°C
T <sub>stg</sub>	storage temperature		-65	+150	°C
V <sub>es</sub>	electrostatic handling	note 1			
V <sub>n</sub>	voltage at all other pins to pin GND		0	V <sub>CC</sub>	V

### Note to the limiting values

1. Human body model: C = 100 pF; R = 1.5 kΩ; V = 2 kV; charge device model: C = 200 pF; R = 0 Ω; V = 300 V.

## THERMAL RESISTANCE

SYMBOL	PARAMETER	THERMAL RESISTANCE
R <sub>thj-a</sub>	from junction to ambient in free air	
	SOT247AH	43 K/W
	SOT188CG	38 K/W

Requirements for the composite input signal to ensure proper system performance.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
COMP <sub>L+R</sub>	composite input level for 100% modulation L + R (25 kHz deviation), RMS, f = 300 Hz	measured at COMP	162	250	363	mV
ΔCOMP	composite input level spreading under operating conditions	T <sub>amb</sub> = -20 to +70 °C; aging; power supply influence	-0.5	-	+0.5	dB
Z <sub>o</sub>	output impedance	note 1	-	low-ohmic	5	kΩ
f <sub>-2 dB</sub>	roll-off frequencies (25 kHz deviation L + R)	low frequency (-2 dB)	-	-	5	Hz
		high frequency (-2 dB)	100	-	-	kHz
THD	total harmonic distortion L + R; f = 1 kHz	25 kHz deviation	-	-	0.5	%
		125 kHz deviation; note 2	-	-	1.5	%
S/N	signal-to-noise ratio L + R/noise	CCIR 468-2 weighted quasi peak; L + R; 25 kHz deviation; f = 1 kHz; 75 μs de-emphasis				
		critical picture modulation	44	-	-	dB
		with sync only	54	-	-	dB
α <sub>SB</sub>	side band suppression mono into unmodulated SAP carrier; SAP carrier/side band	mono signal: 25 kHz deviation, f = 1 kHz; side band: SAP carrier frequency ±1 kHz	46	-	-	dB
α <sub>SP</sub>	spectral spurious attenuation L + R/spurious	50 Hz to 100 kHz; mainly n x f <sub>H</sub> ; no de-emphasis; L + R; 25 kHz deviation, f = 1 kHz	40	-	-	dB

### Notes to the requirements

- Low-ohmic preferred, otherwise the signal loss and spreading at COMP, caused by Z<sub>o</sub> and the composite input impedance (see input level adjustment control) must be taken into account.
- In order to prevent clipping at overmodulation (maximum deviation in the BTSC system for 100% modulation is 73 kHz).

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## CHARACTERISTICS

All voltages are measured relative to GND;  $V_{CC} = 8.5$  V, source resistance  $\leq 600 \Omega$ , output load  $R_L \geq 10$  k $\Omega$ ,  $C_L \leq 2.5$  nF, AC coupled;  $f = 1$  kHz;  $T_{amb} = +25$  °C; volume gain control  $G_c = 0$  dB; bass linear; treble linear; loudness off; AVL off; effects linear; composite input signal according to BTSC standard; see block diagram unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{CC}$	supply voltage		8.0	8.5	9.0	V
$I_{CC}$	supply current		50	75	95	mA
$V_{DC}$	DC voltage at signal handling pins		–	$V_{CC}/2$	–	V
<b>DECODER SECTION</b>						
<b>Input level adjustment control</b>						
$G_{LA}$	input level adjustment control	maximum gain	–	4.0	–	dB
		maximum attenuation	–	–3.5	–	dB
$G_{step}$	step resolution		–	0.5	–	dB
$V_{i(RMS)}$	maximum input level		2	–	–	V
$Z_i$	input impedance		29.5	35	40.5	k $\Omega$
<b>Stereo decoder</b>						
$MPX_{L+R}$	input level for 100% modulation L + R (25 kHz deviation) (RMS value)	input level adjusted via I <sup>2</sup> C-bus (L + R; $f = 300$ Hz); monitoring LINE OUT	–	250	–	mV
$MPX_{L-R}$	input level for 100% modulation L – R (50 kHz deviation) (peak value)		–	707	–	mV
$MPX_{max}$	headroom for L + R, L, R	$f_{mod} < 15$ kHz; THD < 15% for 75 $\mu$ s equivalent input modulation	9	–	–	dB
$MPX_{pilot}$	nominal stereo pilot level (RMS value)		–	50	–	mV
$ST_{ON}$	pilot threshold STEREO ON (RMS value)	data STS = 1	–	–	35	mV
		data STS = 0	–	–	30	mV
$ST_{OFF}$	pilot threshold STEREO OFF (RMS value)	data STS = 1	15	–	–	mV
		data STS = 0	10	–	–	mV
$Hyst$	hysteresis		–	2.5	–	dB
$Out_{L+R}$	output level for 100% modulation L + R at LINE OUT	input level adjusted via I <sup>2</sup> C-bus (L + R; $f = 300$ Hz); monitoring LINE OUT	480	500	520	mV
$\alpha_{ST}$	stereo channel separation L/R at LINE OUT	aligned with dual tone 14% modulation; alignment at $f_L = 300$ Hz; $f_R = 3.1$ kHz				
		$f_L = 300$ Hz; $f_R = 3$ kHz	25	35	–	dB
		$f_L = 300$ Hz; $f_R = 8$ kHz	20	30	–	dB
		$f_L = 300$ Hz; $f_R = 10$ kHz	15	25	–	dB
$L, R(f)$	L, R frequency response	14% modulation; $f_{reference} = 300$ Hz L or R				
		50 Hz to 11 kHz	–3	–	–	dB
		12 kHz	–	–3	–	dB

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
THD <sub>L,R</sub>	total harmonic distortion L, R at LINE OUT	modulation L or R 1% to 100%; f = 1 kHz	–	0.2	1.0	%
S/N	S/N CCIR 468-2 weighted; quasi peak; V <sub>O</sub> = 500 mV (RMS)	LINE OUT in position MONO	50	60	–	dB
<b>Stereo decoder, oscillator (VCXO)</b>						
f <sub>o</sub>	nominal VCXO frequency (32f <sub>H</sub> )	with nominal ceramic resonator	–	503.5	–	kHz
f <sub>of</sub>	spread of free running frequency		500.0	–	507.0	kHz
Remark: The oscillator is designed to work together with MURATA resonator CSB503F58 for TDA9855. Change of the resonator supplier is possible, but the resonator specification must be close to CSB503F58 for TDA9855.						
Δf <sub>H</sub>	capture range (nominal pilot)		±190	±265	–	Hz
<b>SAP demodulator</b>						
Remark: The internal SAP carrier level is determined by the composite input level and the level adjust gain.						
SAP <sub>IN</sub>	nominal SAP carrier input level (RMS value)	15 kHz frequency deviation of intercarrier	–	150	–	mV
SAP <sub>ON</sub>	pilot threshold SAP ON (RMS value)		–	–	85	mV
SAP <sub>OFF</sub>	pilot threshold SAP OFF (RMS value)		35	–	–	mV
SAP <sub>HYS</sub>	hysteresis		–	2	–	dB
SAP <sub>LEV</sub>	SAP output level at LINE OUT (RMS value)	LINE OUT (LOL, LOR) in position SAP / SAP; f <sub>mod</sub> = 300 Hz; 100% modulation	–	500	–	mV
F <sub>res</sub>	frequency response	14% modulation; 50 Hz to 8 kHz; f <sub>reference</sub> = 300 Hz	–3	–	–	dB
THD	total harmonic distortion	1 kHz	–	0.5	2.0	%
<b>LINE OUT (at pins LOL, LOR)</b>						
V <sub>o</sub>	nominal output voltage (RMS value)	100% modulation	–	500	–	mV
Headr	output headroom		9	–	–	dB
Z <sub>o</sub>	output impedance		–	80	120	Ω
OutDC	DC output voltage		0.45V <sub>CC</sub>	0.5V <sub>CC</sub>	0.55V <sub>CC</sub>	V
R <sub>L</sub>	output load resistance (AC)		5	–	–	kΩ
C <sub>L</sub>	output load capacitance		–	–	2.5	nF
α <sub>ST-SAP</sub>	idle crosstalk L, R into SAP	100% modulation; f = 1 kHz; L or R; LINE OUT switched to SAP / SAP	50	–	–	dB
α <sub>SAP-ST</sub>	idle crosstalk SAP into L, R	100% modulation; f = 1 kHz; SAP; LINE OUT switched to stereo	50	–	–	dB
ΔV <sub>ST-SAP</sub>	output voltage difference if switched from L, R to SAP	250 Hz to 6.3 kHz	–	–	3	dB

# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>dbx noise reduction circuit</b>						
$t_{adj}$	stereo adjust time	see adjustment procedure	–	–	1	s
$I_s$	nominal timing current for nominal release rate of spectral RMS detector	$I_s$ can be measured at pin 17 (pin 22) via current meter connected to $V_{CC}/2 + 1$ V	–	24	–	$\mu$ A
$\Delta I_s$	spread of timing current		–	–	15	%
$I_{s\ range}$	timing current adjustment range	7 steps via I <sup>2</sup> C-bus	–	$\pm 30$	–	%
$t_t$	timing current for release rate of wideband RMS detector		–	$I_s/3$	–	$\mu$ A
$Rel_{rate}$	nominal RMS detector release rate wideband spectral	nominal timing current and external capacitor values	–	125	–	dB/s
			–	381	–	dB/s
<b>AUDIO PART</b>						
Circuit section from pins LIL, LIR to pins OUTL, OUTR, OUTS						
Select in to input line control						
B	roll-off frequencies	$C_6, C_7, C_{10}, C_{26}, C_{27}, C_{29} = 2.2 \mu\text{F}; Z_i = Z_{i\ min}$ low frequency (–3 dB) high frequency (–0.5 dB)	–	–	20	Hz kHz
THD	total harmonic distortion	$V_i = 1$ V (RMS); $G_c = 0$ dB; AVL on	–	0.2	0.5	%
		$V_i = 2$ V (RMS); $G_c = 0$ dB; AVL on	–	0.2	0.5	%
		$V_i = 1$ V (RMS); $G_c = 0$ dB; AVL off	–	0.05	–	%
		$V_i = 2$ V (RMS); $G_c = 0$ dB; AVL off	–	0.02	–	%
RR	power supply ripple rejection	$V_{r(RMS)} < 200$ mV; $f = 100$ Hz	47	50	–	dB
$\alpha_B$	crosstalk ( $20 \log V_{bus(p-p)} / V_{o(RMS)}$ ) between bus inputs and signal outputs	note 1	–	110	–	dB
$V_{no}$	noise output voltage	CCIR 468-2 weighted; quasi peak	–	40	80	$\mu$ V
		measured in dBA	–	8	–	$\mu$ V
$\alpha_{cs}$	channel separation	$V_i = 1$ V; $f = 1$ kHz	75	–	–	dB
		$V_i = 1$ V; $f = 12.5$ kHz	75	–	–	dB
<b>Selector (from pins LOL, LOR, LIL, LIR to pins SOL, SOR)</b>						
$Z_i$	input impedance		16	20	24	k $\Omega$
$\alpha_s$	input isolation of one selected source to the other input	$f = 1$ kHz; $V_i = 1$ V	86	96	–	dB
		$f = 12.5$ kHz; $V_i = 1$ V	80	96	–	dB
$V_{i(RMS)}$	maximum input voltage	THD < 0.5%	2	2.3	–	V
$V_{DC\ OFF}$	DC offset voltage at selector out by selection of any inputs		–	–	25	mV
$Z_o$	output impedance		–	80	120	$\Omega$
$R_L$	output load resistance (AC)		5	–	–	k $\Omega$
$C_L$	output load capacitance		–	–	2.5	nF
$G_c$	voltage gain, selector		–	0	–	dB

