Ordering number : EN4881A

CMOS LSI

LC75382E

Electronic Tone Controls for Car Stereo Systems

Overview

The LC75382E is an electronic tone control IC that can implement, with minimal external components, the complete range of tone and volume controls required in a car stereo, including volume, balance, fader, bass and treble, input switching and input level controls.

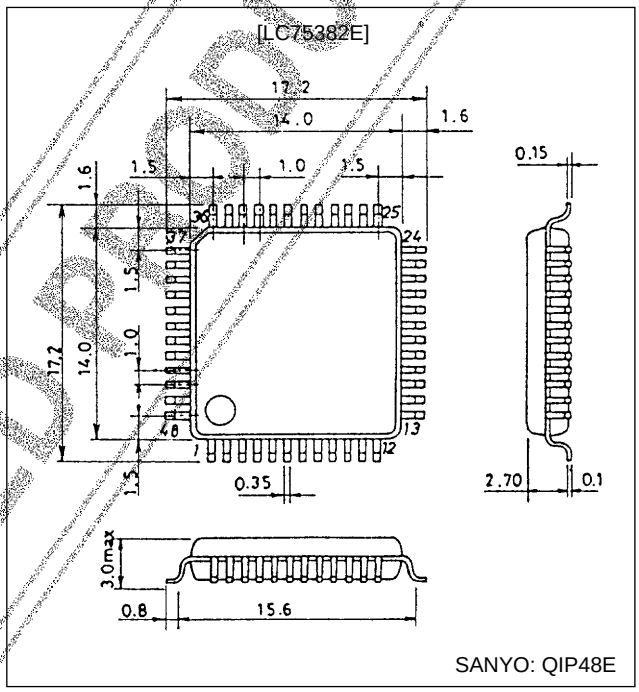
Features

- Volume: Controls the left and right volume levels independently from 0 dB to –78 dB (in 2 dB steps) and –∞ dB (41 settings). Since the left and right levels are independent this circuit also functions as a balance control.
- Fader: Attenuates either the rear or front outputs over 16 levels, from 0 dB to –20 dB in 2 dB steps, from –20 dB to –25 dB in 5 dB step, from –25 dB to –45 dB in 10 dB steps and then to –60 dB and –∞ dB.
- Bass/treble: Implements 21 position bass and treble controls with the addition of external capacitors.
- Input selector: Selects one of four inputs for both the left and right channels. The selected input signal can be amplified by between 0 dB and +18 dB in 6 dB steps.
- The provision of on-chip operational amplifiers means that few external components are required.
- Fabricated in a silicon gate process for minimal switching noise.
- All functions can be controlled by serial data over a CCB interface.

Package Dimensions

unit: mm

3156-QFP48E



- **CCB is a trademark of SANYO ELECTRIC CO., LTD.**
- **CCB is SANYO's original bus format and all the bus addresses are controlled by SANYO.**

Specifications

Absolute Maximum Ratings at Ta = 25°C, V_{SS} = 0 V

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{DD} max	V_{DD}	12	V
Maximum input voltage	V_{IN} max	CL, DI, CE, LTIN, RTIN, L10dBIN, R10dBIN, L2dBIN, R2dBIN, LFIN, RFIN, L1 to L4, R1 to R4	V_{SS} – 0.3 to V_{DD} + 0.3	V
Allowable power dissipation	Pd max	Ta ≤ 85°C	310	mW
Operating temperature	Topr		–40 to +85	°C
Storage temperature	Tstg		–50 to +125	°C

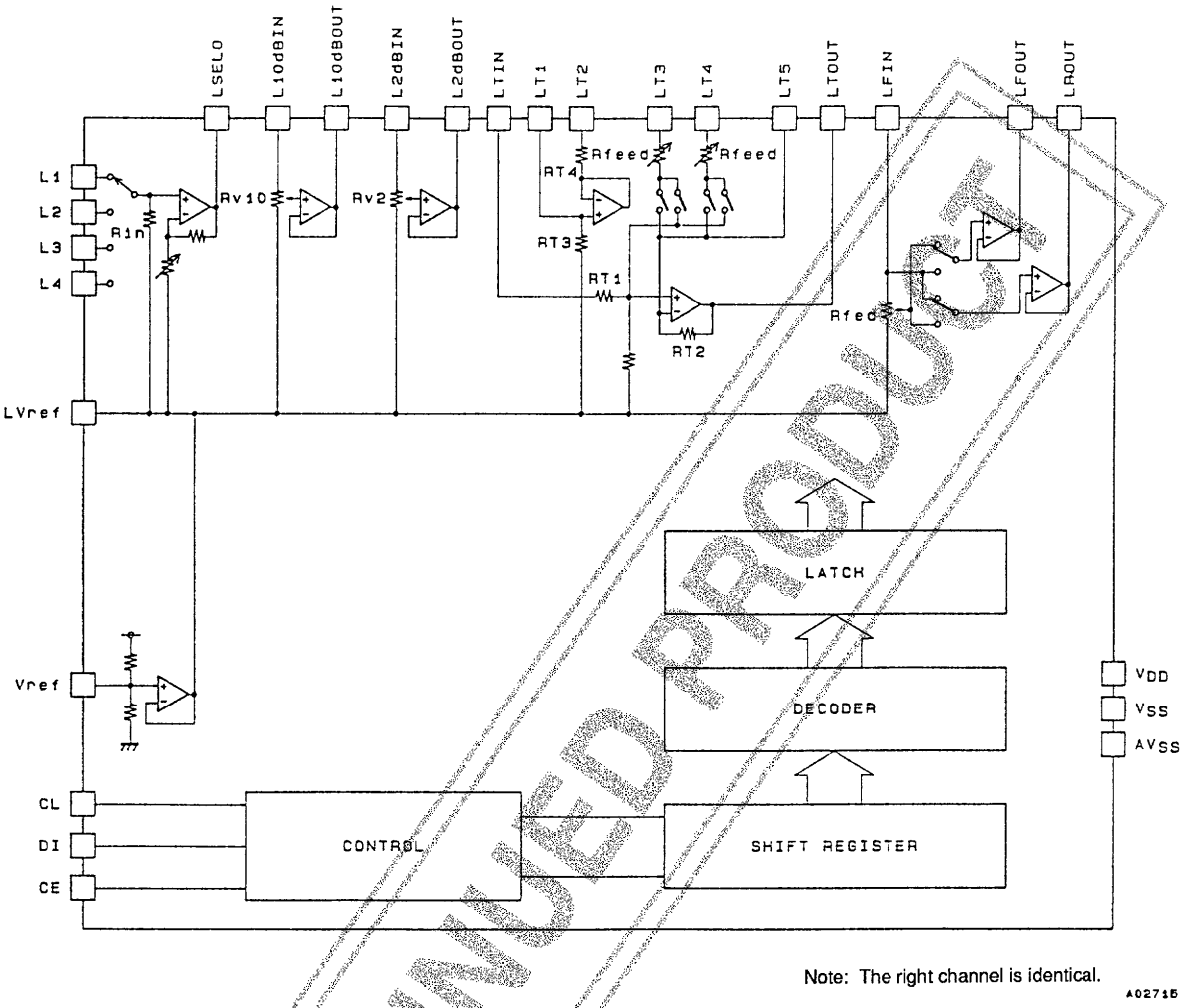
Allowable Operating Ranges at Ta = 25°C, V_{SS} = 0 V

Parameter	Symbol	Conditions	min	typ	max	Unit
Supply voltage	V_{DD}	V_{DD}	6.0		11.0	V
Input high level voltage	V_{IH}	CL, DI, CE	4.0		V_{DD}	V
Input low level voltage	V_{IL}	CL, DI, CE	V_{SS}		1.0	V
Input voltage amplitude	V_{IN}	LTIN, RTIN, L10dBIN, R10dBIN, L2dBIN, R2dBIN, LFIN, RFIN, L1 to L4, R1 to R4	V_{SS}		V_{DD}	Vp-p
Input pulse width	$t_{øW}$	CL	1			µs
Setup time	t_{setup}	CL, DI, CE	1			µs
Hold time	t_{hold}	CL, DI, CE	1			µs
Operating frequency	fopg	CL			500	kHz

