Ordering number : EN5002A

CMOS LSI

LC75383E

Electronic Volume Control for Car Audio Systems

Overview

The LC75383E is an electronic volume control that provides volume, balance, fader, bass/treble, input switching and input level controls. The LC75383E supports all these functions while requiring a minimum number of external components.

Features

- Volume: 0 dB to –79 dB (in 1 dB steps) and –∞; 81 positions.
  A balance function can be implemented using the LC75383E independent left and right volume control functions.
- Fader: The rear channels or the front channels can be attenuated over 16 positions: from 0 dB to –20 dB in 2 dB steps, from –20 dB to –25 dB in one 5 dB step, from –25 dB to –45 dB in 10 dB steps, –60 dB, and –∞ for a total of 16 positions.
- Bass/treble: The LC75383E supports 21 position bass and treble controls using external capacitors.
- Input selector: The LC75383E can select one of four L/R inputs. The selected input signal can be amplified from 0 dB to +18 dB in 6 dB steps.
- Built-in operational amplifiers mean that few external components are required.
- Silicon gate process for minimal switching noise.
- All controls can be set from serial input data (CCB).

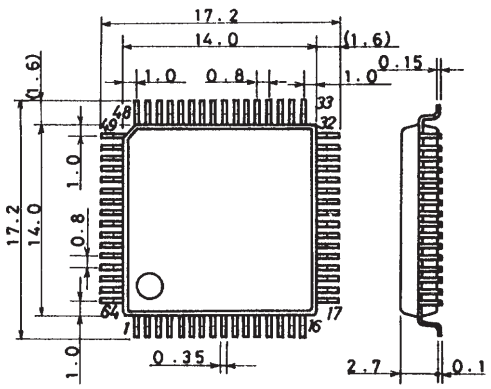
- **CCB is a trademark of SANYO ELECTRIC CO., LTD.**
- **CCB is SANYO's original bus format and all the bus addresses are controlled by SANYO.**

Package Dimensions

unit: mm

3159-QFP64E

[LC75383E]



SANYO: QIP64E

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, L1dBIN, R1dBIN, 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

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TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

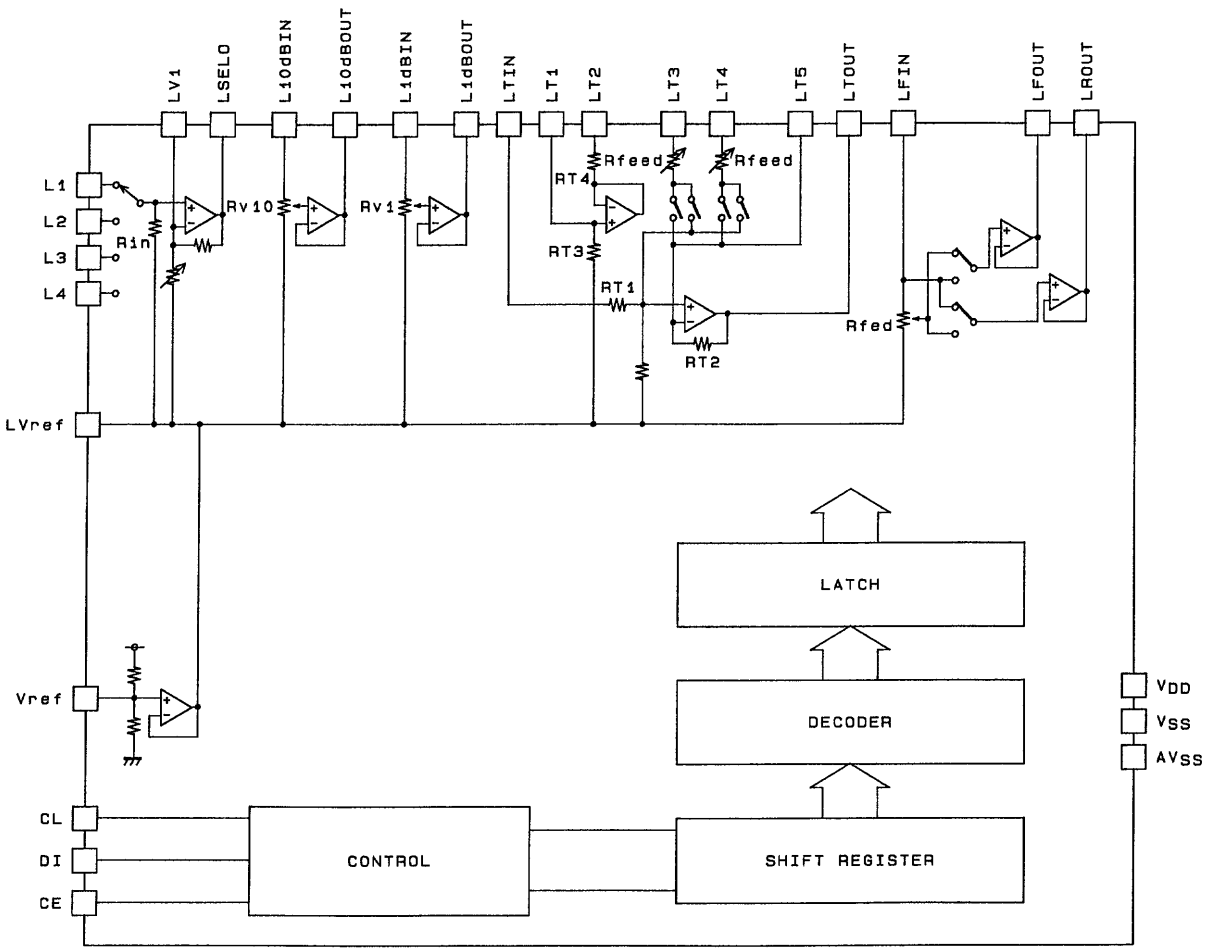
Allowable Operating Ranges at Ta = 25°C, V_{SS} = 0 V