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# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Automatic volume level control (AVL)</b>						
Z <sub>i</sub>	input impedance		8.8	11.0	13.2	kΩ
V <sub>i(RMS)</sub>	maximum input voltage	THD < 0.2%	2	–	–	V
G <sub>v</sub>	gain, maximum boost		5	6	7	dB
	maximum attenuation		14	15	16	dB
G <sub>step</sub>	equivalent step width between the input stages (soft switching system)		–	1.5	–	dB
V <sub>i(RMS)</sub>	input level at maximum boost	see Fig.4	–	0.1	–	V
	input level at maximum attenuation		–	1.125	–	V
V <sub>o(RMS)</sub>	output level in AVL operation range		160	200	250	mV
V <sub>DC OFF</sub>	DC offset between different gain steps	note 2; voltage at pin CAV				
		6.50 V to 6.33 V	–	–	6	mV
		6.33 V to 6.11 V	–	–	6	mV
		6.11 V to 5.33 V	–	–	6	mV
		5.33 V to 2.60 V	–	–	6	mV
R <sub>att</sub>	discharge resistors for attack time constant	note 3;				
		AT1 = 0; AT2 = 0	340	420	520	Ω
		AT1 = 1; AT2 = 0	590	730	910	Ω
		AT1 = 0; AT2 = 1	0.96	1.2	1.5	kΩ
		AT1 = 1; AT2 = 1	1.7	2.1	2.6	kΩ
I <sub>dec</sub>	charge current for decay time	note 4	1.6	2.0	2.4	μA
<b>Effect controls</b>						
α <sub>spat1</sub>	anti-phase crosstalk by spatial effect		–	52	–	%
α <sub>spat2</sub>			–	30	–	%
φ	phase shift by pseudo-stereo	see Fig.5	–	–	–	–
<b>Volume tone control part (input pins VIL, VIR to pins OUTX, to pin OUTS)</b>						
Z <sub>i</sub>	input impedance volume input		8.0	10.0	12.0	kΩ
Z <sub>o</sub>	output impedance		–	80	120	Ω
R <sub>L</sub>	output load resistance (AC)		5	–	–	kΩ
C <sub>L</sub>	output load capacitance		–	–	2.5	nF
V <sub>i(RMS)</sub>	maximum input voltage	THD < 0.5%	2.0	2.15	–	V
V <sub>no</sub>	noise output voltage	CCIR 468-2 weighted; quasi peak				
		G <sub>c</sub> = 16 dB	–	110	220	μV
		G <sub>c</sub> = 0 dB	–	33	50	μV
		mute position	–	10	–	μV
G <sub>c</sub>	total continuous control range					
	maximum boost		–	16	–	dB
	maximum attenuation		–	71	–	dB
G <sub>step</sub>	step resolution		–	1	–	dB
	step error between any adjoining step		–	–	0.5	dB
ΔG <sub>a</sub>	attenuator set error	G <sub>c</sub> = +16 to –50 dB	–	–	2	dB
		G <sub>c</sub> = –51 to –71 dB	–	–	3	dB
ΔG <sub>t</sub>	gain tracking error	G <sub>c</sub> = +16 to –50 dB	–	–	2	dB

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# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$\alpha_m$	mute attenuation		80	–	–	dB
V <sub>DC OFF</sub>	DC step offset between any adjacent step	$G_c = +16$ to 0 dB	–	0.2	10.0	mV
		$G_c = 0$ to –71 dB	–	–	5	mV
	DC step offset between any step to mute	$G_c = +16$ to +1 dB	–	2	15	mV
		$G_c = 0$ to –71 dB	–	1	10	mV
<b>Loudness control part</b>						
L <sub>B</sub>	maximum loudness boost	loudness on; referred to loudness off; boost is determined by external components; see Fig.6; f = 40 Hz f = 10 kHz	– –	17 4.5	– –	dB dB
<b>Bass control (see Fig.7)</b>						
G <sub>b</sub>	bass control maximum boost	f = 40 Hz	15.5	16.5	17.5	dB
	maximum attenuation	f = 40 Hz	11	12	13	dB
G <sub>step</sub>	step resolution	f = 40 Hz	–	1.5	–	dB
	step error between any adjoining step		–	–	0.5	dB
V <sub>DC OFF</sub>	DC step offset between any adjacent step		–	–	15	mV
<b>Treble control (see Fig.8)</b>						
G <sub>t</sub>	treble control maximum boost	f = 15 kHz	11	12	13	dB
	maximum attenuation	f = 15 kHz	11	12	13	dB
	maximum boost	f > 15 kHz	–	–	15	dB
G <sub>step</sub>	step resolution	f = 15 kHz	–	3	–	dB
	step error between any adjoining step		–	–	0.5	dB
V <sub>DC OFF</sub>	DC step offset between any adjacent step		–	–	10	mV
<b>Subwoofer or surround control</b>						
G <sub>s</sub>	subwoofer control maximum boost	f = 40 Hz	12	14	16	dB
	maximum attenuation		12	14	16	dB
G <sub>step</sub>	step resolution		–	2	–	dB
$\alpha_m$	mute attenuation		60	–	–	dB
V <sub>DC OFF</sub>	DC step offset between any adjacent step	$G_s = 0$ to +14 dB	–	–	10	mV
		$G_s = 0$ to –14 dB	–	–	5	mV
	DC step offset between any step to mute	$G_s = +2$ to +14 dB without input offset (pin SW connected to V <sub>REF</sub> )	–	–	15	mV
		$G_s = +2$ to +14 dB inclusive offset from OUTR, OUTL	–	–	50	mV
		$G_s = 0$ to –14 dB	–	–	10	mV
R <sub>F</sub>	internal resistor for low-pass filter with external capacitor at pin SW		4	5	6	k $\Omega$
L + R <sub>REJ</sub>	common mode rejection in surround sound at pin OUTS	mono signal at V <sub>L</sub> /V <sub>R</sub> ; f = 1 kHz; V <sub>i</sub> = 1 V; balance = 0 dB	26	36	–	dB

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# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Muting at power supply drop for OUTL, OUTR, OUTS</b>						
V <sub>CC-DROP</sub>	supply drop for mute active		–	V <sub>CAP</sub> – 0.7	–	V
<b>Power on reset</b>						
When reset is active the GMU-bit (general mute) and the LMU-bit (LINEOUT - mute) is set and the I <sup>2</sup> C-bus receiver is in reset position						
V <sub>CC</sub>	start of reset	increasing supply voltage	–	–	2.5	V
	end of reset		5.2	6	6.8	V
	start of reset	decreasing supply voltage	4.2	5	5.8	V
<b>Digital part (I<sup>2</sup>C-bus pins; note 5)</b>						
V <sub>IH</sub>	HIGH level input voltage		3	–	V <sub>CC</sub>	V
V <sub>IL</sub>	LOW level input voltage		–0.3	–	+1.5	V
I <sub>IH</sub>	HIGH level input current		–10	–	+10	μA
I <sub>IL</sub>	LOW level input current		–10	–	+10	μA
V <sub>OL</sub>	LOW level output voltage	I <sub>L</sub> = 3 mA	–	–	0.4	V

### Notes to the characteristics

#### 1. The transmission contains:

- total initialization with MAD and SAD for volume and 11 DATA words, see also definition of characteristics
- clock frequency = 50 kHz
- repetition burst rate = 400 Hz
- maximum bus signal amplitude = 5 V<sub>p-p</sub>.

#### 2. The listed pin voltage corresponds with typical gain steps of +6 dB, +3 dB, 0 dB, –6 dB, –15 dB.

#### 3. Attack time constant = C<sub>AV</sub> × R<sub>att</sub>.

$$4. \quad \text{Decay time} = \frac{C_{AV} \times 0.76 \text{ V} \left( 10^{-\frac{G_{V1}}{20}} - 10^{-\frac{G_{V2}}{20}} \right)}{I_{dec}}$$

Example: C<sub>AV</sub> = 4.7 μF; I<sub>dec</sub> = 2 μA; G<sub>V1</sub> = –9 dB; G<sub>V2</sub> = +6 dB → decay time result: 4.14 s.

#### 5. The AC characteristics are in accordance with the I<sup>2</sup>C-bus specification. Full specification of I<sup>2</sup>C-bus will be supplied on request. The maximum clock frequency is 100 kHz.

# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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## ADJUSTMENT PROCEDURE

Composite input level adjustment. Feed in from FM demodulator the composite signal with 100% modulation (25 kHz deviation) L + R, f = 300 Hz. Set input level control via I<sup>2</sup>C-bus monitoring line out (500 mV ± 20 mV). Store the setting in a none volatile memory. Adjustment of spectral and wideband expander via stereo channel separation adjust.

### Automatic adjustment procedure

- Capacitors of external inputs EIL, EIR must be grounded
- Composite input signal L = 300 Hz, R = 3.1 kHz, 14% modulation for each channel; volume gain +16 dB via I<sup>2</sup>C-bus. To avoid ancing sound level set GMU bit to '1' during adjustment procedure
- Effects, AVL, loudness off
- Selector setting SC0, SC1, SC2 = 0, 0, 0 (see Table 8)
- Line out setting bits: STEREO = 1, SAP = 0 (see Table 15)
- Start adjustment by transmission ADJ = 1 in register ALI3. The decoder will align itself
- After 1 s, stop alignment by transmitting ADJ = 0 in register ALI3 read the alignment data by an I<sup>2</sup>C-bus read operation from ALR1 and ALR2 (see I<sup>2</sup>C-bus protocol) and store it in a none volatile memory. The alignment procedure overwrites the previous data stored in ALI1 and ALI2
- Disconnect the capacitors of external inputs from ground.

### Manual adjust

Manual adjust is necessary when no dual tone generator is available (e.g. for service).

- Spectral and wideband data have to be set to 10000 (middle position for adjustment range)
- Composite input L = 300 Hz, 14% modulation
- Adjust channel separation by varying wideband data
- Composite input L = 3 kHz, 14% modulation
- Adjust channel separation by varying spectral data
- Iterative spectral/wideband operation for optimal adjust
- Store data in none volatile memory.

After every POWER ON, the alignment data and the input level adjustment data must be loaded from the none volatile memory.

### Timing current for release rate

Due to possible internal and external spreading, the timing current can be adjusted via I<sup>2</sup>C-bus, see Table 19, as recommended by dbx.

# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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## I<sup>2</sup>C-BUS PROTOCOL

### I<sup>2</sup>C-bus format to read (slave transmits data)

S	SLAVE ADDRESS	R/W	A	DATA	MA	DATA	P
---	---------------	-----	---	------	----	------	---

**Where:**

- S = start condition, generated by the master
- standard SLAVE ADDRESS = 101 101 1 pin MAD not connected
- pin programmable SLAVE ADDRESS = 101 101 0 pin MAD connected to ground
- R/W = 1 (read), generated by the master
- A = acknowledge, generated by the slave
- DATA = slave transmits an 8-bit data word
- MA = acknowledge, generated by the master
- P = stop condition, generated by the master

**Table 1** Definition of the transmitted bytes after read condition.

FUNCTION	BYTE	MSB								LSB
		D7	D6	D5	D4	D3	D2	D1	D0	
Alignment read 1	ALR1	Y	SAPP	STP	A14	A13	A12	A11	A10	
Alignment read 2	ALR2	Y	SAPP	STP	A24	A23	A22	A21	A20	

**Function of the bits:**

- STP stereo pilot identification (stereo received = 1)
- SAPP SAP pilot identification (SAP received = 1)
- A1x to A2x stereo alignment read data
- A1x for wideband expander
- A2x for spectral expander
- Y indefinite

The master generates an acknowledge when it has received the first data word, ALR1, then the slave transmits the next data word ALR2. The master next generates an acknowledge, then the slave begins transmitting the first data word ALR1, and so on until the master generates no acknowledge and transmits condition P.