Electrical Characteristics at Ta = 25°C, V_{DD} = 9 V, V_{SS} = 0 V

Parameter	Symbol	Conditions	min	typ	max	Unit
[Input Block]						
Input resistance	Rin	L1 to L4, R1 to R4		1		MΩ
Clipping level	Vcl	LSELO, RSELO: THD = 1.0%		2.35		Vrms
Output load resistance	R_L	LSELO, RSELO	10			kΩ
Minimum input gain	Gin min		–2	0	+2	dB
Maximum input gain	Gin max		+16.0	+18.0	+20.0	dB
Step resolution	Gstep			+6.0		dB
[Volume Block]						
Input resistance	Rv10	L10dBIN, R10dBIN: 10 dB steps	21	35	49	kΩ
	Rv2	L2dBIN, R2dBIN: 2 dB steps	6	10	14	kΩ
Step resolution	ATstep			2		dB
Step error	ATerr	step = 0 to –40 dB	–2	0	+2	dB
[Fader Volume Block]						
Input resistance	Rfed	LFIN, RFIN	12	20	28	kΩ
Step resolution	ATstep	step = 0 to –20 dB		2		dB
		step = –20 to –25 dB		5		dB
		step = –25 to –45 dB		10		dB
Step error	ATerr	step = 0 to –40 dB, step = –40 to –60 dB	–2	0	+2	dB
Output load resistance	R_L	LFOUT, LROUT, RFOUT, RROUT	10			kΩ
[Bass/Treble Control Block]						
Control range	Gbass, Gtre	Max. Boost/Cut	±15	±17	±19	dB
Step resolution	Bstep		0.7	1.7	2.7	dB
Internal feedback resistance	Rfeed		46	76	107	kΩ
[Overall Characteristics]						
Total harmonic distortion	THD (1)	V_{IN} = 300 mVrms, f = 1 kHz, all controls flat overall		0.005	0.01	%
	THD (2)	V_{IN} = 300 mVrms, f = 20 kHz, all controls flat overall		0.008	0.02	%
Crosstalk	CT	V_{IN} = 1 Vrms, f = 1 kHz, all controls flat overall, Rg = 1 kΩ	60	84.5		dB
Output at maximum attenuation	V_O min	V_{IN} = 1 Vrms, f = 1 kHz, Main volume at –∞	–65	–74.5		dB
Output noise voltage	V_N (1)	All controls flat overall (IHF-A), Rg = 1 kΩ		5.2	12	µV
	V_N (2)	All controls flat overall (DIN-AUDIO), Rg = 1 kΩ		7.2	16	µV
	V_N (3)	All controls flat overall (NO-FILTER), Rg = 1 kΩ		9.2	20	µV
	V_N (4)	Gv = +18dB (IHF-A), Rg = 1 kΩ		23	50	µV
	V_N (5)	Bass at maximum boost, treble at maximum boost (IHF-A), Rg = 1 kΩ		48	120	µV
Current drain	I_{DD}	V_{DD} – V_{SS} = 11 V		28	33	mA
Input high level current	I_{IH}	CL, DI, CE: V_{IN} = 9 V			10	µA
Input low level current	I_{IL}	CL, DI, CE: V_{IN} = 0 V	–10			µA

Equivalent Circuit Block Diagram



Note: The right channel is identical.

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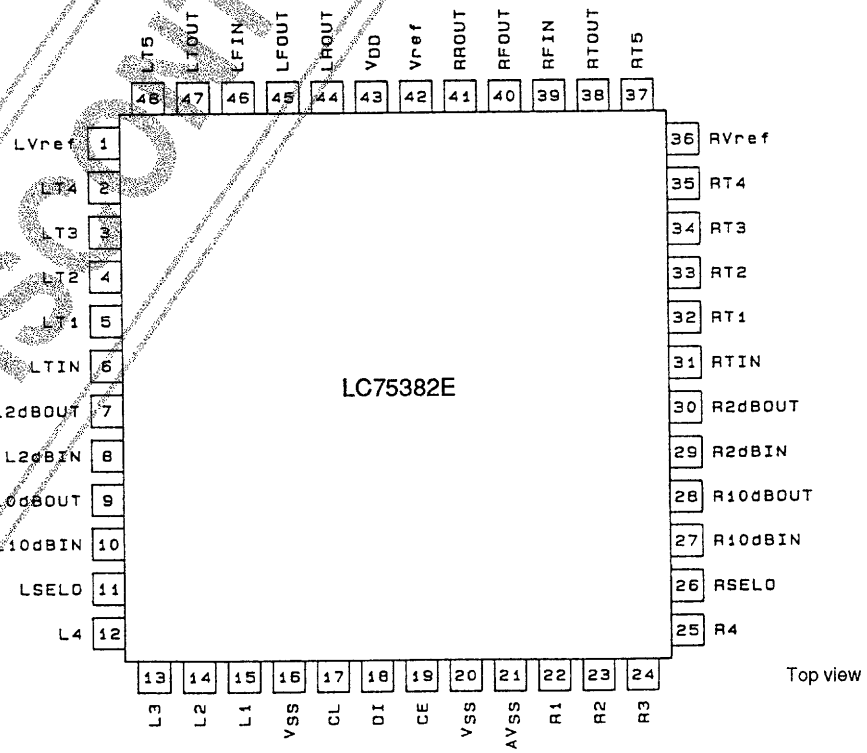
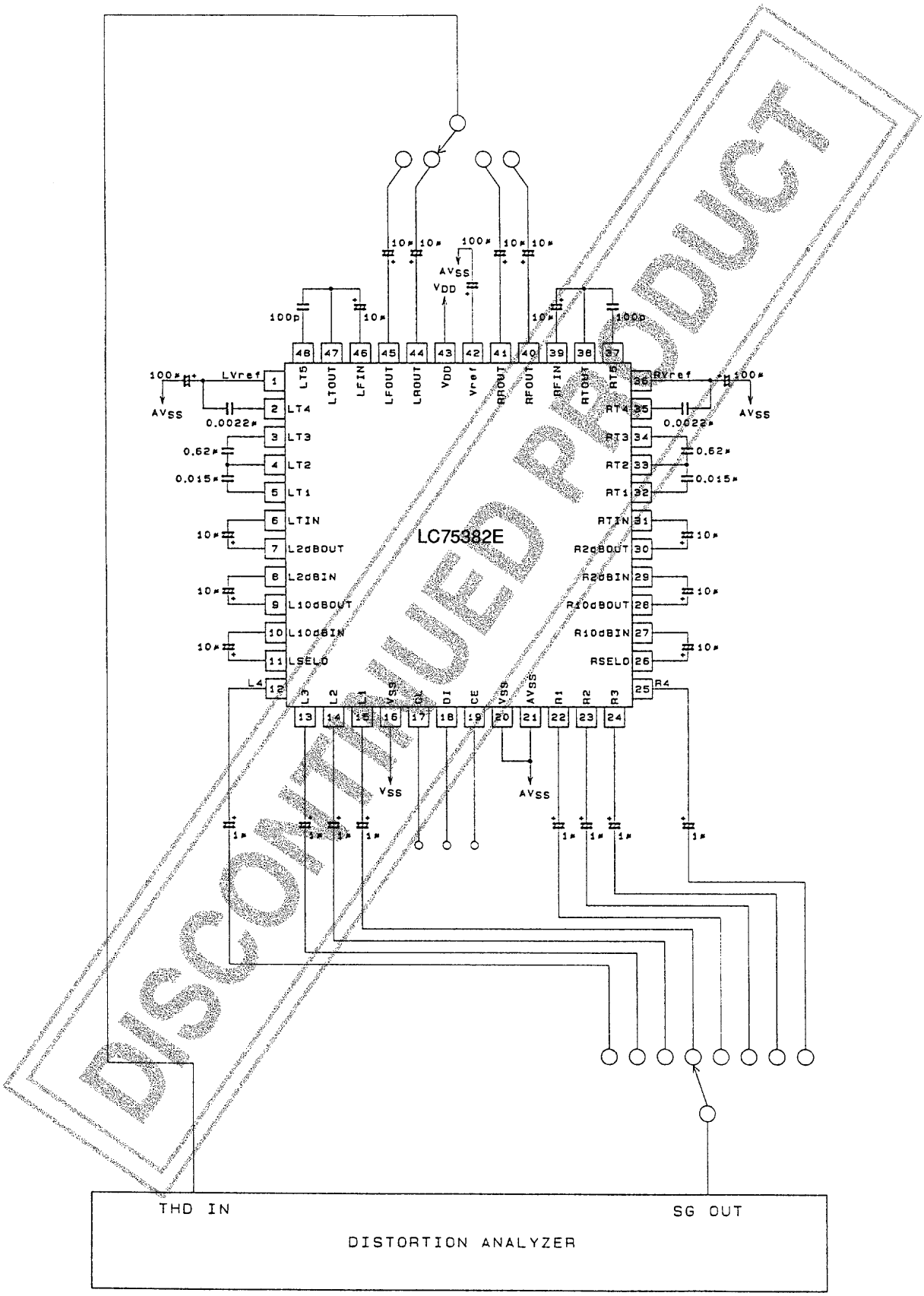
Pin Assignment