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, L1dBIN, R1dBIN, 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, L2, L3, L4, R1, R2, R3, 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
	Rv1	L1dBIN, R1dBIN: 1 dB steps	6	10	14	kΩ
Step resolution	ATstep			1		dB
Step error	ATerr	Step = 0 to –40 dB, –40 to –60 dB	–1	0	+1	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, –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]						
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
Maximum attenuation	Vo min	V_{IN} = 1 Vrms, f = 1 kHz, main volume at –∞	–65	–80		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 = +18 dB (IHF-A), Rg = 1 kΩ		23	50	µV
	V_N (5)	Bass = max. boost, treble = max. 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

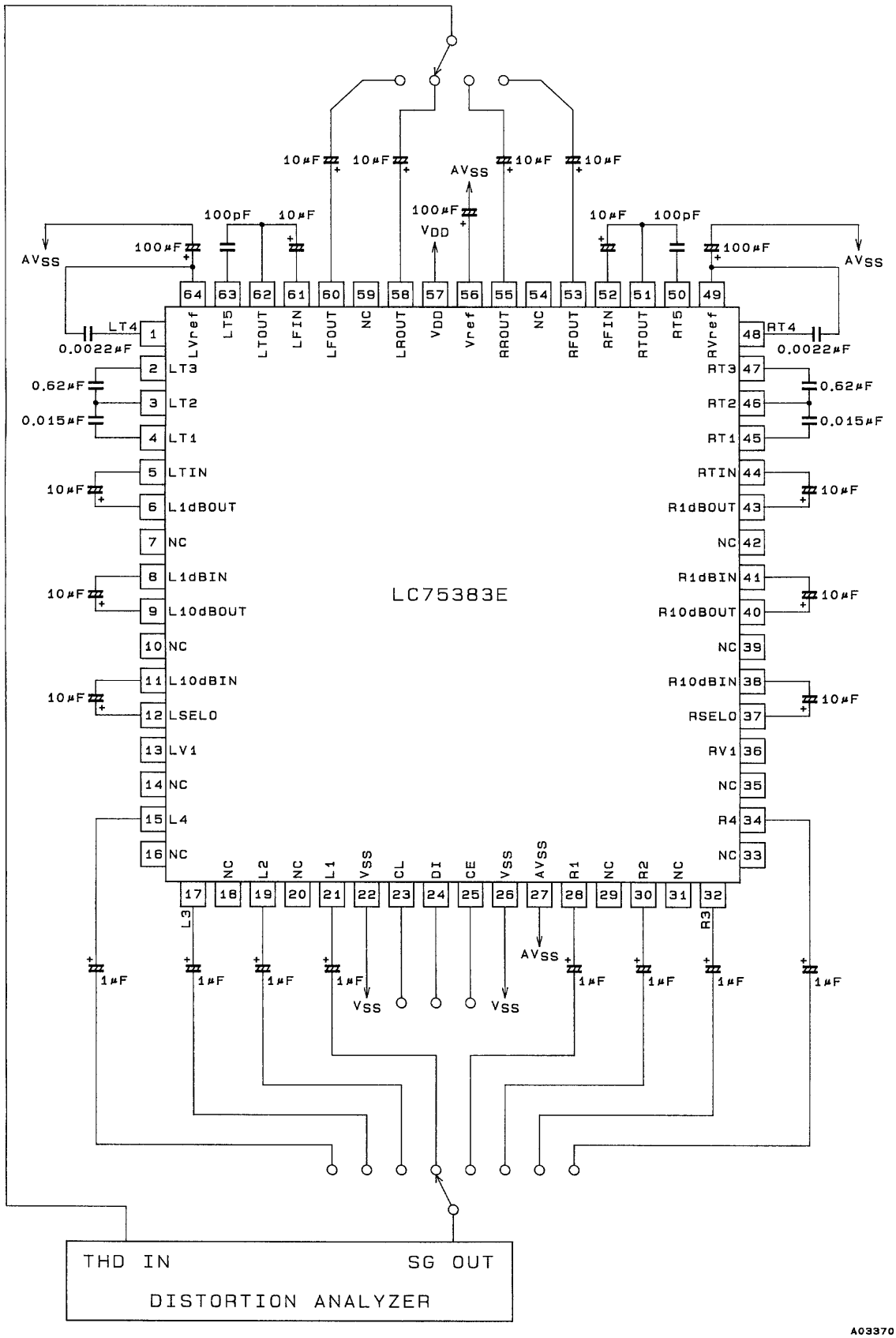


The right channel is identical.