### I<sup>2</sup>C-bus format to write (slave receives data)

S	SLAVE ADDRESS	R/W	A	SUBADDRESS	A	DATA	A	P
---	---------------	-----	---	------------	---	------	---	---

**Where:**

- S = start condition
- standard SLAVE ADDRESS = 101 101 1 pin MAD not connected
- pin programmable SLAVE ADDRESS = 101 101 0 pin MAD connected to ground
- R/W = 0 (write)
- A = acknowledge, generated by the slave
- SUBADDRESS (SAD) = see Table 2
- DATA = see Table 3
- P = stop condition

If more than 1 byte of DATA is transmitted, then auto-increment is performed, starting from the transmitted subaddress and auto-increment of subaddress according to the order of Table 2 is performed.


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**Subaddress****Table 2** Second byte after slave address.

FUNCTION	REGISTER	MSB							LSB		HEX
		D7	D6	D5	D4	D3	D2	D1	D0		
volume right	VR	0	0	0	0	0	0	0	0	00	
volume left	VL	0	0	0	0	0	0	0	1	01	
bass	BA	0	0	0	0	0	0	1	0	02	
treble	TR	0	0	0	0	0	0	1	1	03	
subwoofer	SW	0	0	0	0	0	1	0	0	04	
control 1	CON1	0	0	0	0	0	1	0	1	05	
control 2	CON2	0	0	0	0	0	1	1	0	06	
control 3	CON3	0	0	0	0	0	1	1	1	07	
alignment 1	ALI1	0	0	0	0	1	0	0	0	08	
alignment 2	ALI2	0	0	0	0	1	0	0	1	09	
alignment 3	ALI3	0	0	0	0	1	0	1	0	0A	

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## Definition of third byte

**Table 3** Third byte after slave address.

FUNCTION	REGISTER	MSB								LSB
		D7	D6	D5	D4	D3	D2	D1	D0	
volume right	VR	0	VR6	VR5	VR4	VR3	VR2	VR1	VR0	
volume left	VL	0	VL6	VL5	VL4	VL3	VL2	VL1	VL0	
bass	BA	0	0	0	BA4	BA3	BA2	BA1	BA0	
treble	TR	0	0	0	TR4	TR3	TR2	TR1	0	
subwoofer	SW	0	0	SW5	SW4	SW3	SW2	0	0	
control 1	CON1	GMU	AVLON	LOFF	0	SUR	SC2	SC1	SC0	
control 2	CON2	SAP	STEREO	TZCM	VZCM	LMU	EF2	EF1	EF0	
control 3	CON3	0	0	0	0	L3	L2	L1	L0	
alignment 1	ALI1	0	0	0	A14	A13	A12	A11	A10	
alignment 2	ALI2	STS	0	0	A24	A23	A22	A21	A20	
alignment 3	ALI3	ADJ	AT1	AT2	0	1	TC2	TC1	TC0	

### Function of the bits:

VR0 to VR6	volume control right
VL0 to VL6	volume control left
BA0 to BA4	bass control
TR1 to TR3	treble control
SW2 to SW5	subwoofer, surround control
GMU	mute control for all outputs (general mute)
AVLON	AVL on/off
LOFF	switch loudness on/off
SUR	surround/subwoofer SUR = 1 → (L - R)/2;      SUR = 0 → (L + R)/2
SC0 to SC2	selection between line in and line out
STEREO, SAP	mode selection for line out
TZCM	zero cross mode in mute operation (treble and subwoofer/surround output stage)
VZCM	zero cross mode in volume operation
LMU	mute control for line out
EF0 to EF2	selection between mono, stereo linear, spatial stereo and pseudo mode
L0 to L3	input level adjust
ADJ	stereo adjust on/off
A1X	stereo alignment data for wideband expander
A2X	stereo alignment data for spectral expander
AT1, AT2	attack time at AVL
TC0 to TC2	timing current alignment data
STS	stereo level switch

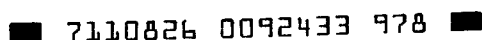
# I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

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Table 4 Volume setting in register VR and VL.

G <sub>c</sub> (dB)	DATA							HEX
	D6 V6	D5 V5	D4 V4	D3 V3	D2 V2	D1 V1	D0 V0	
16	1	1	1	1	1	1	1	7F
15	1	1	1	1	1	1	0	7E
14	1	1	1	1	1	0	1	7D
13	1	1	1	1	1	0	0	7C
12	1	1	1	1	0	1	1	7B
11	1	1	1	1	0	1	0	7A
10	1	1	1	1	0	0	1	79
9	1	1	1	1	0	0	0	78
8	1	1	1	0	1	1	1	77
7	1	1	1	0	1	1	0	76
6	1	1	1	0	1	0	1	75
5	1	1	1	0	1	0	0	74
4	1	1	1	0	0	1	1	73
3	1	1	1	0	0	1	0	72
2	1	1	1	0	0	0	1	71
1	1	1	1	0	0	0	0	70
0	1	1	0	1	1	1	1	6F
-1	1	1	0	1	1	1	0	6E
-2	1	1	0	1	1	0	1	6D
-3	1	1	0	1	1	0	0	6C
-4	1	1	0	1	0	1	1	6B
-5	1	1	0	1	0	1	0	6A
-6	1	1	0	1	0	0	1	69
-7	1	1	0	1	0	0	0	68
-8	1	1	0	0	1	1	1	67
-9	1	1	0	0	1	1	0	66
-10	1	1	0	0	1	0	1	65
-11	1	1	0	0	1	0	0	64
-12	1	1	0	0	0	1	1	63
-13	1	1	0	0	0	1	0	62
-14	1	1	0	0	0	0	1	61
-15	1	1	0	0	0	0	0	60
-16	1	0	1	1	1	1	1	5F
-17	1	0	1	1	1	1	0	5E
-18	1	0	1	1	1	0	1	5D
-19	1	0	1	1	1	0	0	5C
-20	1	0	1	1	0	1	1	5B
-21	1	0	1	1	0	1	0	5A
-22	1	0	1	1	0	0	1	59
-23	1	0	1	1	0	0	0	58
-24	1	0	1	0	1	1	1	57
-25	1	0	1	0	1	1	0	56
-26	1	0	1	0	1	0	1	55
-27	1	0	1	0	1	0	0	54
-28	1	0	1	0	0	1	1	53
-29	1	0	1	0	0	1	0	52
-30	1	0	1	0	0	0	1	51
-31	1	0	1	0	0	0	0	50
-32	1	0	0	1	1	1	1	4F
-33	1	0	0	1	1	1	0	4E

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G <sub>c</sub> (dB)	DATA							HEX
	D6 V6	D5 V5	D4 V4	D3 V3	D2 V2	D1 V1	D0 V0	
-34	1	0	0	1	1	0	1	4D
-35	1	0	0	1	1	0	0	4C
-36	1	0	0	1	0	1	1	4B
-37	1	0	0	1	0	1	0	4A
-38	1	0	0	1	0	0	1	49
-39	1	0	0	1	0	0	0	48
-40	1	0	0	0	1	1	1	47
-41	1	0	0	0	1	1	0	46
-42	1	0	0	0	1	0	1	45
-43	1	0	0	0	1	0	0	44
-44	1	0	0	0	0	1	1	43
-45	1	0	0	0	0	1	0	42
-46	1	0	0	0	0	0	1	41
-47	1	0	0	0	0	0	0	40
-48	0	1	1	1	1	1	1	3F
-49	0	1	1	1	1	1	0	3E
-50	0	1	1	1	1	0	1	3D
-51	0	1	1	1	1	0	0	3C
-52	0	1	1	1	0	1	1	3B
-53	0	1	1	1	0	1	0	3A
-54	0	1	1	1	0	0	1	39
-55	0	1	1	1	0	0	0	38
-56	0	1	1	0	1	1	1	37
-57	0	1	1	0	1	1	0	36
-58	0	1	1	0	1	0	1	35
-59	0	1	1	0	1	0	0	34
-60	0	1	1	0	0	1	1	33
-61	0	1	1	0	0	1	0	32
-62	0	1	1	0	0	0	1	31
-63	0	1	1	0	0	0	0	30
-64	0	1	0	1	1	1	1	2F
-65	0	1	0	1	1	1	0	2E
-66	0	1	0	1	1	0	1	2D
-67	0	1	0	1	1	0	0	2C
-68	0	1	0	1	0	1	1	2B
-69	0	1	0	1	0	1	0	2A
-70	0	1	0	1	0	0	1	29
-71	0	1	0	1	0	0	0	28
mute	0	1	0	0	1	1	1	27

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Table 5 Bass setting in register BA.

G <sub>b</sub> (dB)	DATA					HEX
	D4 BA4	D3 BA3	D2 BA2	D1 BA1	D0 BA0	
16.5	1	1	0	0	1	19
15	1	1	0	0	0	18
13.5	1	0	1	1	1	17
12	1	0	1	1	0	16
10.5	1	0	1	0	1	15
9	1	0	1	0	0	14
7.5	1	0	0	1	1	13
6	1	0	0	1	0	12
4.5	1	0	0	0	1	11
3	1	0	0	0	0	10
1.5	0	1	1	1	1	0F
0	0	1	1	1	0	0E
-1.5	0	1	1	0	1	0D
-3	0	1	1	0	0	0C
-4.5	0	1	0	1	1	0B
-6	0	1	0	1	0	0A
-7.5	0	1	0	0	1	09
-9	0	1	0	0	0	08
-10.5	0	0	1	1	1	07
-12	0	0	1	1	0	06

Table 6 Treble setting in register TR.

G <sub>t</sub> (dB)	DATA				HEX
	D4 TR4	D3 TR3	D2 TR2	D1 TR1	
12	1	0	1	1	16
9	1	0	1	0	14
6	1	0	0	1	12
3	1	0	0	0	10
0	0	1	1	1	0E
-3	0	1	1	0	0C
-6	0	1	0	1	0A
-9	0	1	0	0	08
-12	0	0	1	1	06



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**Table 7** Subwoofer/surround setting in register SW.

G <sub>s</sub> (dB)	DATA				HEX
	D5 SW5	D4 SW4	D3 SW3	D2 SW2	
14	1	1	1	1	3C
12	1	1	1	0	38
10	1	1	0	1	34
8	1	1	0	0	30
6	1	0	1	1	2C
4	1	0	1	0	28
2	1	0	0	1	24
0	1	0	0	0	20
-2	0	1	1	1	1C
-4	0	1	1	0	18
-6	0	1	0	1	14
-8	0	1	0	0	10
-10	0	0	1	1	0C
-12	0	0	1	0	08
-14	0	0	0	1	04
mute	0	0	0	0	00

**Table 8** Selector setting in register CON1.

FUNCTION: input connected to output	SOR, SOL	DATA		
		D2 SC2	D1 SC1	D0 SC0
input	LOR, LOL	0	0	0
input	LOR, LOR	0	0	1
input	LOL, LOL	0	1	0
input	LOL, LOR	0	1	1
input	LIR, LIL	1	0	0
input	LIR, LIR	1	0	1
input	LIL, LIL	1	1	0
input	LIL, LIR	1	1	1

**Table 9** SUR bit setting in register CON1.

FUNCTION	DATA D3
surround sound	1
subwoofer	0

**Table 10** LOFF bit setting in register CON1.

CHARACTERISTIC	DATA D5
with loudness	0
linear	1

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**Table 11** AVLON bit setting in register CON1.

FUNCTION	DATA D6
automatic volume control off	0
automatic volume control on	1

**Table 12** Mute setting.

REGISTER CON1		REGISTER CON2	
FUNCTION	DATA D7 GMU	FUNCTION	DATA D3 LMU
forced mute at OTR, OUTL, OUTS	1	forced mute at LOR, LOL	1
audio processor controlled outputs	0	stereo processor controlled outputs	0

**Table 13** Effects setting in register CON2.

FUNCTION	DATA		
	D2 EF2	D1 EF1	D0 EF0
stereo linear on	0	0	0
pseudo on	0	0	1
spatial stereo, 30% anti-phase crosstalk	0	1	0
spatial stereo, 50% anti-phase crosstalk	0	1	1
forced mono	1	1	1

**Table 14** Zero cross detection setting in register CON2.

FUNCTION	DATA D5 TZCM	FUNCTION	DATA D4 VZCM
direct mute control	0	direct volume control	0
mute control delayed until the next zero crossing	1	volume control delayed until the next zero crossing	1

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Table 15 Switch setting at line out.