Top view

Electrical Characteristics Test Circuit

1. Total harmonic distortion



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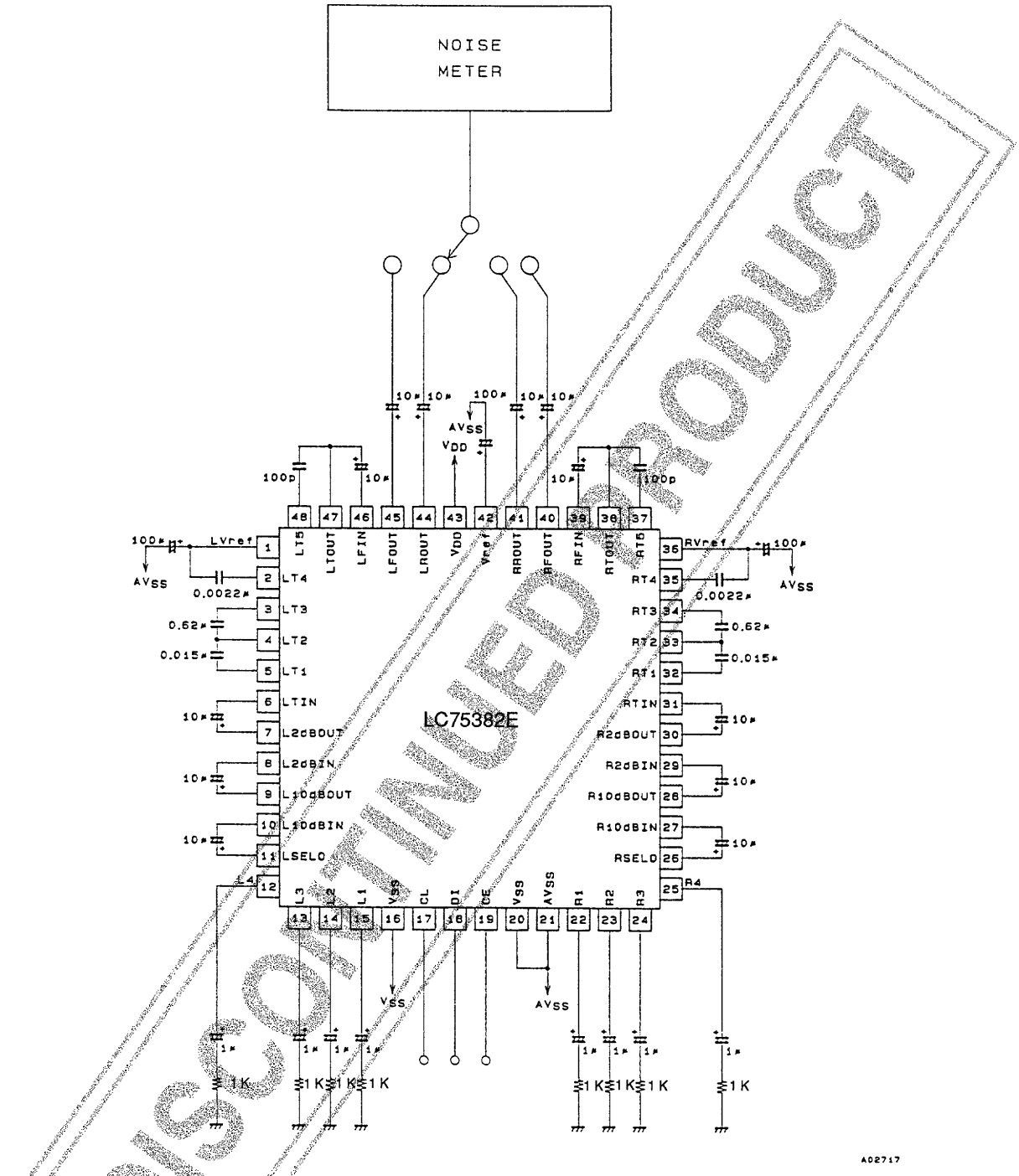
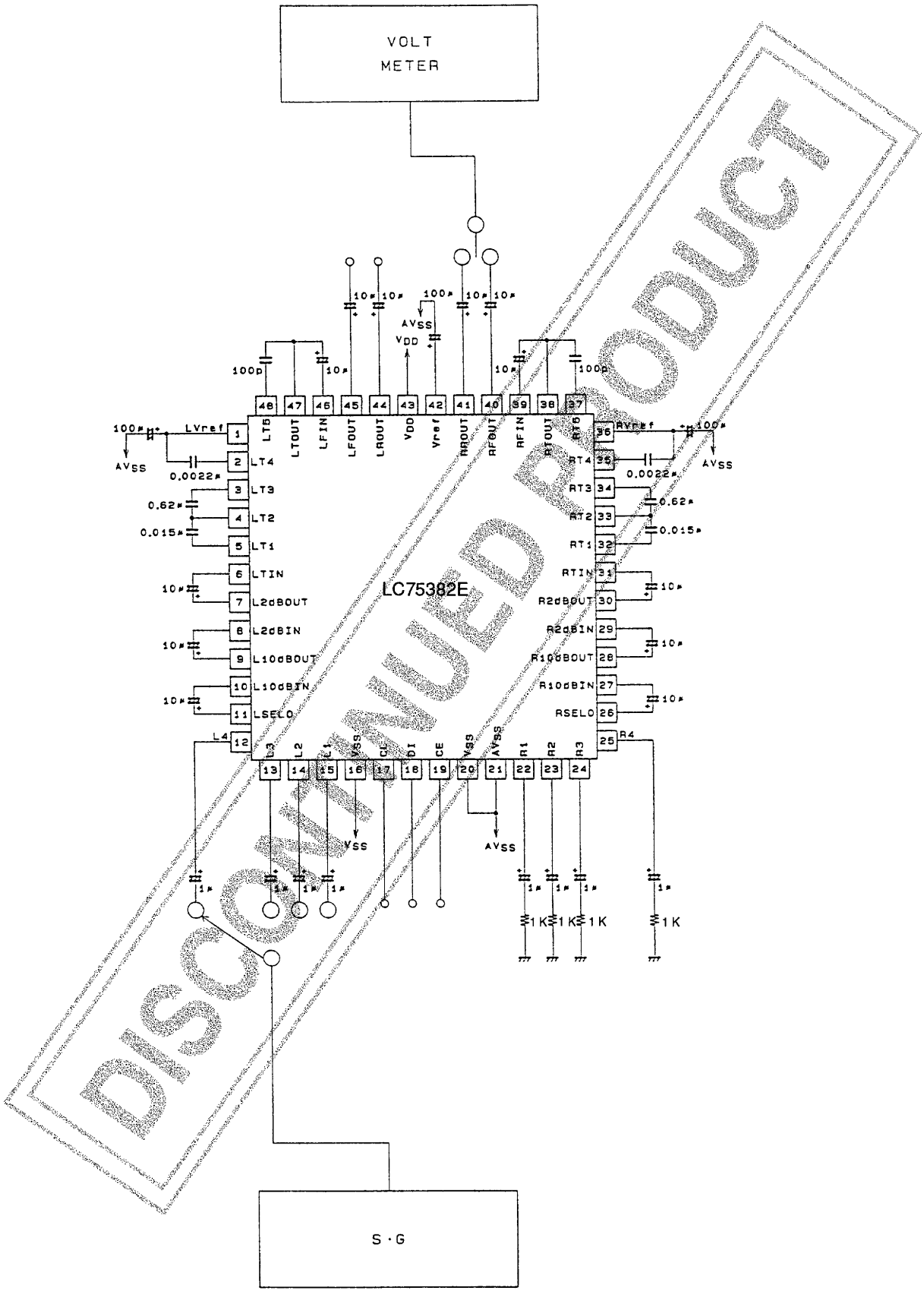
Unit (capacitance: F)