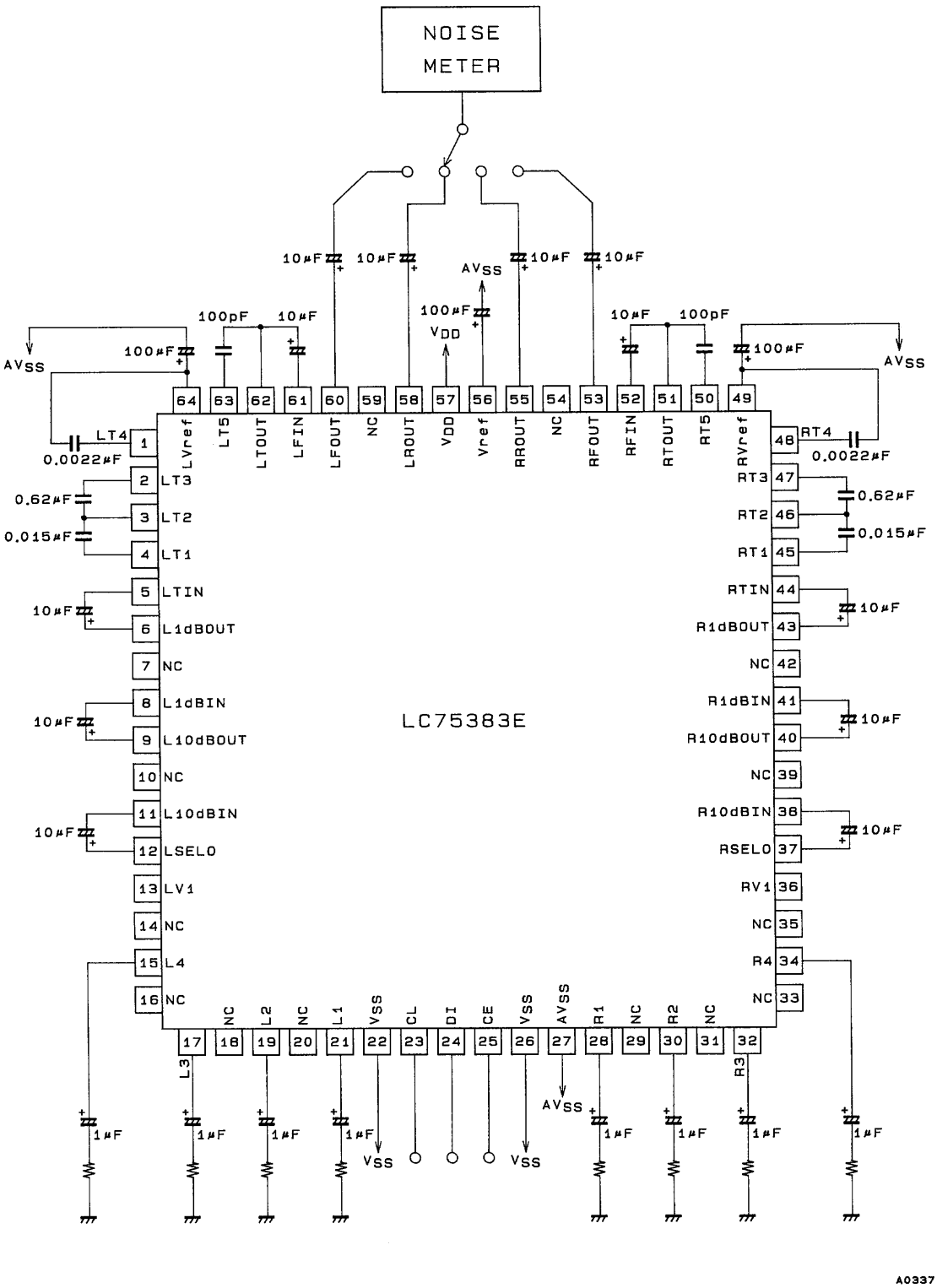
A03369

Electrical Characteristics Test Circuits

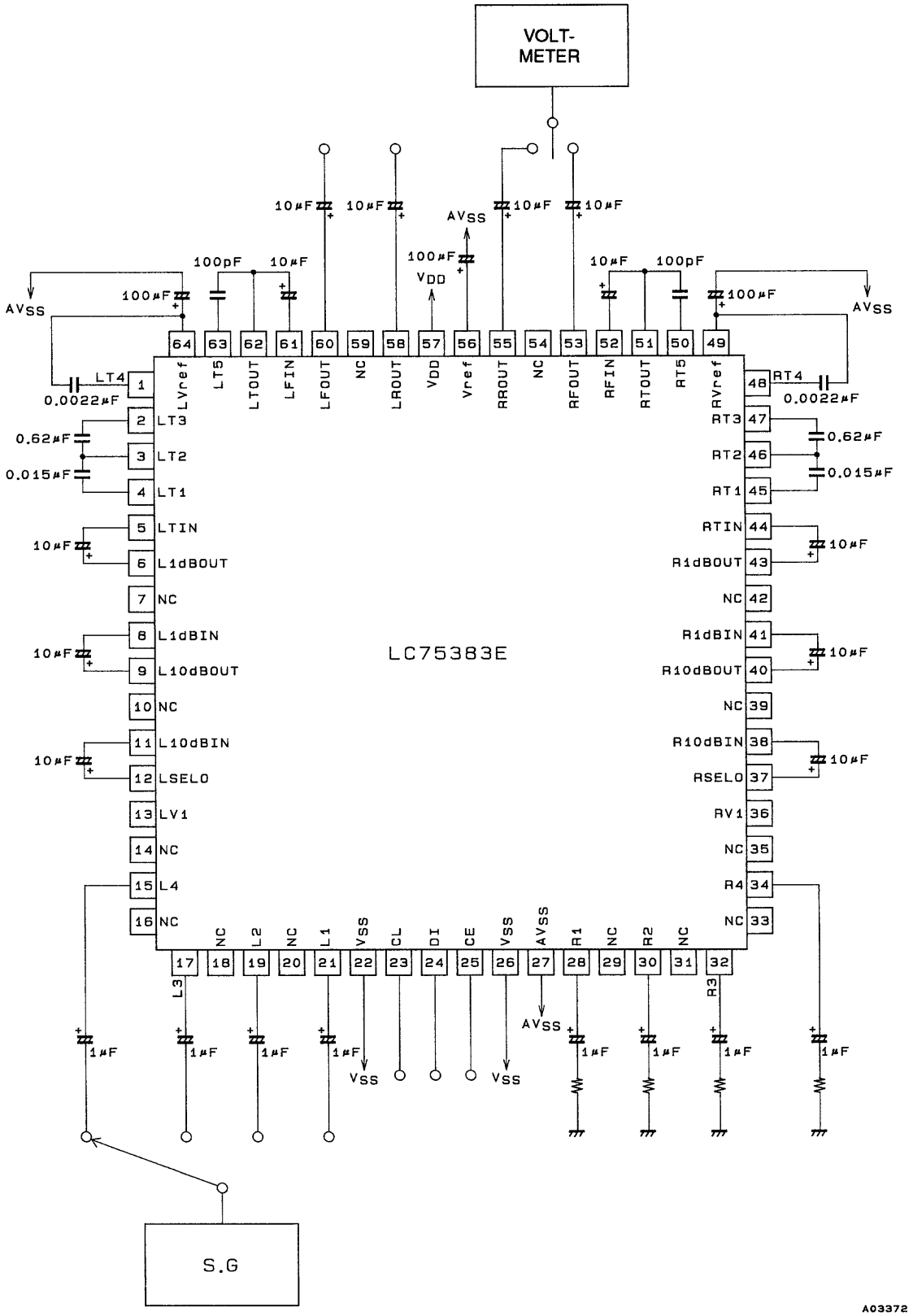
1. Total Harmonic Distortion



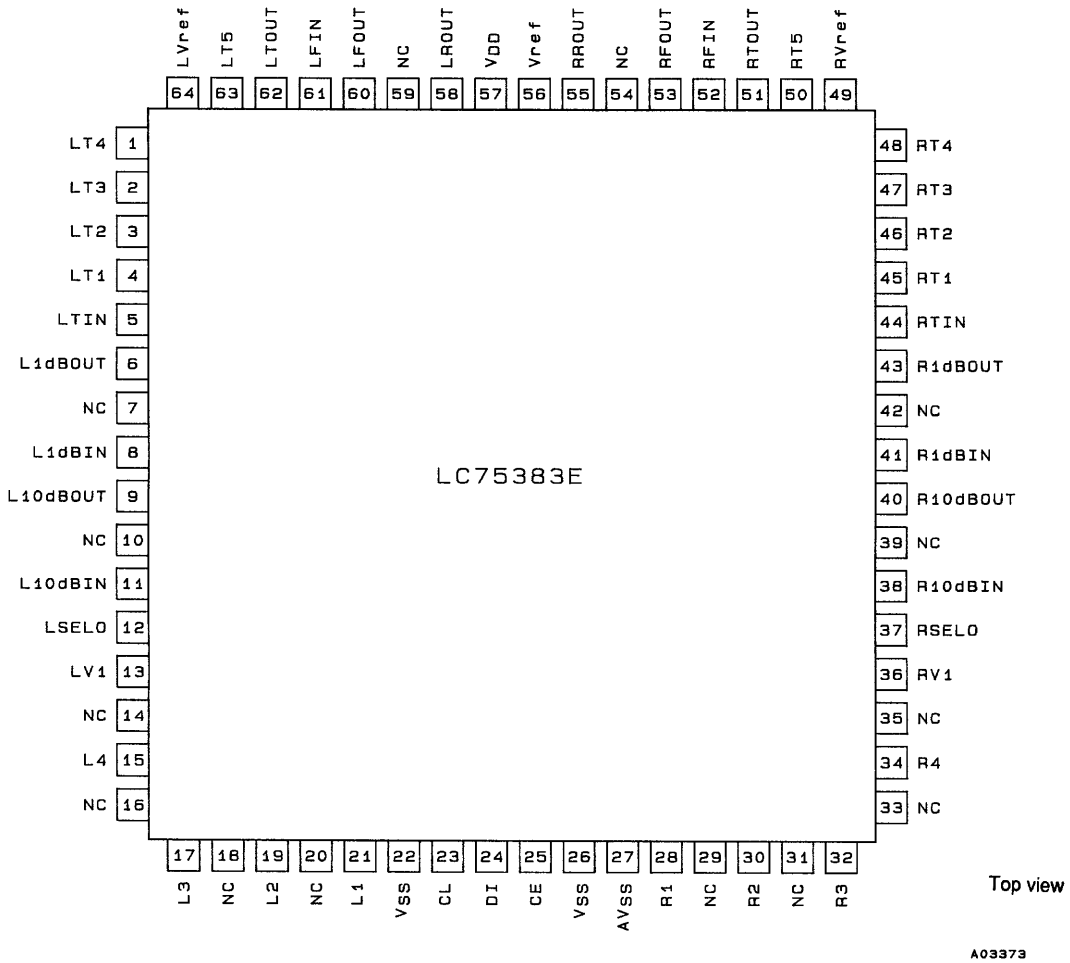
2. Output Noise Voltage



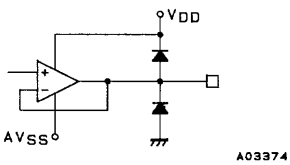
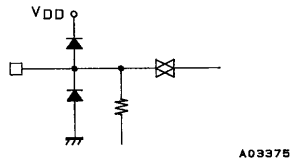
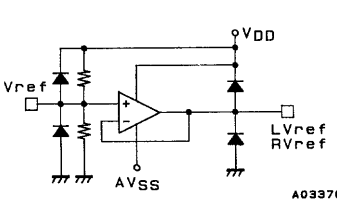
3. Crosstalk


VOLT-
METER
LC75383E
S.G
AVSS
VDD
VSS
10μF
100pF
100μF
0.0022μF
0.62μF
0.015μF
1μF
LT4
RT4
LT3
LT2
LT1
LTIN
L1dBOUT
NC
L1dBIN
L10dBOUT
L10dBIN
LSELO
LV1
L4
LVref
LT5
LTOUT
LFIN
LFOUT
LROUT
Vref
RROUT
RFOUT
RFIN
RTOUT
RT5
RVref
RT3
RT2
RT1
RTIN
R1dBOUT
R1dBIN
R10dBOUT
R10dBIN
RSELO
RV1
R4
L3
L2
L1
CL
DI
CE
R1
R2
R3
A03372

Pin Assignment



Pin Functions

Pin No.	Symbol	Function	Note
58 60 55 53	LROUT LFOUT RROUT RFOUT	Fader block outputs. Only the front or rear channels are attenuated. The left and right attenuations are identical. Since these are operational amplifier outputs, the output is low impedance.	