FUNCTION		DATA	DATA	
line out signals at		transmission status	setting bits in register CON2	
LOL	LOR	Internal switch readable bits in register ALR1, ALR2: D6 D5 SAPP STP	D7 SAP	D6 STEREO
SAP	SAP	SAP received	1	1
mute	mute	no SAP received	1	1
left	right	stereo received	0	1
mono	mono	no stereo received	0	1
mono	SAP	SAP received	1	0
mono	mute	no SAP received	1	0
mono	mono		0	0

Table 16 Level adjust setting in register CON3.

G <sub>i</sub> (dB)	DATA				HEX
	D3 L3	D2 L2	D1 L1	D0 L0	
+4	1	1	1	1	0F
+3.5	1	1	1	0	0E
+3	1	1	0	1	0D
+2.5	1	1	0	0	0C
+2	1	0	1	1	0B
+1.5	1	0	1	0	0A
+1	1	0	0	1	09
+0.5	1	0	0	0	08
0	0	1	1	1	07
-0.5	0	1	1	0	06
-1	0	1	0	1	05
-1.5	0	1	0	0	04
-2	0	0	1	1	03
-2.5	0	0	1	0	02
-3	0	0	0	1	01
-3.5	0	0	0	0	00

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**Table 17** Alignment data for expander in read register ALR1 and ALR2 and in write register ALI1 and ALI2.

FUNCTION	DATA				
	D4 AX4	D3 AX3	D2 AX2	D1 AX1	D0 AX0
gain increase	1	1	1	1	1
	1	1	1	1	0
	1	1	1	0	1
	1	1	1	0	0
	1	1	0	1	1
	1	1	0	1	0
	1	1	0	0	1
	1	1	0	0	0
	1	0	1	1	1
	1	0	1	1	0
	1	0	1	0	1
	1	0	1	0	0
	1	0	0	1	1
	1	0	0	1	0
nominal gain	1	0	0	0	0
	0	1	1	1	1
gain decrease	0	1	1	1	0
	0	1	1	0	1
	0	1	1	0	0
	0	1	0	1	1
	0	1	0	1	0
	0	1	0	0	1
	0	1	0	0	0
	0	0	1	1	1
	0	0	1	1	0
	0	0	1	0	1
	0	0	1	0	0
	0	0	0	1	1
	0	0	0	1	0
	0	0	0	0	1
0	0	0	0	0	

**Table 18** STS bit setting in register ALI2 (pilot threshold stereo on).

FUNCTION	DATA D7
STON ≤ 35 mV	1
STON ≤ 30 mV	0

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Table 19 Timing current setting in register ALI3.

I <sub>s</sub> range	DATA		
	D2 TC2	D1 TC1	D0 TC0
+30%	1	0	0
+20%	1	0	1
+10%	1	1	0
nominal	0	1	1
-10%	0	1	0
-20%	0	0	1
-30%	0	0	0

Table 20 AVL attack time setting in register ALI3.

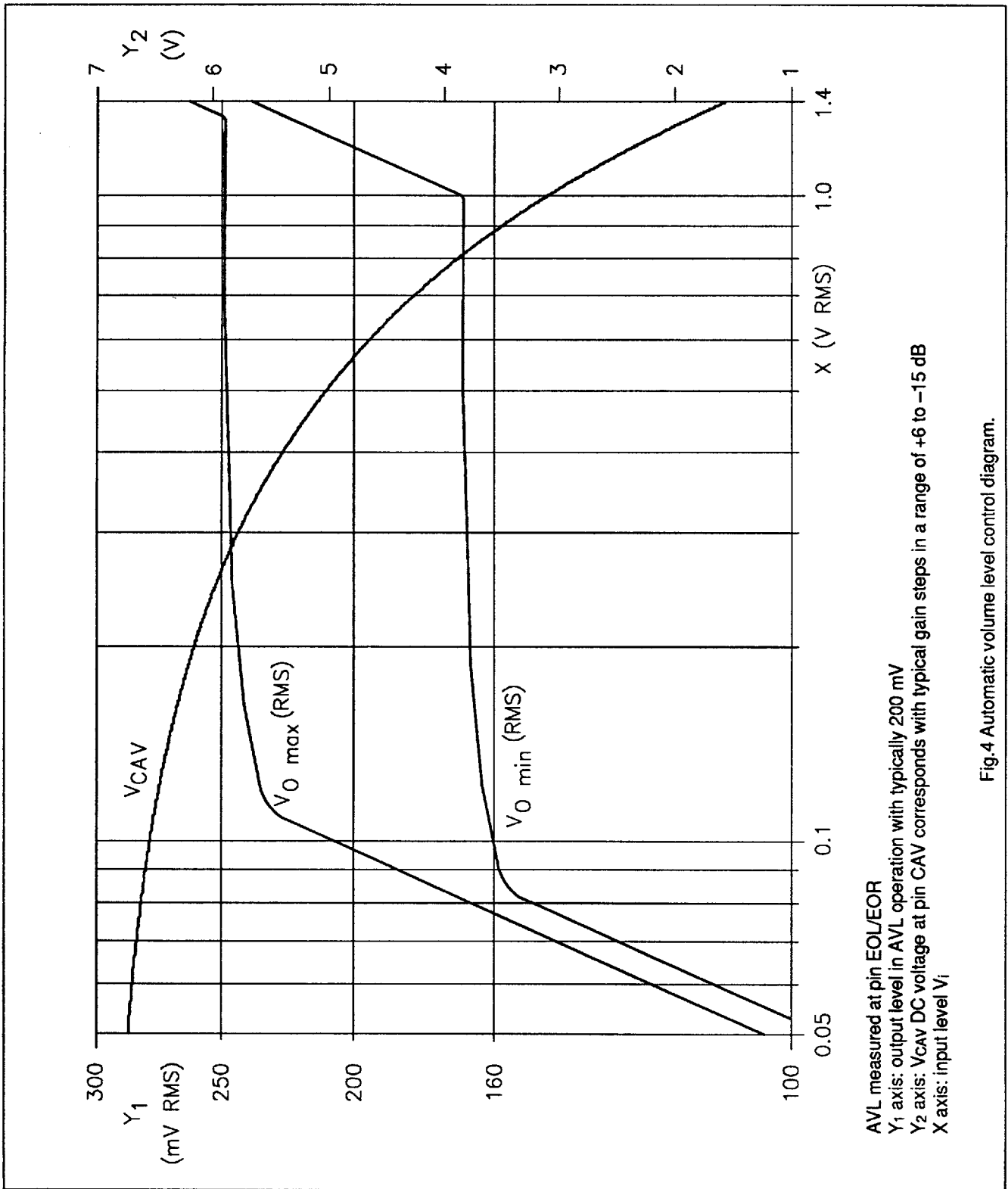
R <sub>att</sub> (Ω)	DATA	
	D6 AT1	D5 AT2
420	0	0
730	1	0
1200	0	1
2100	1	1

Table 21 ADJ bit setting in register ALI3.

FUNCTION	DATA D7
stereo decoder operation mode	0
auto adjustment of channel separation	1

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AVL measured at pin EOL/EOR

$Y_1$  axis: output level in AVL operation with typically 200 mV

$Y_2$  axis:  $V_{CAV}$  DC voltage at pin CAV corresponds with typical gain steps in a range of +6 to -15 dB

X axis: input level  $V_i$

Fig.4 Automatic volume level control diagram.

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CURVE	CAPACITANCE AT PIN 43 (56)	CAPACITANCE AT PIN 42 (55)	EFFECT
	(nF)	(nF)	
1	15	15	normal
2	5.6	47	intensified
3	5.6	68	more intensified

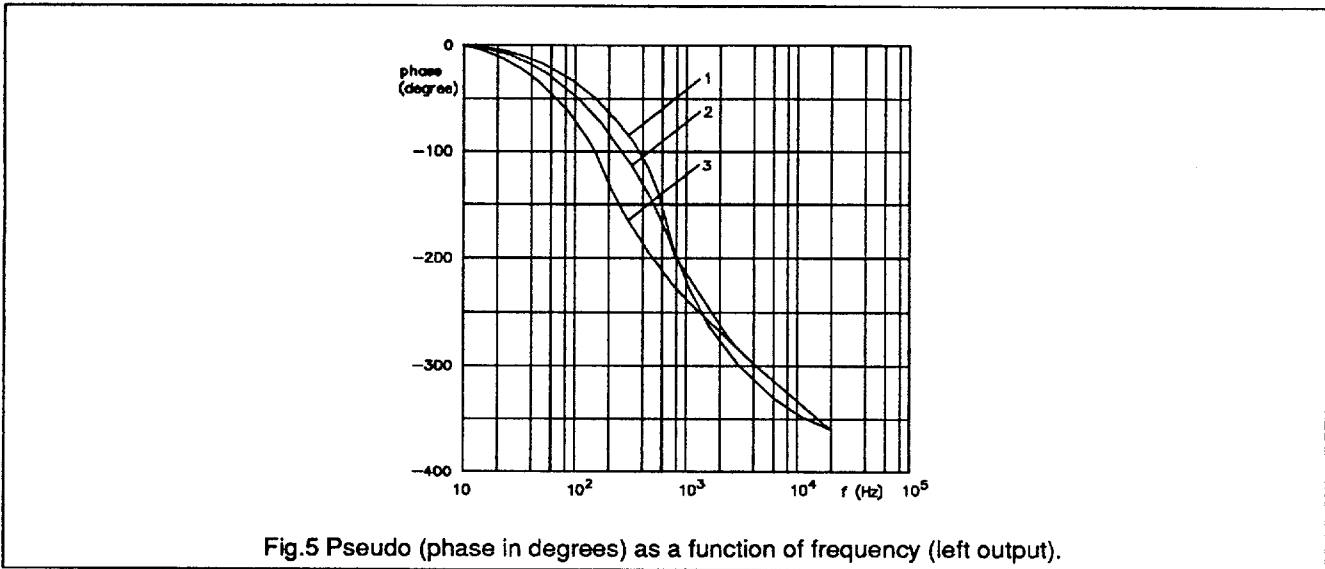


Fig.5 Pseudo (phase in degrees) as a function of frequency (left output).