2. Output noise voltage



Unit (resistance: Ω, capacitance: F)

3. Crosstalk



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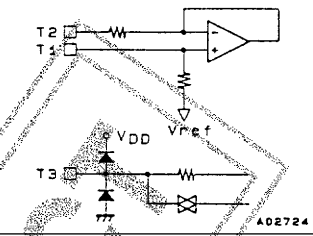
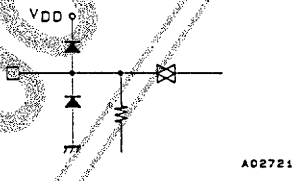
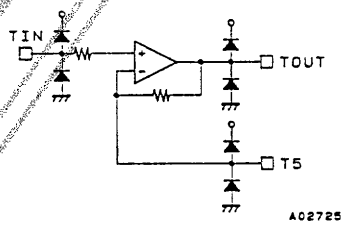
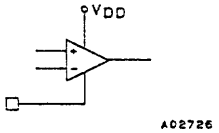
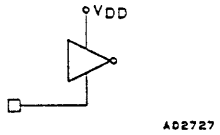
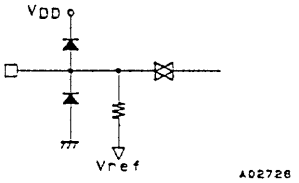
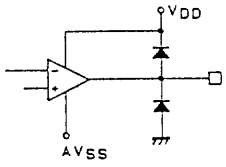
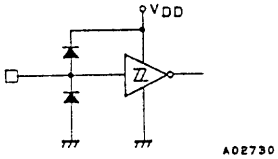
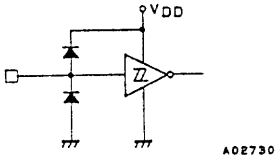
Unit (resistance: Ω, capacitance: F)

Pin Functions

Pin No.	Symbol	Function	Note
44 45 41 40	LROUT LFOUT RROUT RFOUT	Fader block output. Attenuates only the front or rear outputs. The left/right attenuation is identical. These are op amp outputs and thus are low impedance.	
46 39	LFIN RFIN	Fader block input Must be driven by low impedance outputs.	
1 36	LVref RVref	Common pins for the main volume, fader, tone and gain control blocks.	
42	Vref	V_{DD}/2 voltage generation block. Connect a capacitor (about 100 pF) between Vref and AV_{SS} to suppress power supply ripple.	
7 30	L2dBOUT R2dBOUT	Main volume 2 dB step attenuator outputs	
8 29	L2dBIN R2dBIN	Main volume 2 dB step attenuator inputs Must be driven by low impedance outputs	
9 28	L10dBOUT R10dBOUT	Main volume 10 dB step attenuator outputs	
10 27	L10dBIN R10dBIN	Main volume 10 dB step attenuator inputs Must be driven by low impedance outputs.	
47 38	LTOUT RTOUT	Tone control outputs	

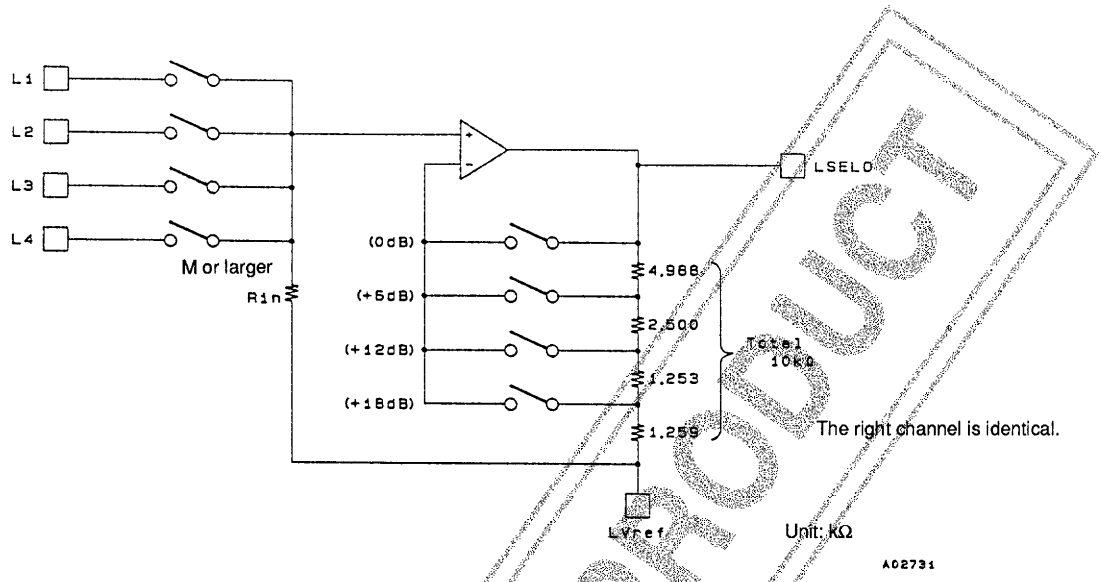
Continued on next page.

Continued from preceding page.

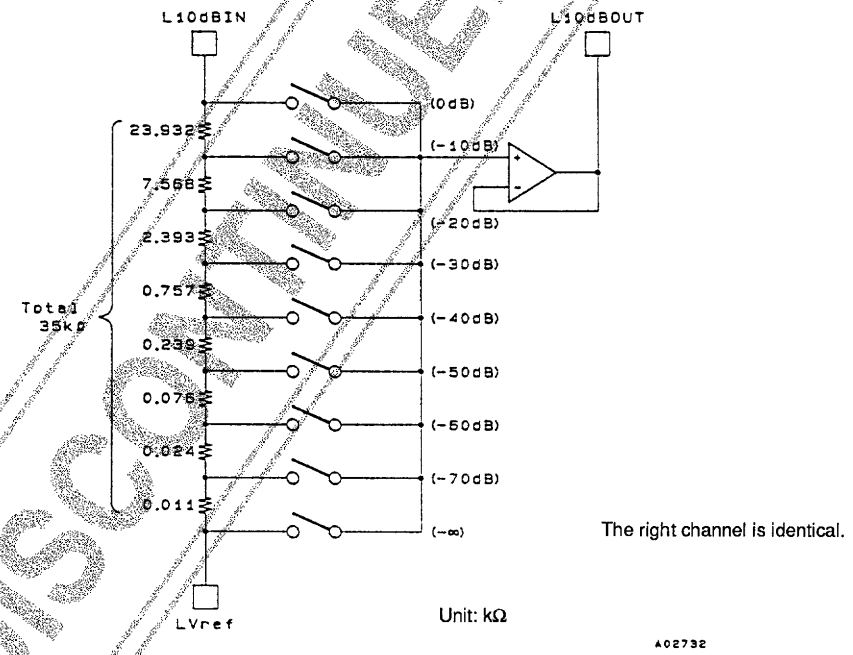
Pin No.	Symbol	Function	Note
5 4 3 32 33 34	LT1 LT2 LT3 RT1 RT2 RT3	Tone circuit low band filter capacitor connections. Connect capacitors between the T1 and T2 pairs and between the T2 and T3 pairs.	
2 35	LT4 RT4	Tone circuit high band filter capacitor connections. Connect high band compensating capacitors between the T4 pins and Vref.	
48 37	LT5 RT5	Tone circuit filter op amp inverting inputs Out of band signals can be excluded by connecting capacitors with appropriate values between the T5 and TOUT pairs.	
6 31	LTIN RTIN	Tone control circuit inputs Must be driven by low impedance outputs.	
43	V_{DD}	Power supply	
21	A. V_{SS}	Internal op amp ground	
16, 20	V_{SS}	Internal logic system ground	
15 14 13 12 22 23 24 25	L1 L2 L3 L4 R1 R2 R3 R4	Audio signal inputs	
11 26	LSELO RSELO	Input selector outputs	
19	CE	Chip enable. Data is written to the internal latch on the high to low transition of this signal. The analog switches operate at that point. Data transfer is enabled when this signal is high.	
18 17	DI CL	Serial data and clock connections for IC control.	