61 52	LFIN RFIN	Fader block inputs. Must be driven by low impedance circuits.	
64 49	LVref RVref	Common connections for the main volume, fader block, tone block and gain control block.	
56	Vref	Capacitors of about 100 µF must be inserted between Vref and AV_{SS} (V_{SS}) to reduce power supply ripple in the V_{DD}/2 voltage generation block.	

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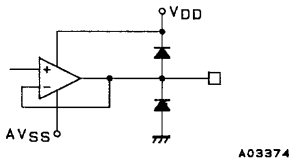
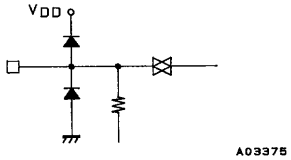
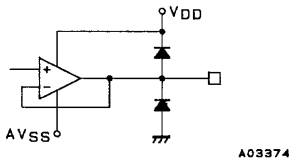
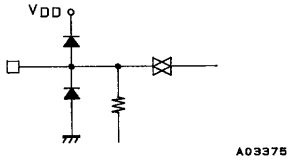
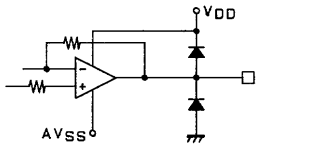
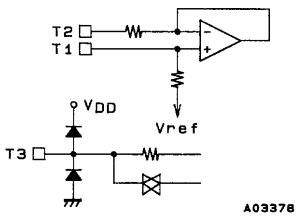
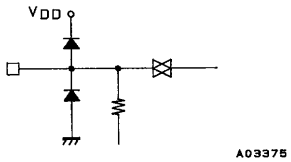
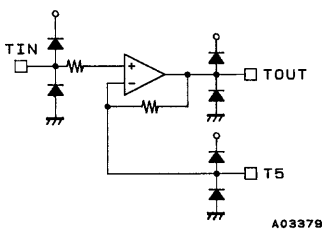
Pin No.	Symbol	Function	Note
6 43	L1dBOUT R1dBOUT	Main volume 1 dB step attenuator outputs	
8 41	L1dBIN R1dBIN	Main volume 1 dB step attenuator inputs Must be driven by low impedance circuits.	
9 40	L10dBOUT R10dBOUT	Main volume 10 dB step attenuator outputs	
11 38	L10dBIN R10dBIN	Main volume 10 dB step attenuator inputs Must be driven by low impedance circuits.	
62 51	LTOUT RTOUT	Tone control outputs	
4 3 2 45 46 47	LT1 LT2 LT3 RT1 RT2 RT3	Connections for the capacitors that form the low frequency (bass) tone control filters Low frequency compensation capacitors must be connected between T1 and T2 and between T2 and T3.	
1 48	LT4 RT4	Connections for the capacitors that form the high frequency (treble) tone control filters High frequency compensation capacitors must be connected between the T4 pins and Vref.	
63 50	LT5 RT5	Inverting inputs for the operational amplifiers that form the tone control circuit filters Unnecessary frequencies can be excluded by inserting capacitors of desired values between the T5 and TOUT pin pairs.	
5 44	LTIN RTIN	Tone control circuit inputs Must be driven by low impedance circuits.	