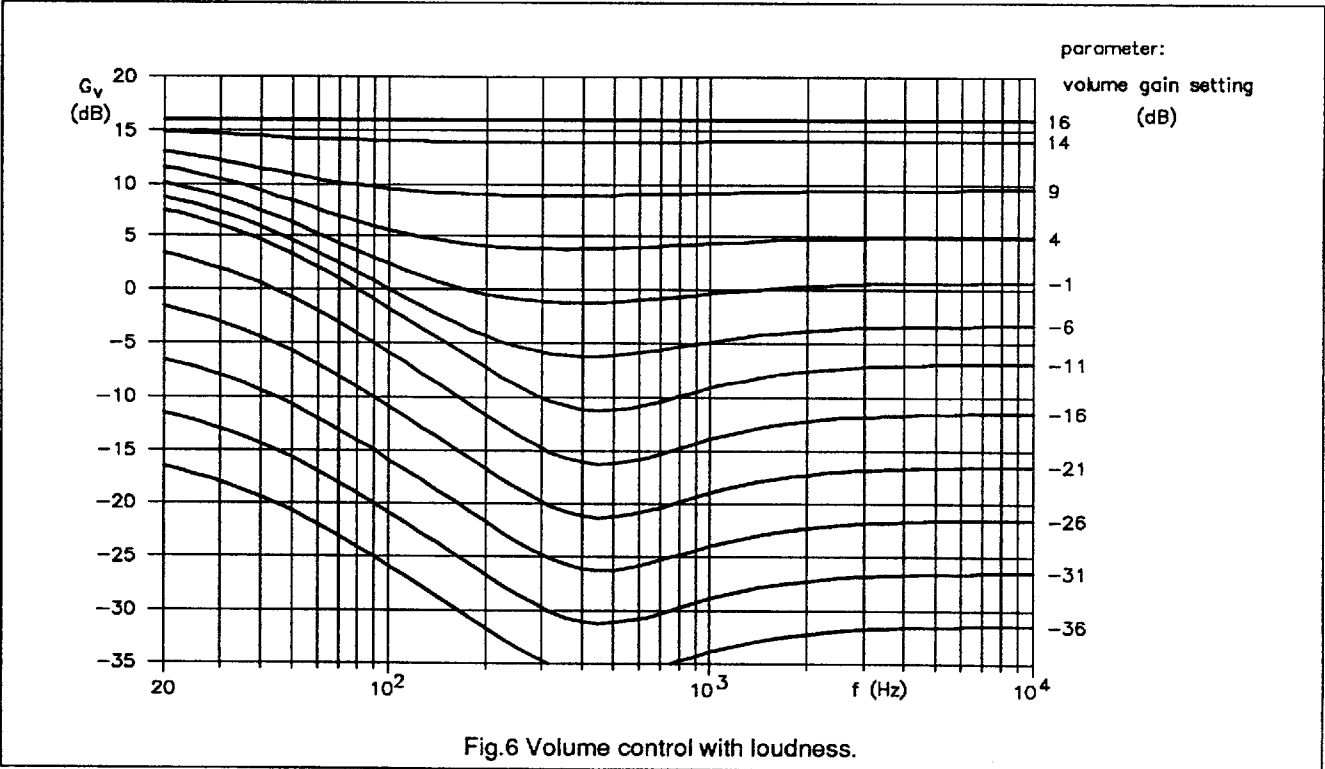
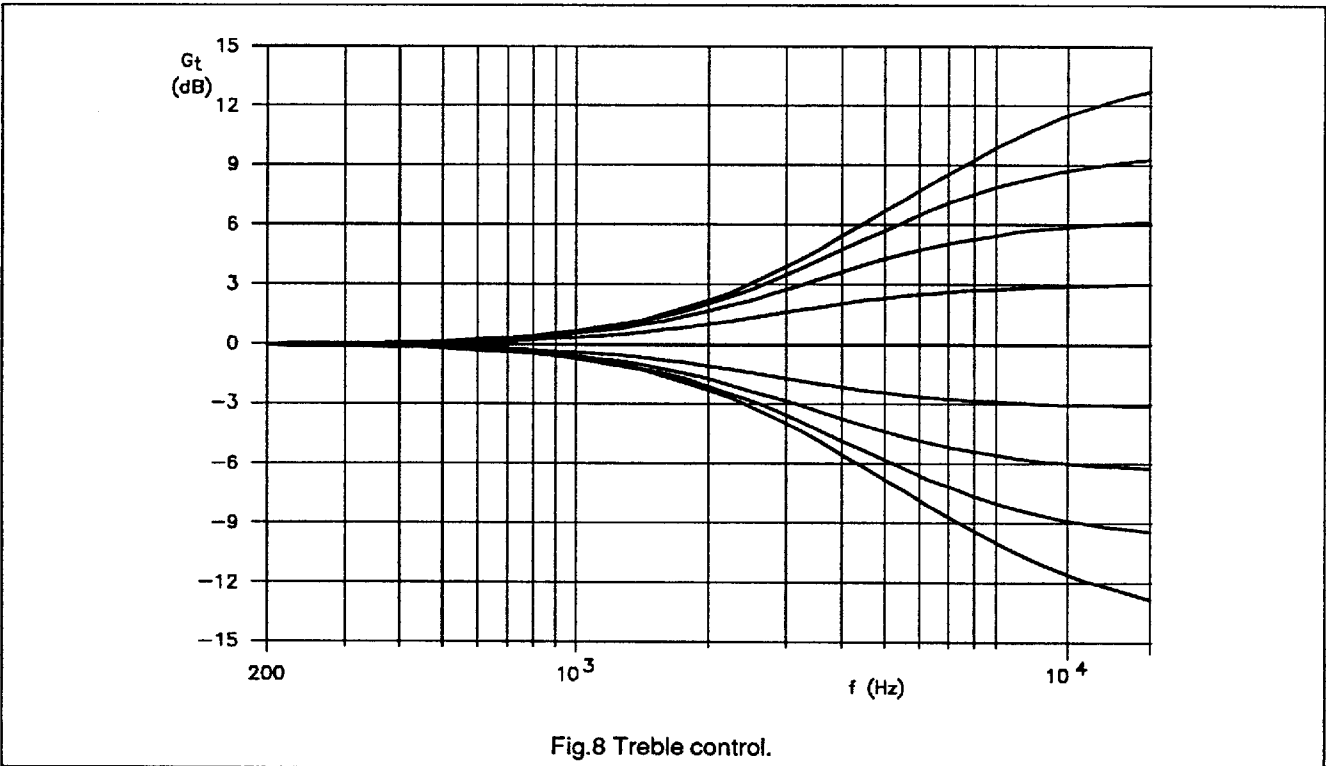
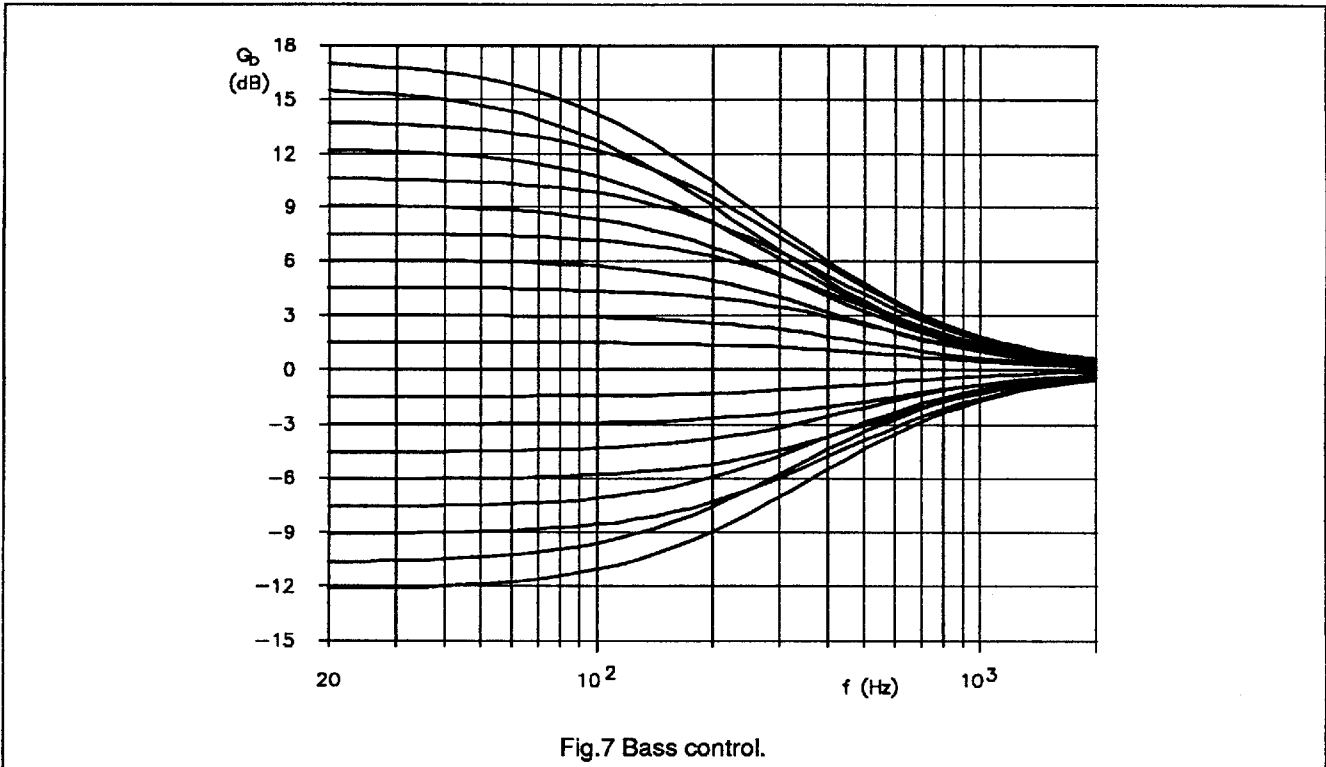


Fig.6 Volume control with loudness.

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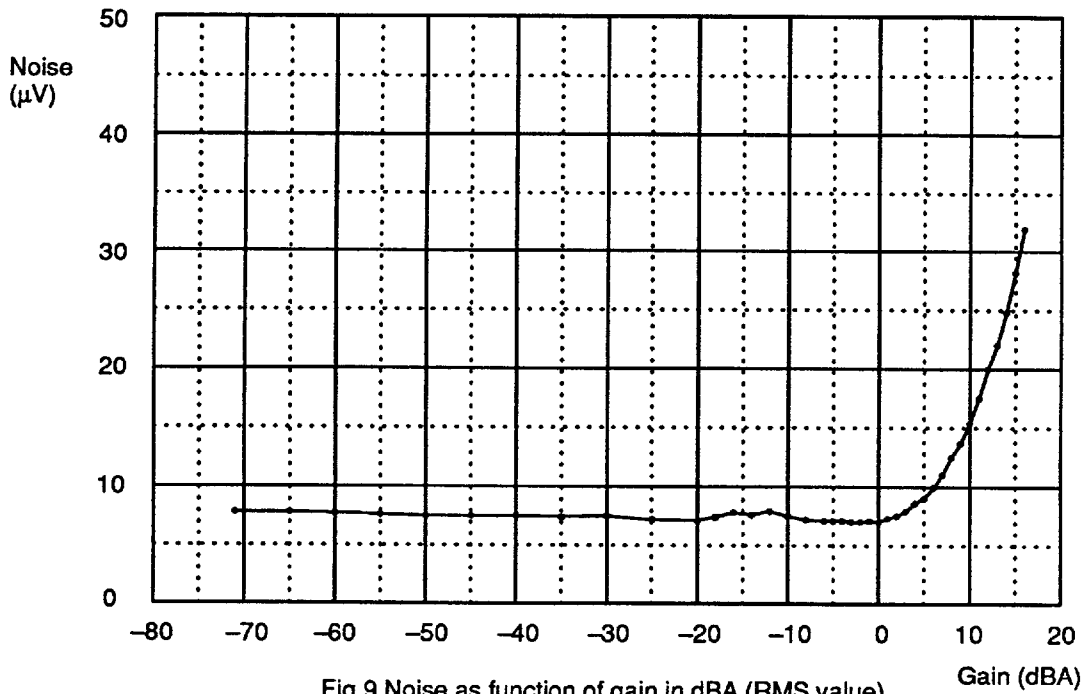


Fig.9 Noise as function of gain in dBA (RMS value).