Internal Equivalent Circuit Details

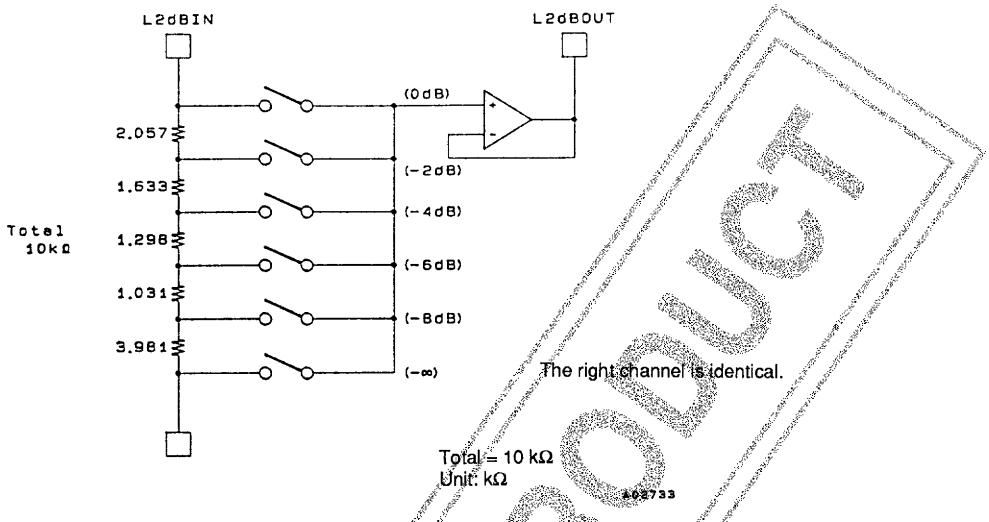
Input Block Equivalent Circuit



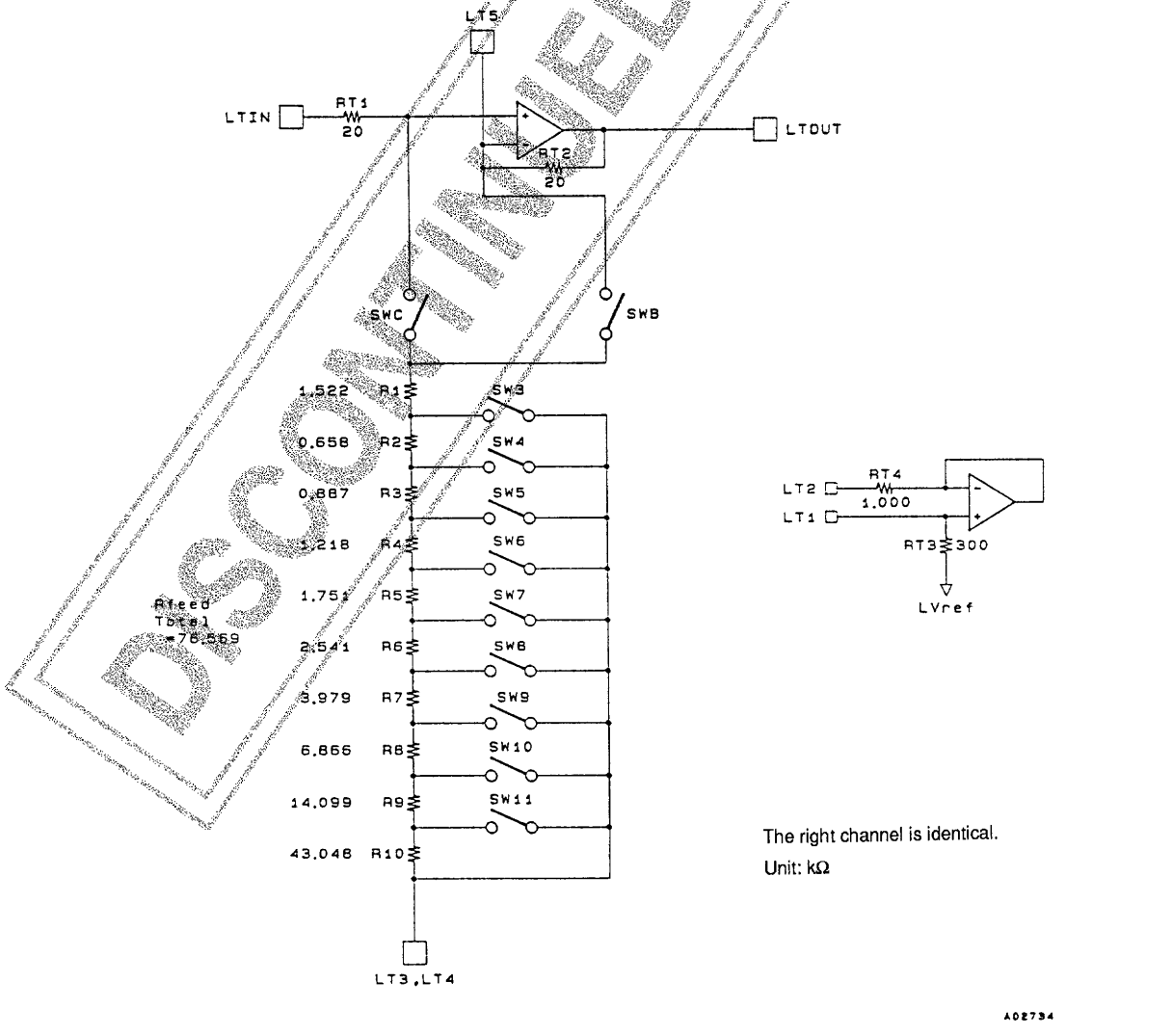
10 dB Step Volume Equivalent Circuit



2 dB Step Equivalent Circuit



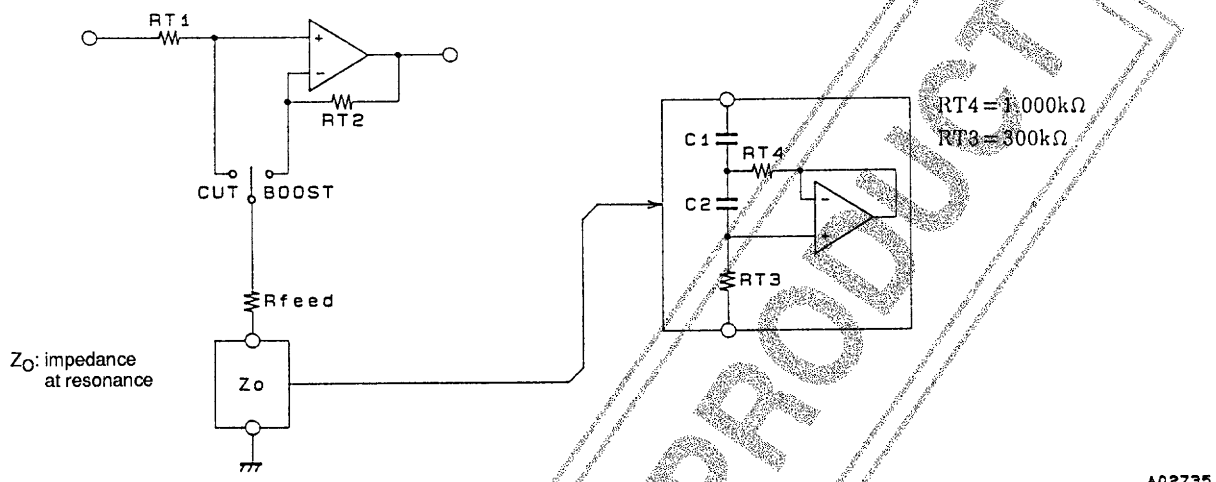
Tone Block Equivalent Circuit



Tone Control Circuit External Capacitor Value Calculation Example

The external capacitors used with the LC75382E are structural components of semiconductor inductors (simulated inductors). This section presents the equivalent circuits and formulas for acquiring the desired center frequencies.

1. Semiconductor inductor equivalent circuit



2. Sample calculation

   Specifications: 1. Center frequency F_O = 100 Hz
   2. Q at maximum boost: Q_{max} = 1.05