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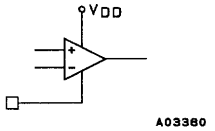
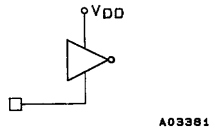
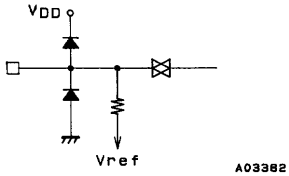
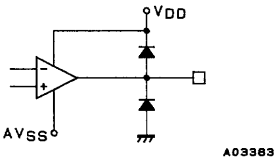
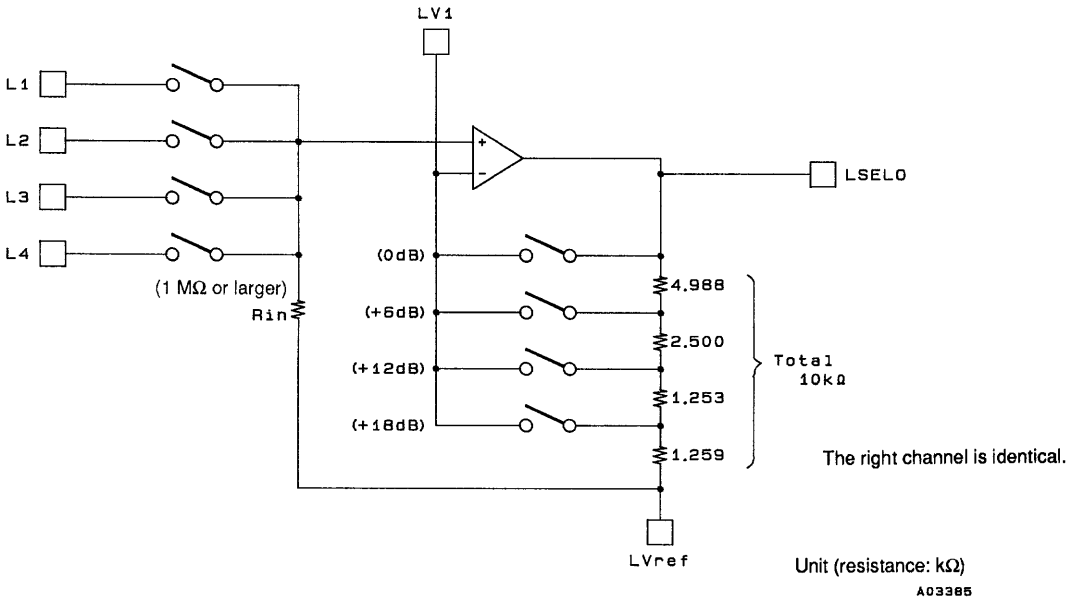
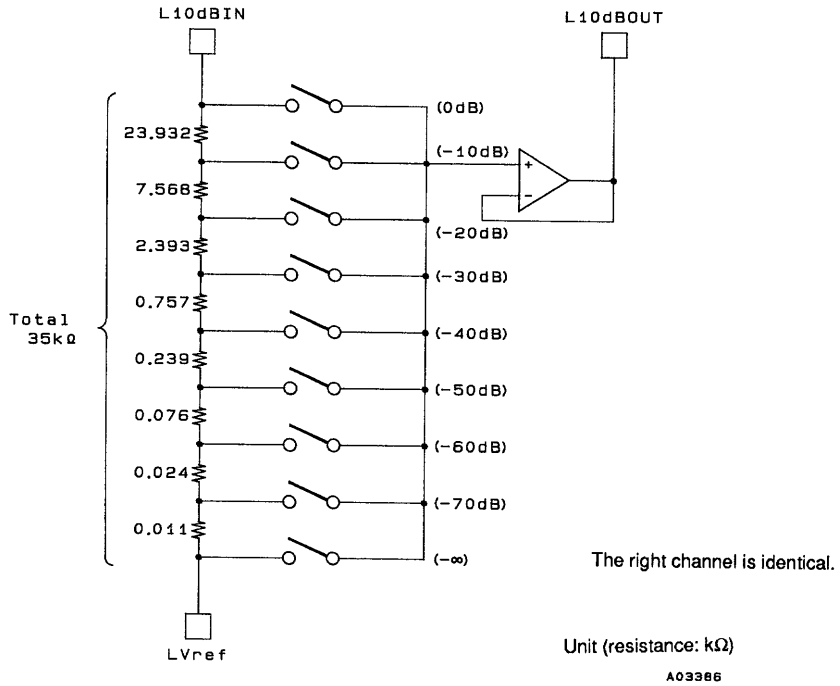
Pin No.	Symbol	Function	Note
57	V_{DD}	Power supply	
27	A. V_{SS}	Ground for internal operational amplifiers	
22, 26	V_{SS}	Ground for the internal logic system	
21 19 17 15 28 30 32 34	L1 L2 L3 L4 R1 R2 R3 R4	Audio signal inputs	
12 37	LSELO RSELO	Input selector outputs	
25	CE	Chip enable. Data is written to the internal latch when this pin goes from high to low. The analog switches operate at that point also. Data transfer is enabled when this pin is high.	
24 23	DI CL	Serial data and clock pins for IC control	
13 36	LV1 RV1	Test pins. These pins must be left open.	
7, 10, 14, 16, 18, 20, 29, 31, 33, 35, 39, 42, 54, 59	NC	No connection pins. These pins must be left open or tied to V_{SS}.	