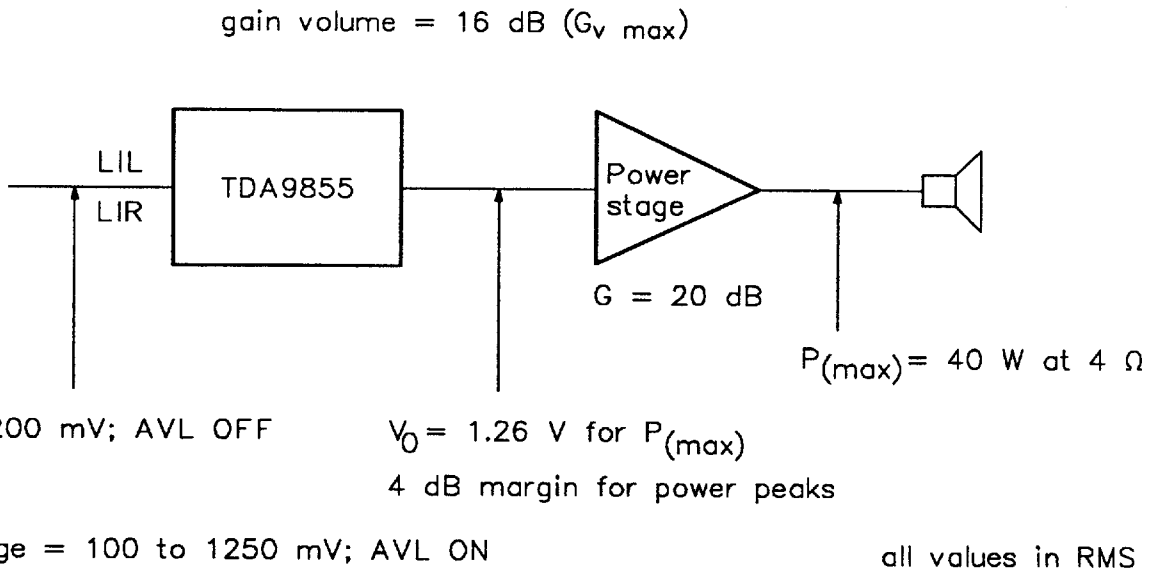


Fig.10 Level diagram.

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## APPLICATION HINTS

### Selection of input signals by using the zero crossing mute mode

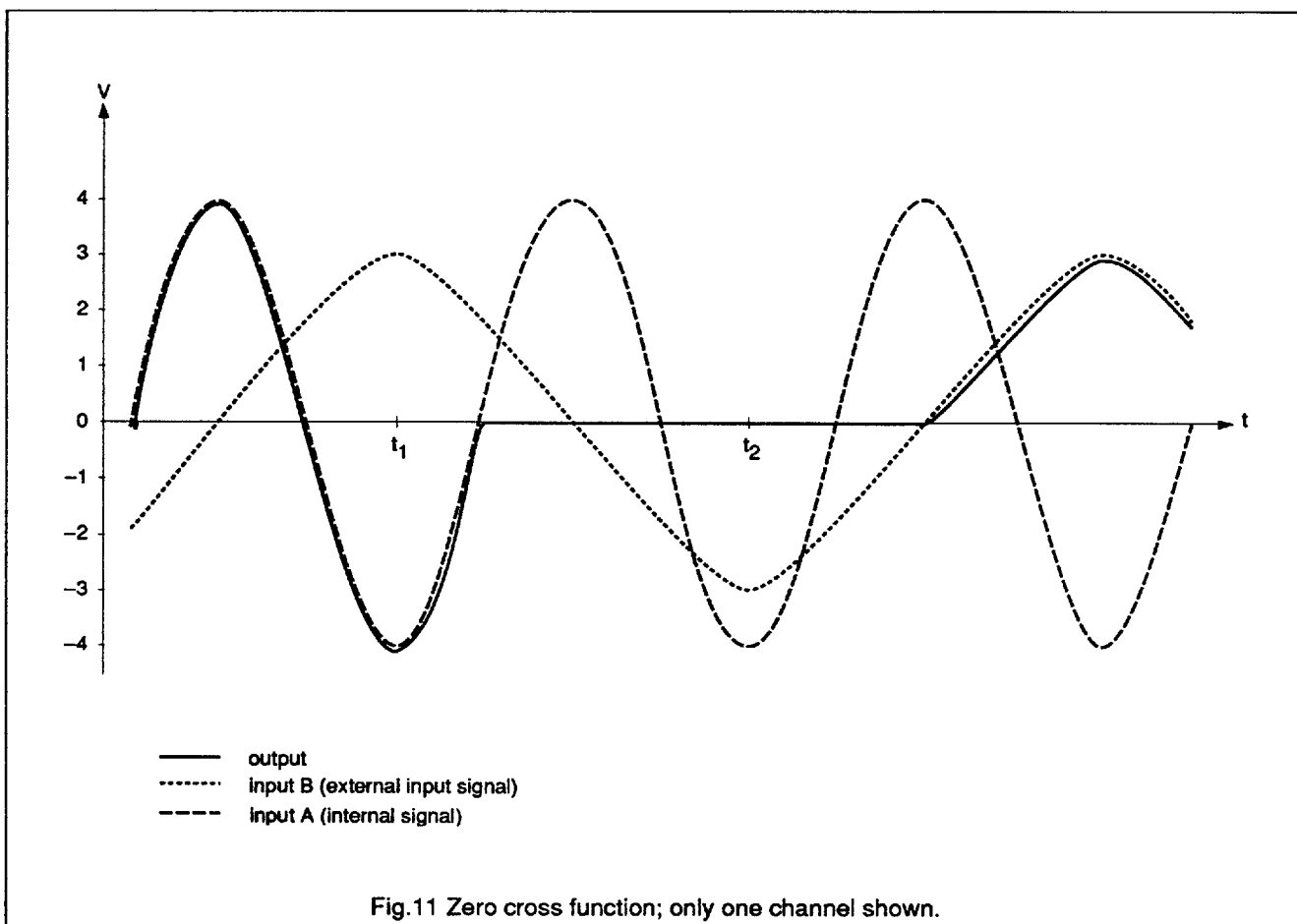
A selection between the internal signal path and the external input LIL/LIR produces a modulation click depending on the difference of the signal values at the time of switching. At  $t_1$  the maximum possible difference between signals is  $7 V_{(p-p)}$  and gives a large click. Using the zero cross detector no modulation click is audible.

For example: The selection is enabled at  $t_1$ , the microcontroller sets the zero cross bit (TZCM = 1) and then the mute bit (GMU = 1) via the I<sup>2</sup>C-bus. The output signal follows the input A signal, until the next zero crossing occurs and then activates mute.

After a fixed delay time before  $t_2$ , the microcontroller has to send the forced mute mode (TZCM = 0) and the return to the zero crossing mode (TZCM = 1) to be sure that mute is enabled.

The output signal remains muted until the next signal zero crossing of input B occurs, and then follows that signal.

The delay time  $t_2 - t_1$  is e. g. 40 ms. The zero cross function is working at the lowest frequency of 40 Hz.



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### Loudness filter calculation example

Fig.12 shows the basic loudness circuit with an external low-pass filter application. R<sub>1</sub> allows an attenuation range of 21 dB while the boost is determined by the gain stage V<sub>1</sub>. Both result in a loudness control range of +16 dB to -12 dB.

Defining f<sub>reference</sub> as the frequency where the level does not change while switching loudness on/off. The external resistor R<sub>3</sub> for f<sub>reference</sub> → ∞ can be calculated as

$$R_3 = R_1 \frac{10^{G_v/20}}{1 - 10^{G_v/20}}$$

with G<sub>v</sub> = -21 dB and R<sub>1</sub> = 33 kΩ results in R<sub>3</sub> = 3.2 kΩ.

For the low-pass filter characteristic the value of the external capacitor C<sub>1</sub> can be determined by setting a specific boost for a defined frequency and referring the gain to G<sub>v</sub> at f<sub>reference</sub> as indicated above.

$$\left| \frac{1}{j\omega C_1} \right| = \frac{(R_1 + R_3) \times 10^{G_v/20} - R_3}{1 - 10^{G_v/20}}$$

For example: 3 dB boost at f = 1 kHz  
G<sub>v</sub> = G<sub>v reference</sub> + 3 dB = -18 dB;  
f = 1 kHz and C<sub>1</sub> = 100 nF

If a loudness characteristic with additional high frequency boost is desired, an additional high-pass section has to be included in the external filter circuit as indicated in the block diagram. A filter configuration that provides AC coupling avoids offset voltage problems.

Fig.13 shows an example of the loudness circuit with bass and treble boost.

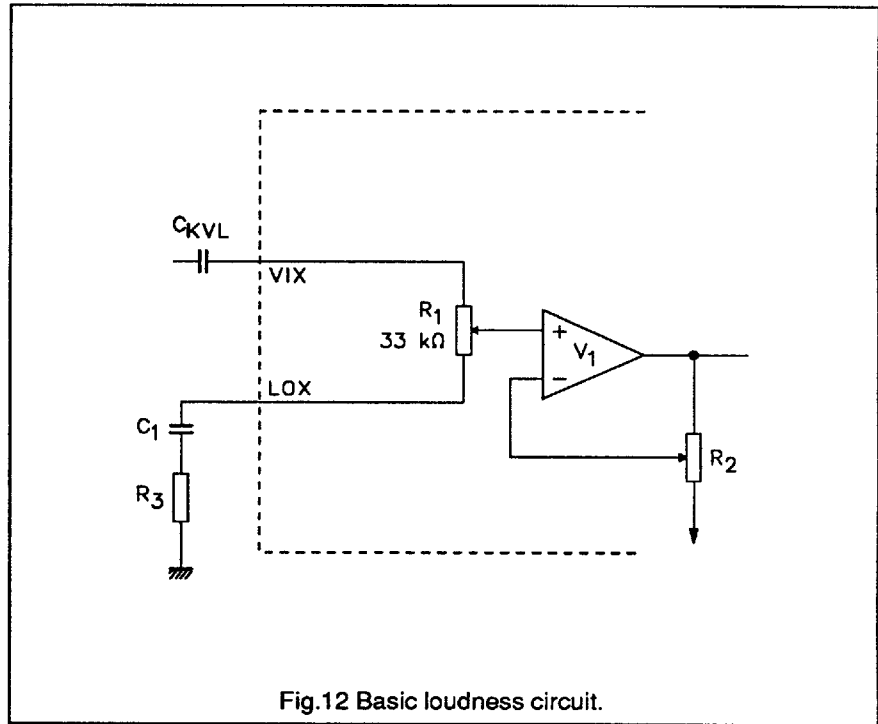


Fig.12 Basic loudness circuit.