   ① Derive the sharpness of the semiconductor inductor itself, Q_O.

   $$Q_O = \frac{(RT4 + Rfeed)}{RT4} \times Q_{max} \doteqdot 2.6481$$

   ② Derive C1.

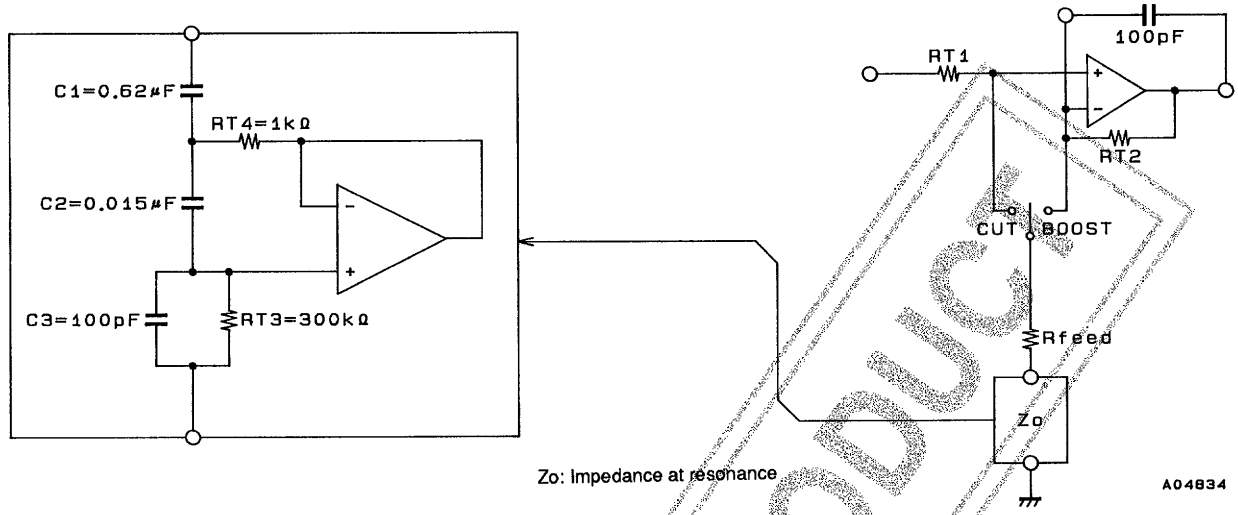
   $C1 = 1/2\pi F_O RT4 Q_O \doteqdot 0.60$ (μF)

   ③ Derive C2.

   $C2 = Q_O/2\pi F_O RT3 \doteqdot 0.014$ (μF)

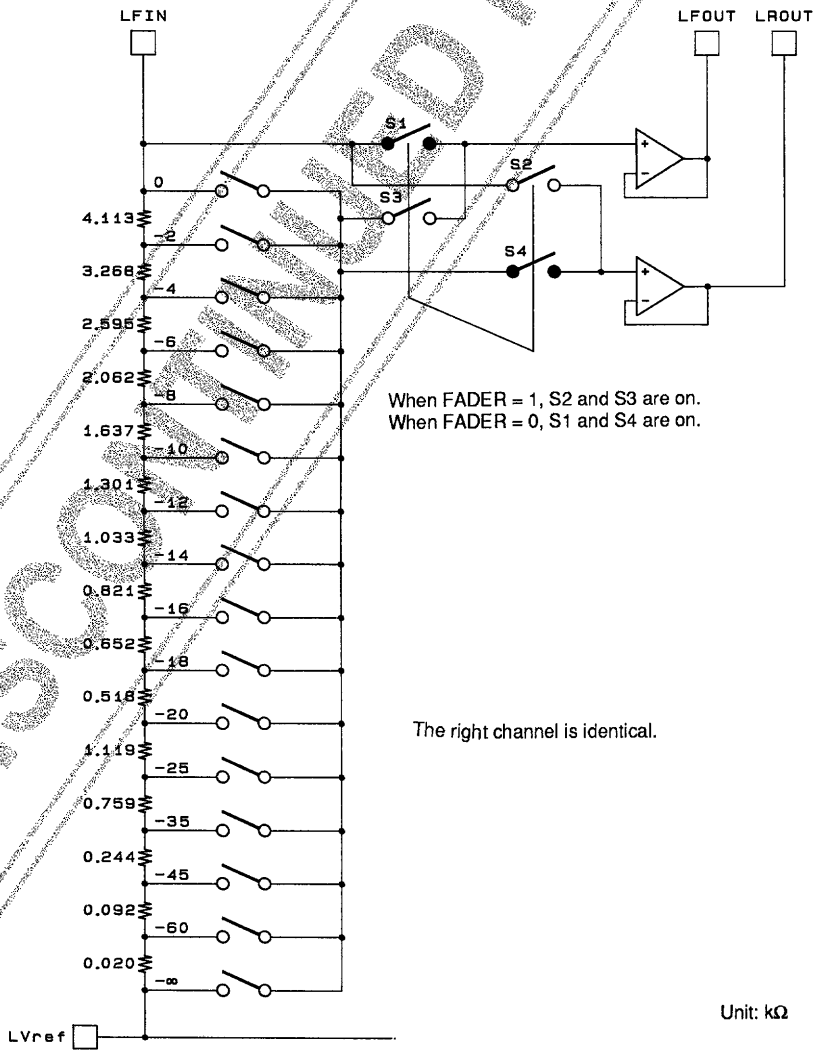
   Note: See the tone block equivalent circuit diagram (page 10) for the internal resistance.

Technique for Reducing Noise in the Tone Circuit Output



The output noise can be improved by about 6 dB by providing an external impedance at resonance of Zo and adding the capacitor C3 with a value of about 100 pF. An even larger noise reduction effect can be acquired by using a low noise operational amplifier in the external circuit.