Equivalent Circuit Details

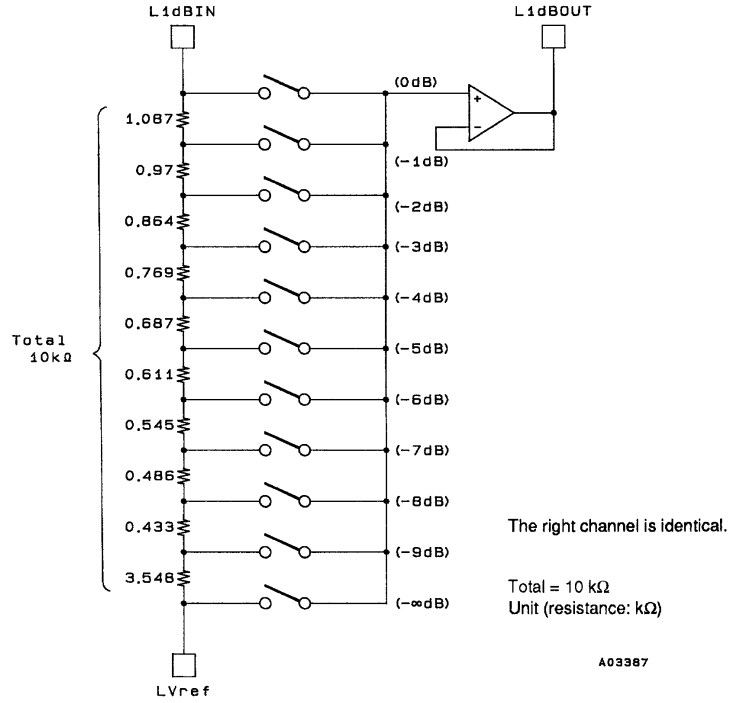
Input Block Equivalent Circuit



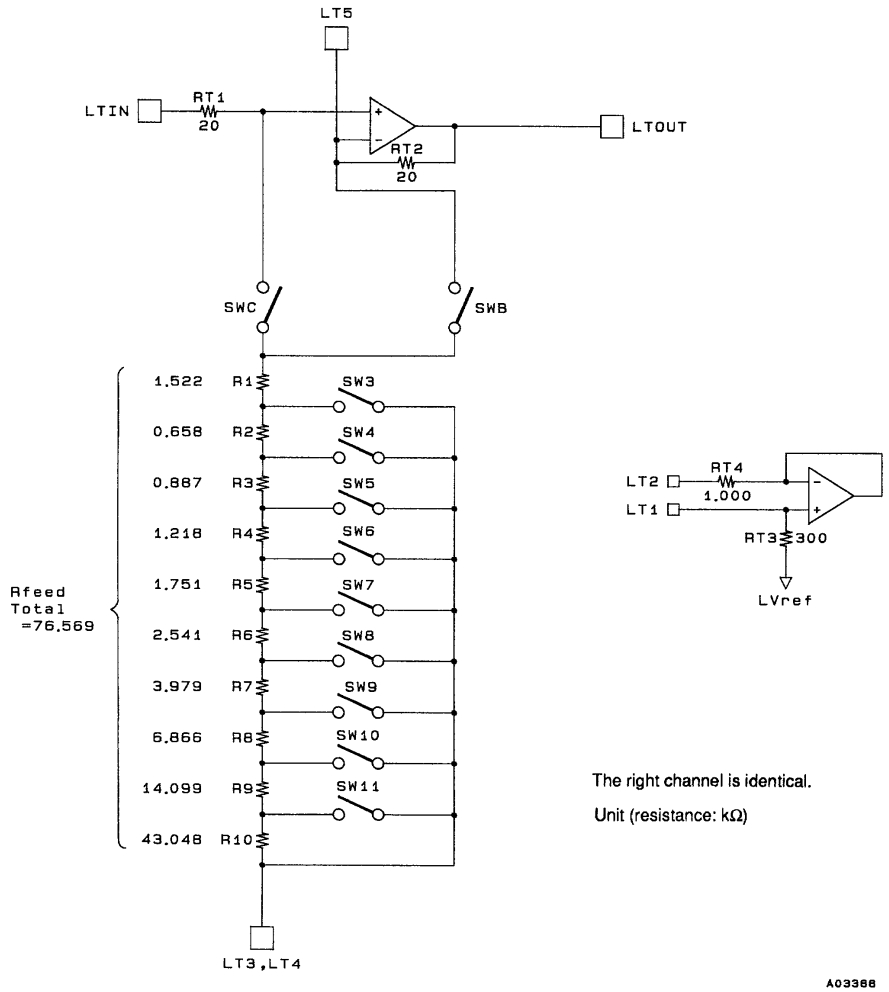
10 dB Step Volume Control Equivalent Circuit