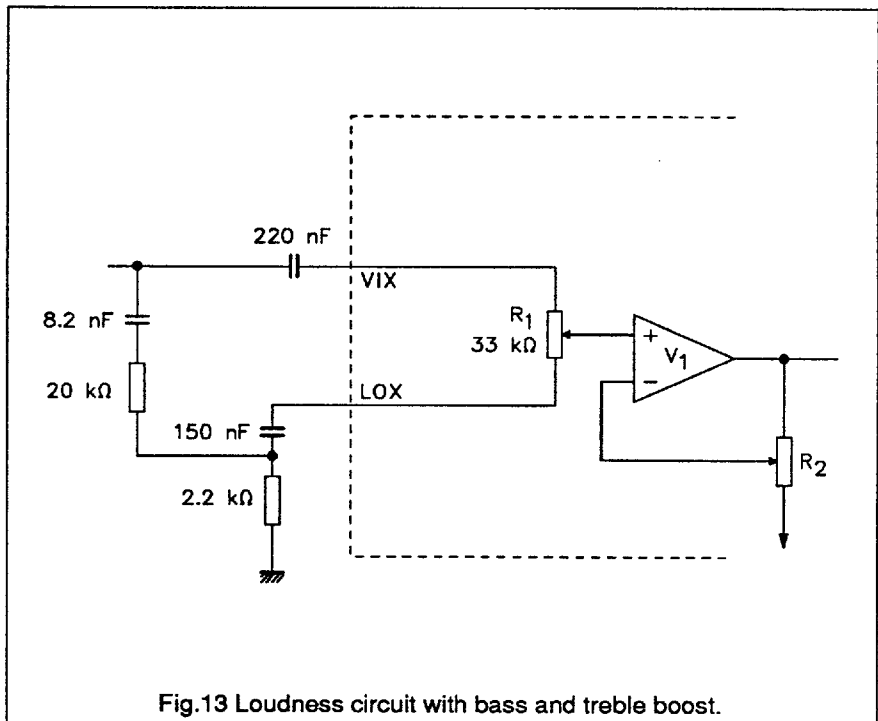
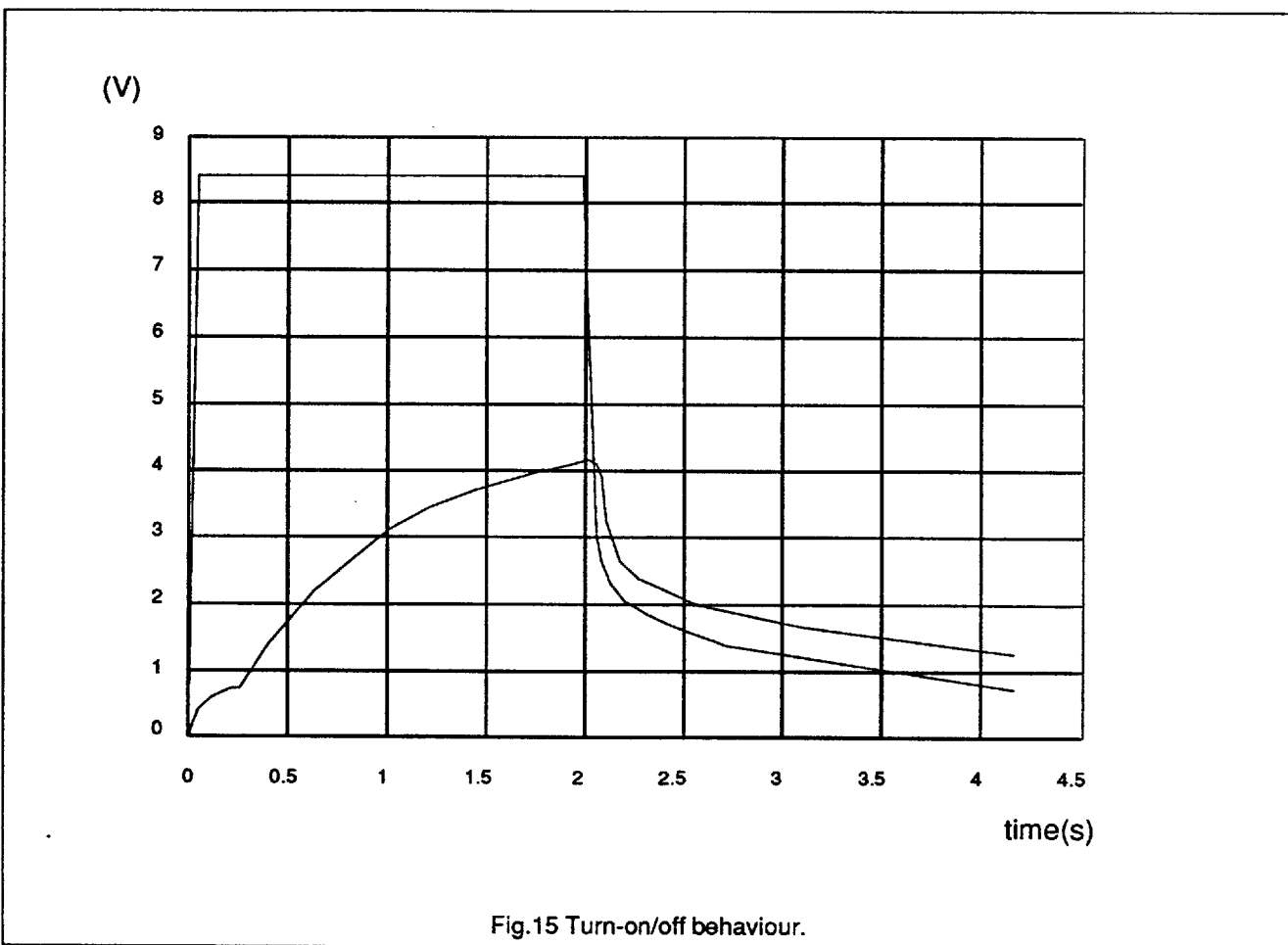
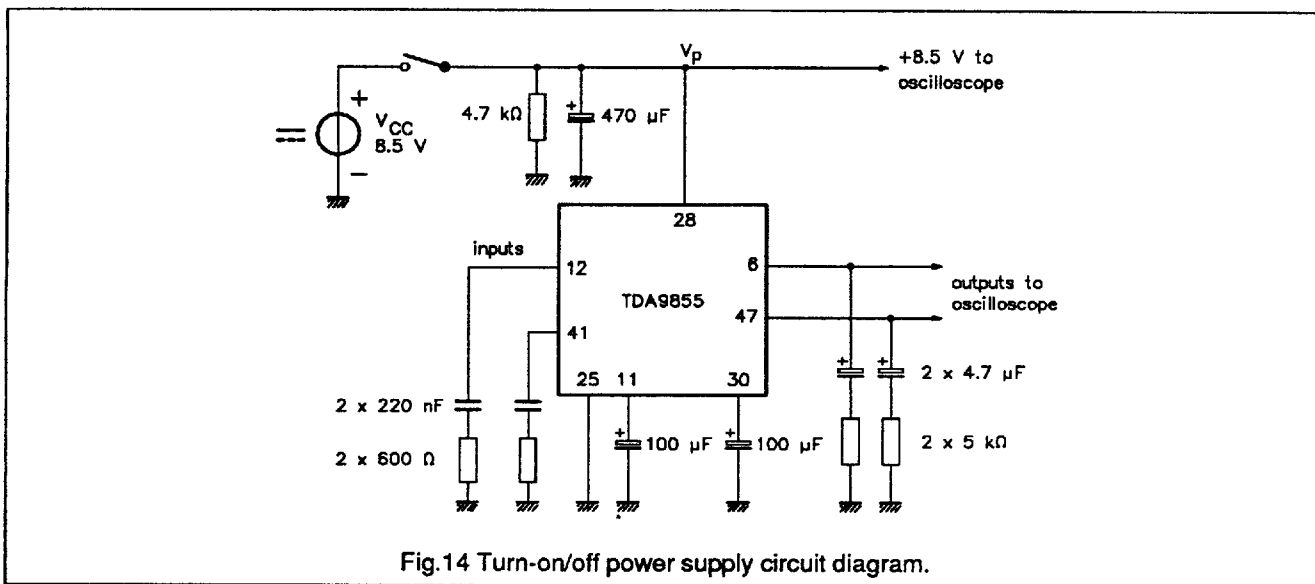


Fig.13 Loudness circuit with bass and treble boost.

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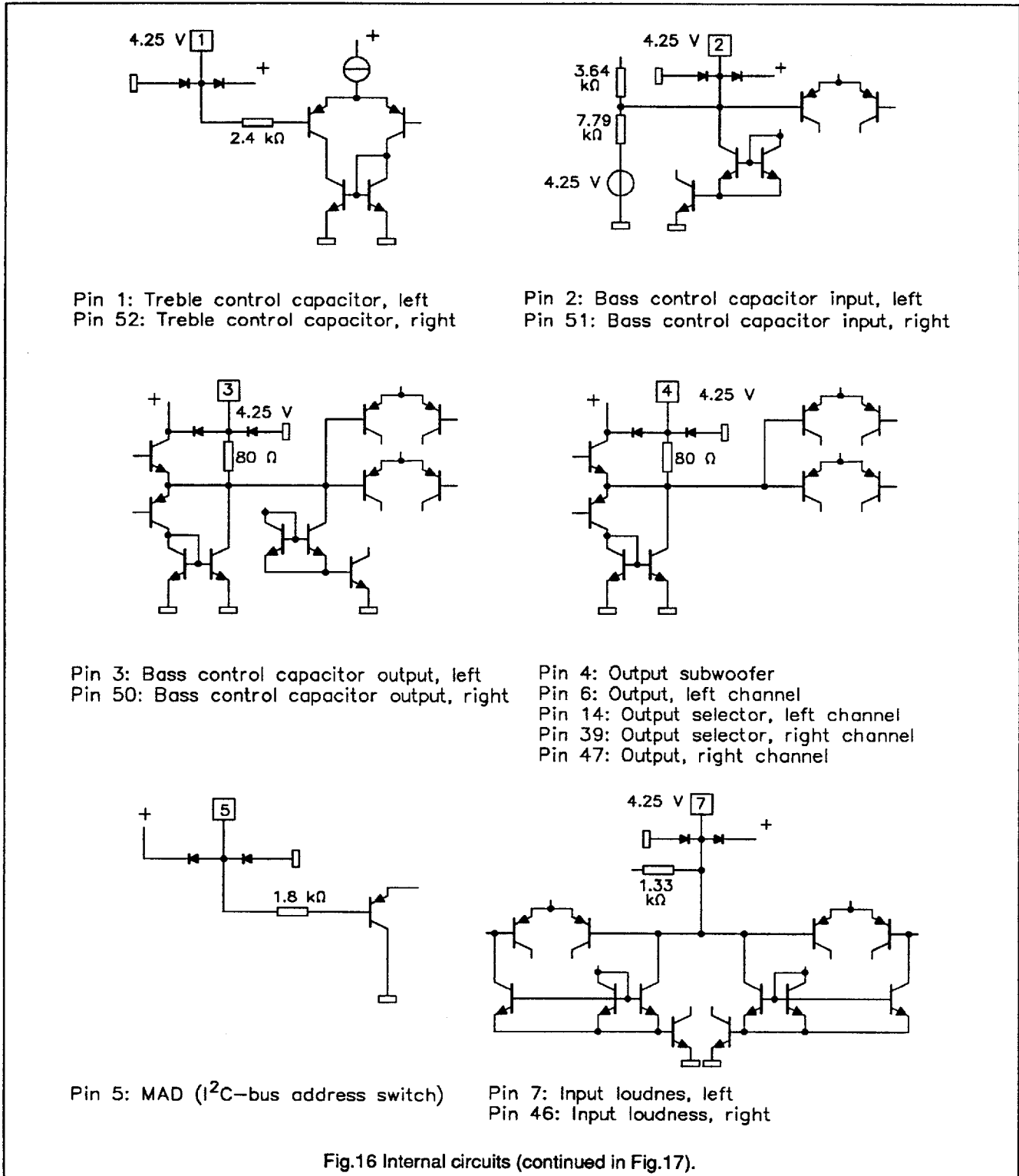
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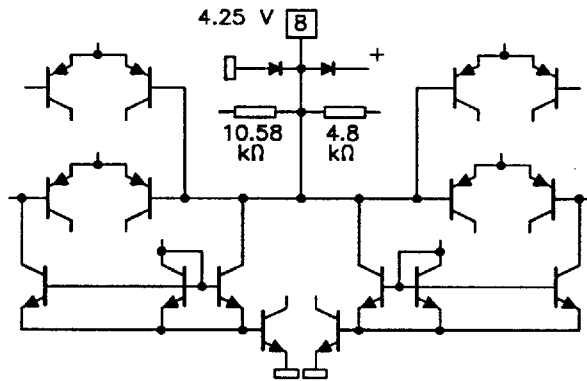
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INTERNAL PIN CONFIGURATIONS (pin numbers for SHRDIL-version)

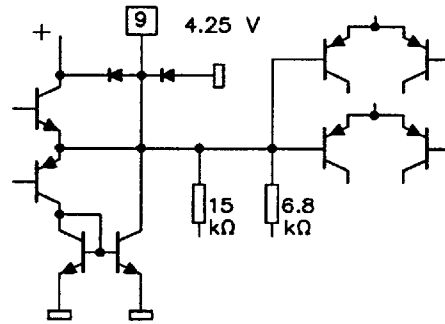


I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

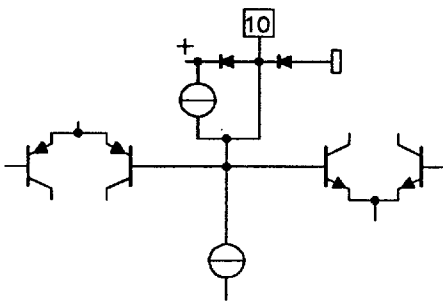
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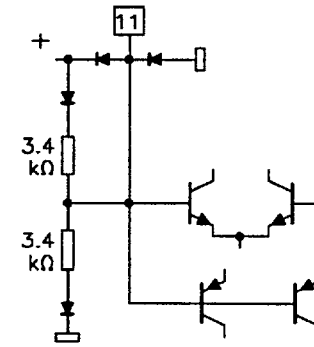
Pin 8: Input volume, left  
Pin 45: Input volume, right