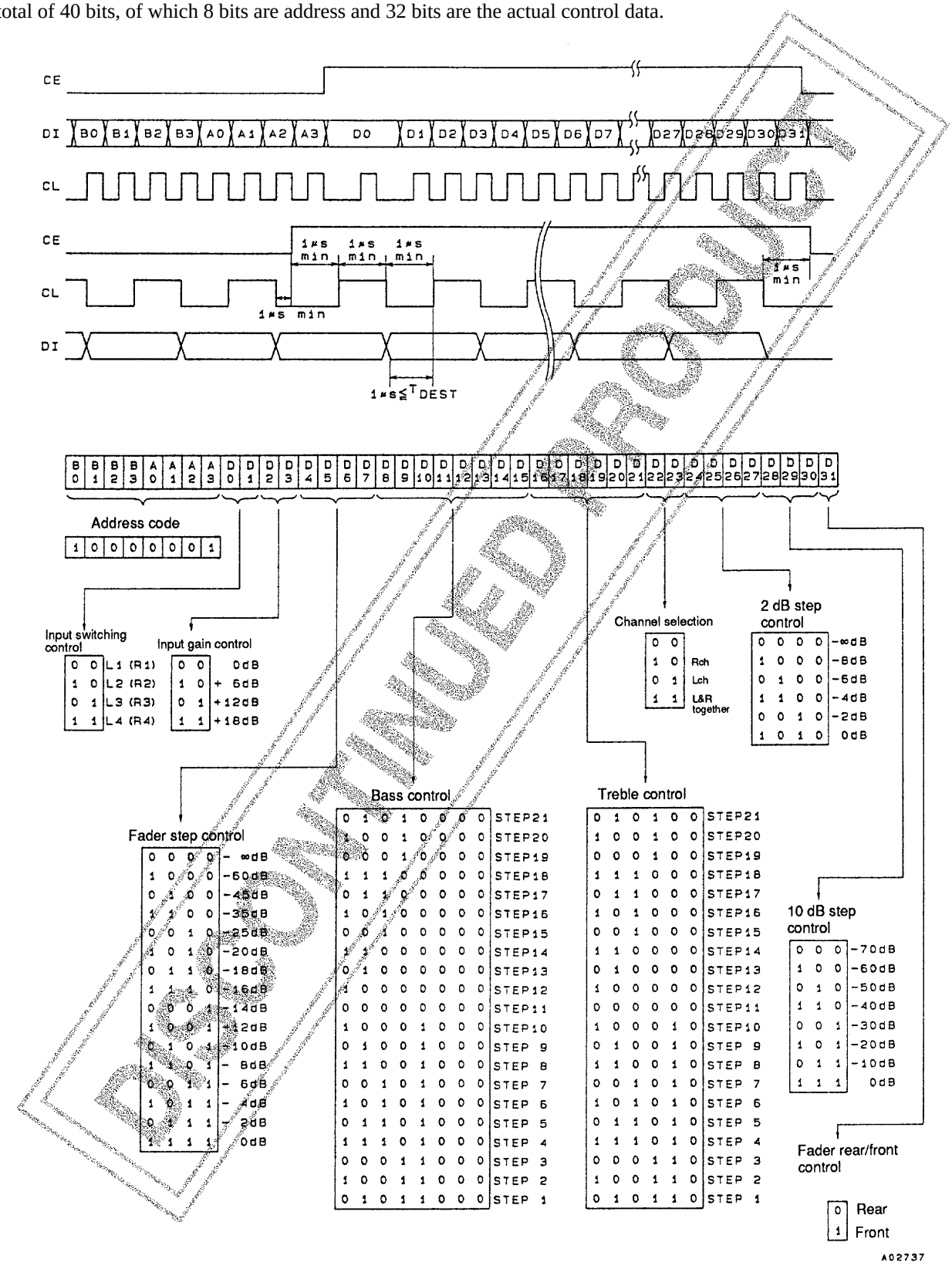
Fader Block Equivalent Circuit



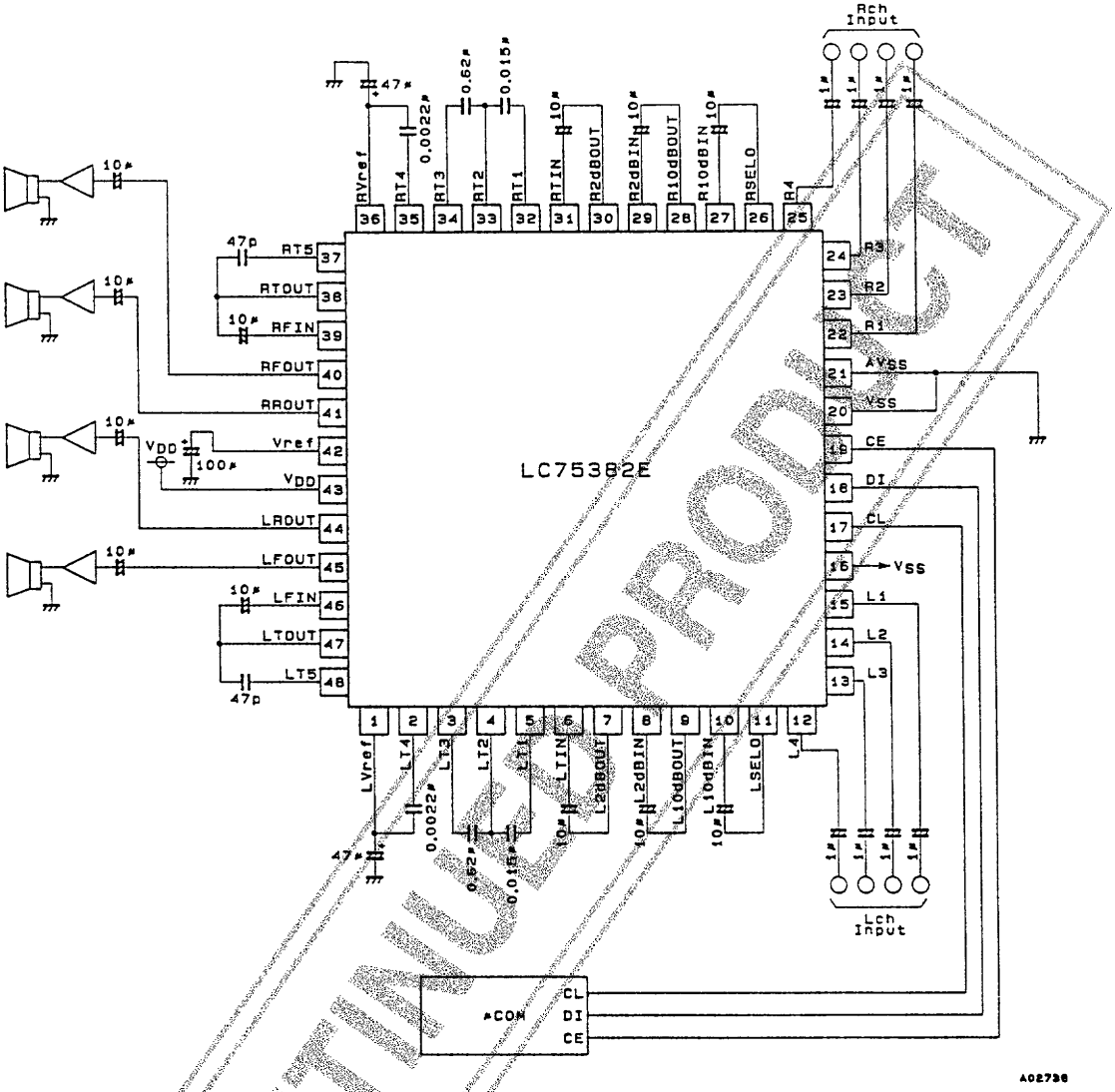
When data specifying a –∞ attenuation in the 2 dB step main volume is issued, S1 and S2 will open and at the same time, S3 and S4 will turn on.

Control System Timing and Data Format

The prescribed data (signals) must be applied to the CE, CL and DI pins to control the LC75382. The data consists of a total of 40 bits, of which 8 bits are address and 32 bits are the actual control data.