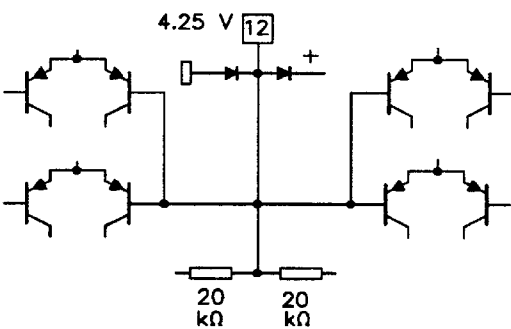
Pin 9: Output effects, left  
Pin 44: Output effects, right



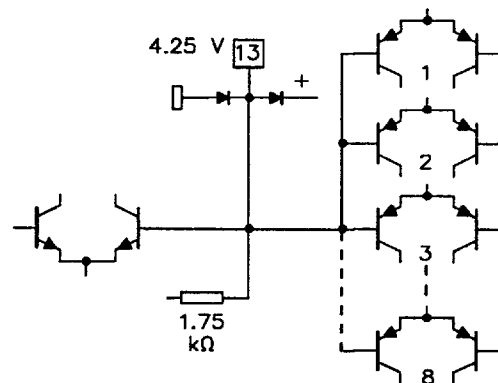
Pin 10: Automatic volume control capacitor



Pin 11: Reference voltage  
 $0.5 \times V_{CC}$



Pin 12: Line input, left  
Pin 41: Line input, right

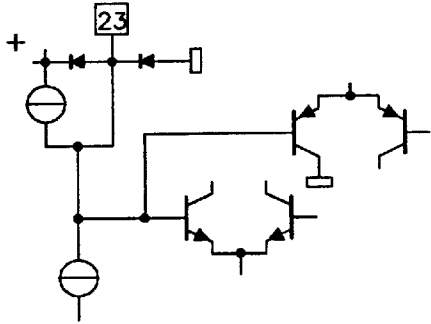


Pin 13: Input automatic volume control, left  
Pin 40: Input automatic volume control, right

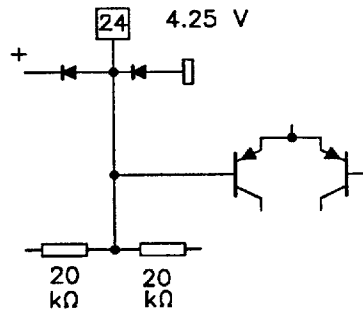
Fig.17 Internal circuits (continued from Fig.16).

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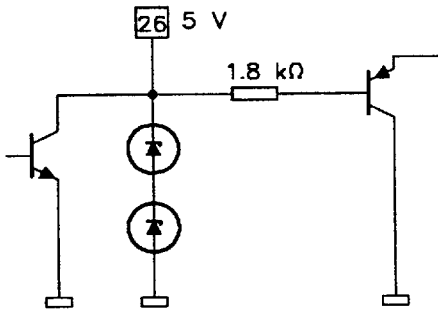
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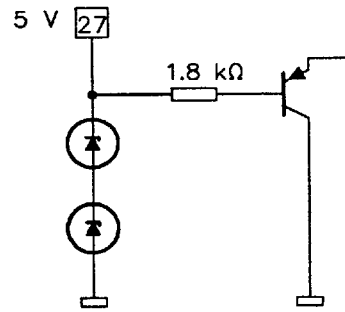
Pin 23: Capacitor mute for SAP



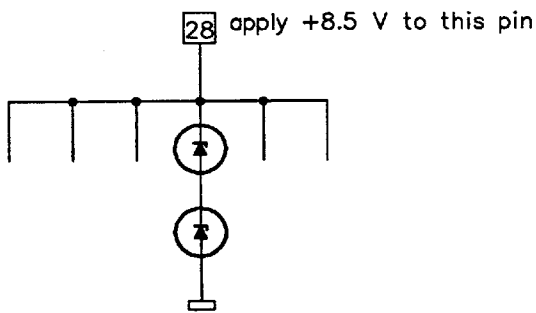
Pin 24: Capacitor DC decoupling for SAP



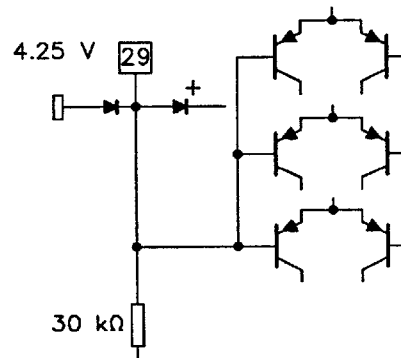
Pin 26: SDA (I<sup>2</sup>C-bus DATA input/output)



Pin 27: SCL (I<sup>2</sup>C-bus CLOCK)



Pin 28: Supply voltage

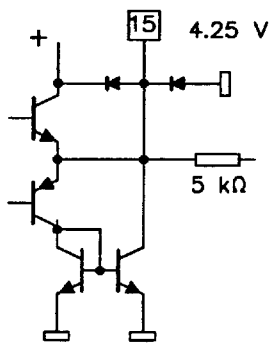


Pin 29: Input composite signal

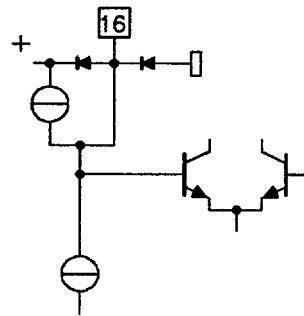
Fig.19 Internal circuits (continued from Fig.18).

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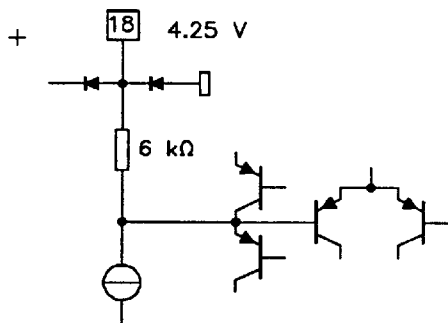
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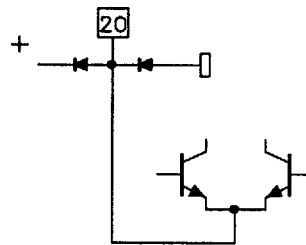
Pin 15: Line output, left  
Pin 38: Line output, right



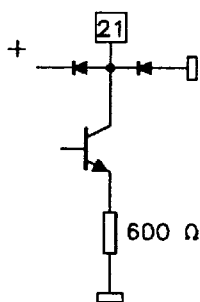
Pin 16: Timing capacitor wideband for DBX  
Pin 17: Timing capacitor spectral for DBX



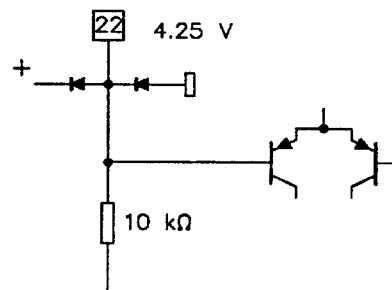
Pin 18: Capacitor wideband for DBX  
Pin 19: Capacitor spectral for DBX



Pin 20: Variable emphasis out for DBX



Pin 21: Variable emphasis in for DBX



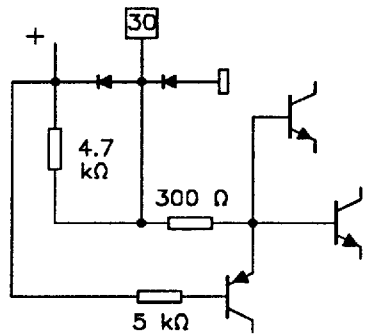
Pin 22: Capacitor noise reduction for DBX

Fig.18 Internal circuits (continued from Fig.17).

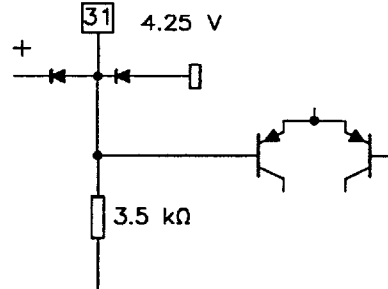


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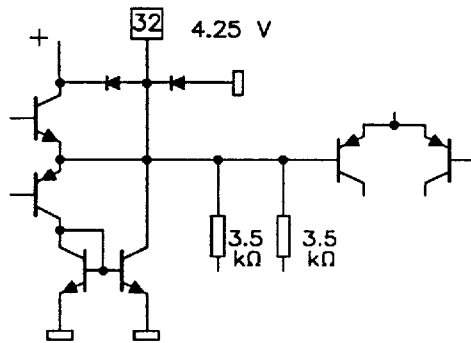
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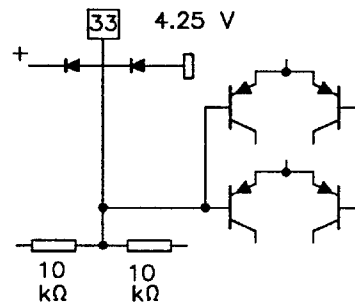
Pin 30: Smoothing capacitor for supply



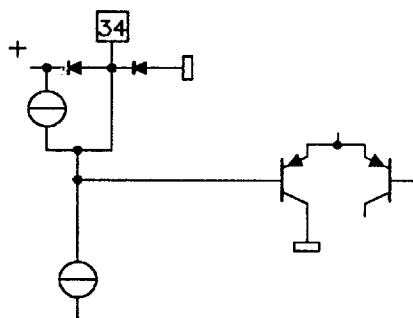
Pin 31: Capacitor for pilot detector



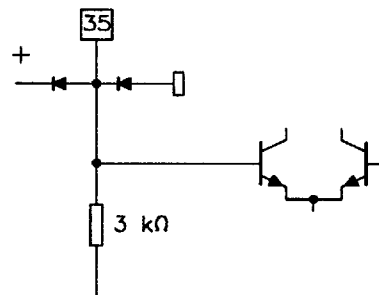
Pin 32: Capacitor for pilot detector



Pin 33: Capacitor for phase detector



Pin 34: Capacitor for filter adjust

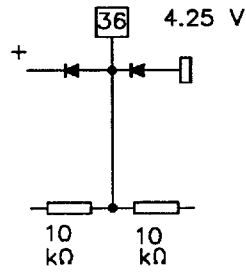


Pin 35: Ceramic resonator

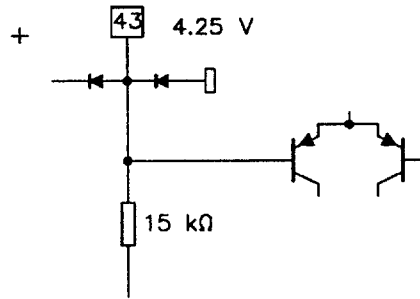
Fig.20 Internal circuits (continued from Fig.19).

I<sup>2</sup>C-bus controlled BTSC stereo / SAP decoder and audio processor

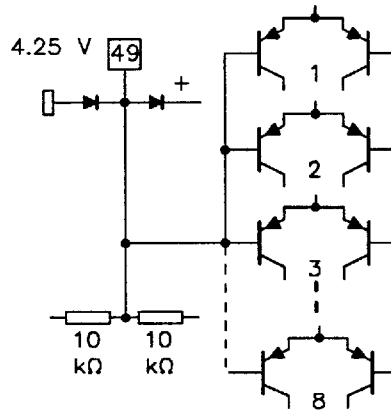
TDA9855



Pin 36: Capacitor DC decoupling mono  
 Pin 37: Capacitor DC decoupling stereo/SAP



Pin 43: Capacitor 1 pseudo function  
 Pin 42: Capacitor 2 pseudo function



Pin 49: Capacitor subwoofer

Fig.21 Internal circuits (continued from Fig.20).