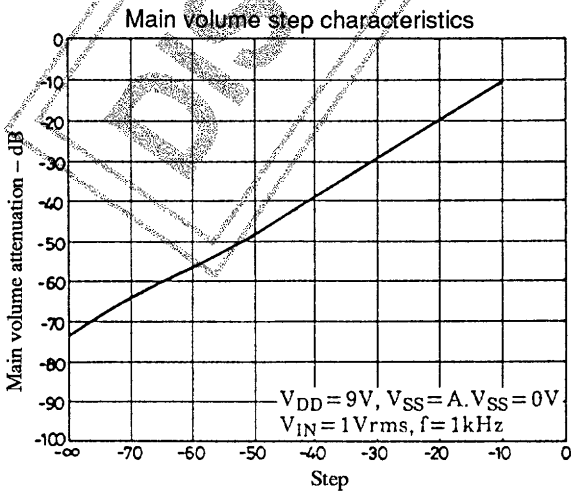
Sample Application Circuit

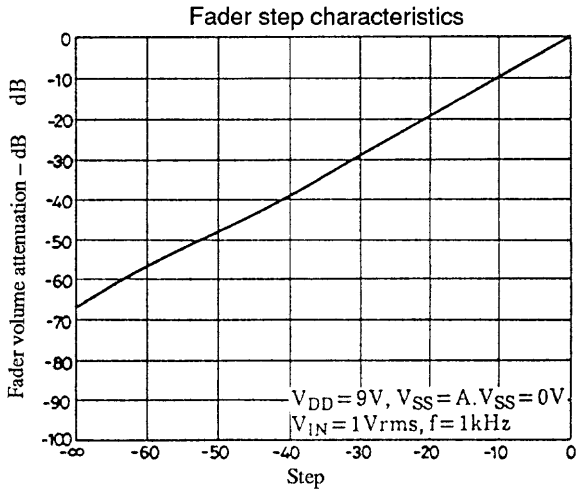


Usage Notes

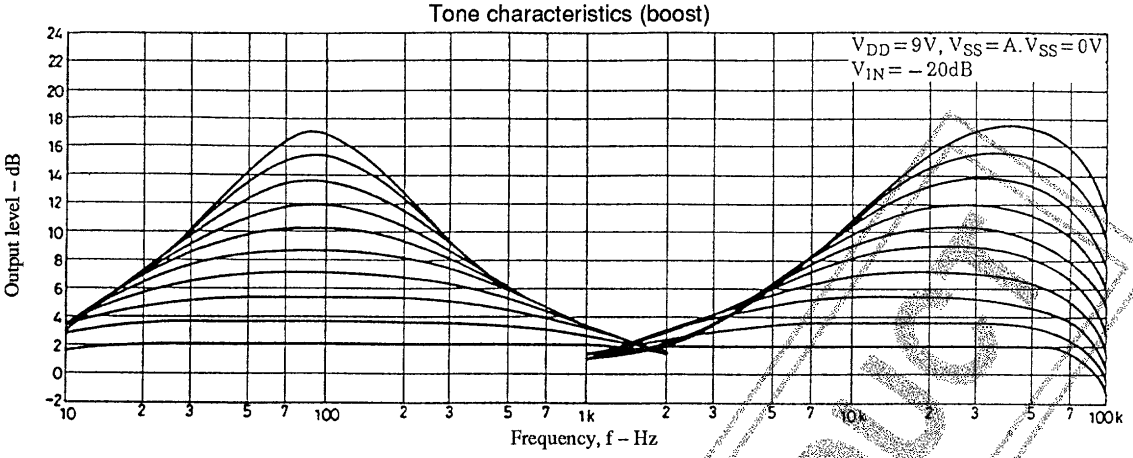
1. The states of the internal analog switches are undefined when power is first applied.
   Muting should be applied externally until data has been transferred.

2. To prevent the high frequency digital signals on the CL, DI and CE pin lines from entering the analog signal system, those lines must be guarded by the ground pattern. Alternatively, shielded cable can be used for those lines.

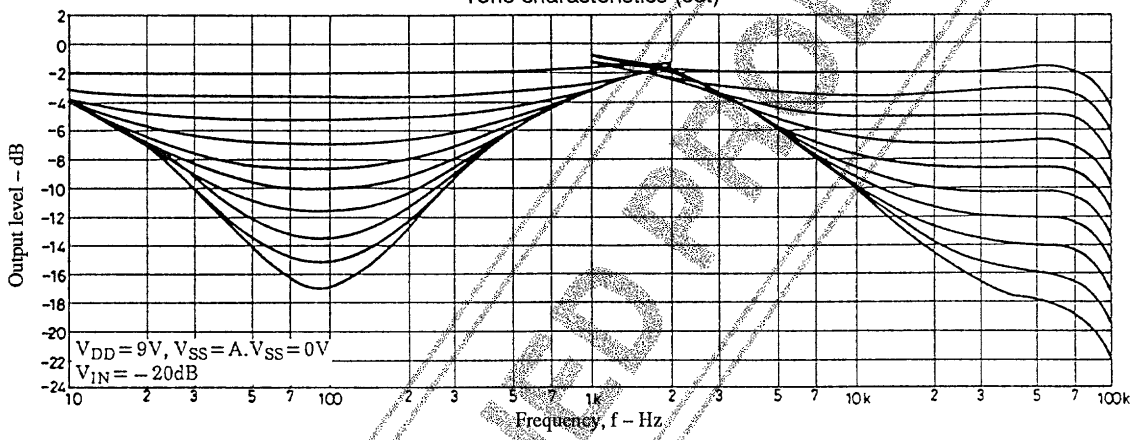




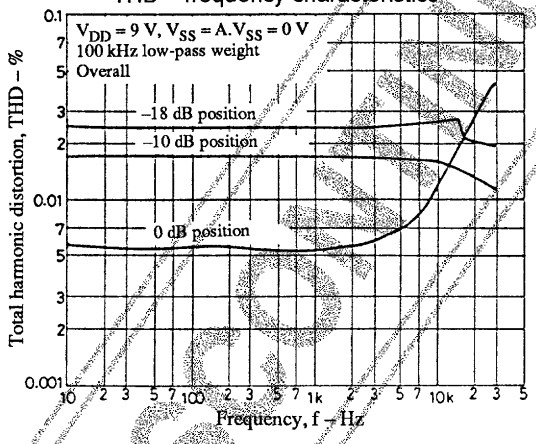
Tone characteristics (boost)



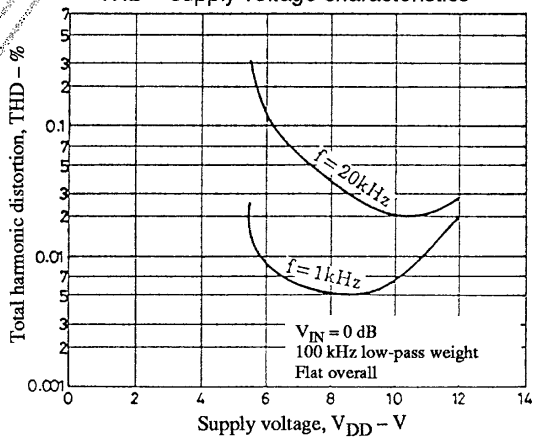
Tone characteristics (cut)



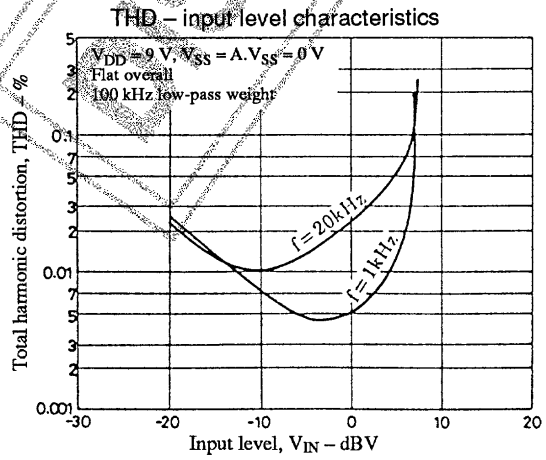
THD – frequency characteristics



THD – supply voltage characteristics



THD – input level characteristics



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