1 dB Step Volume Control Equivalent Circuit



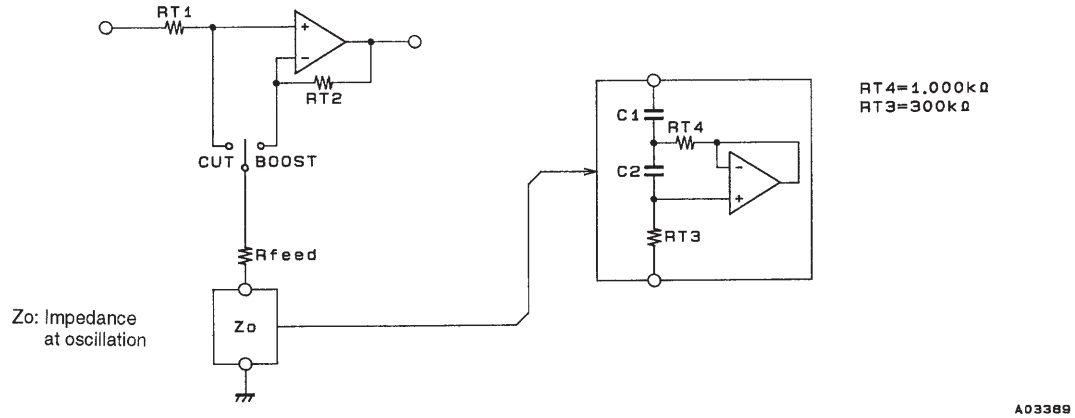
Tone Block Equivalent Circuit



Sample Calculation for the Tone Block External Capacitors

The external capacitors used with the LC75383E are the structural components in semiconductor inductors, i.e., simulated inductors. Here we present the equivalent circuit and the formulas required to acquire the desired center frequency.

1. Semiconductor inductor equivalent circuit



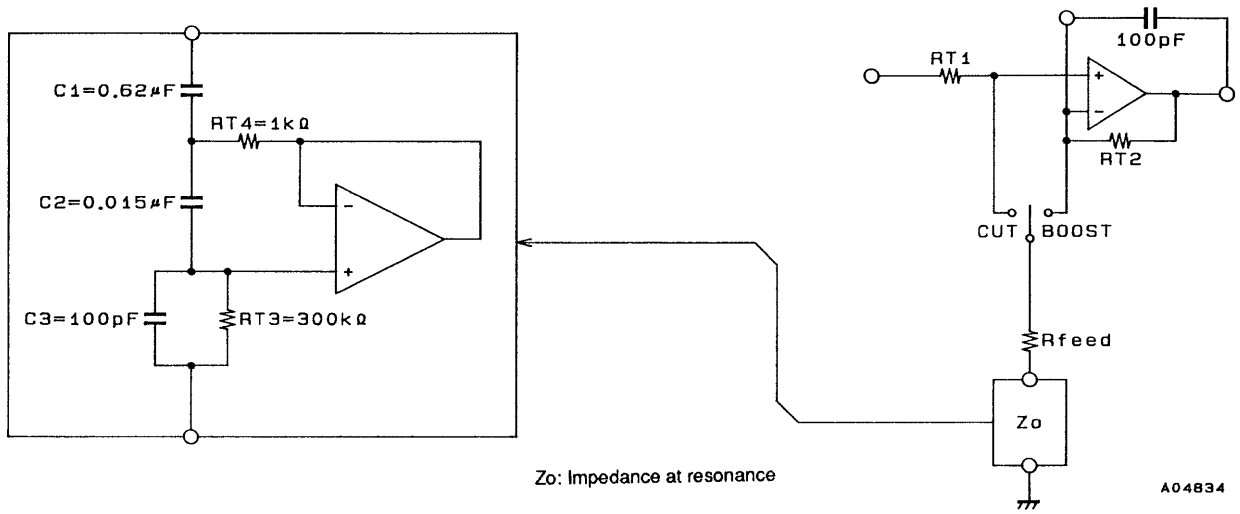
2. Sample calculation
   Specifications: 1) Center frequency: Fo = 100 Hz
   2) Q at maximum boost: $Q_{max} = 1.05$
   - Derive the sharpness, Qo, of the semiconductor inductor itself

$$Qo = \frac{(RT4 + Rfeed)}{RT4} \times Q_{max} \approx 2.6481$$

   - Calculate C1
     $C1 = 1/2\pi FoRT4Qo \neq 0.60\ (\mu F)$
   - Calculate C2
     $C2 = Qo/2\pi FoRT3 \neq 0.014\ (\mu F)$

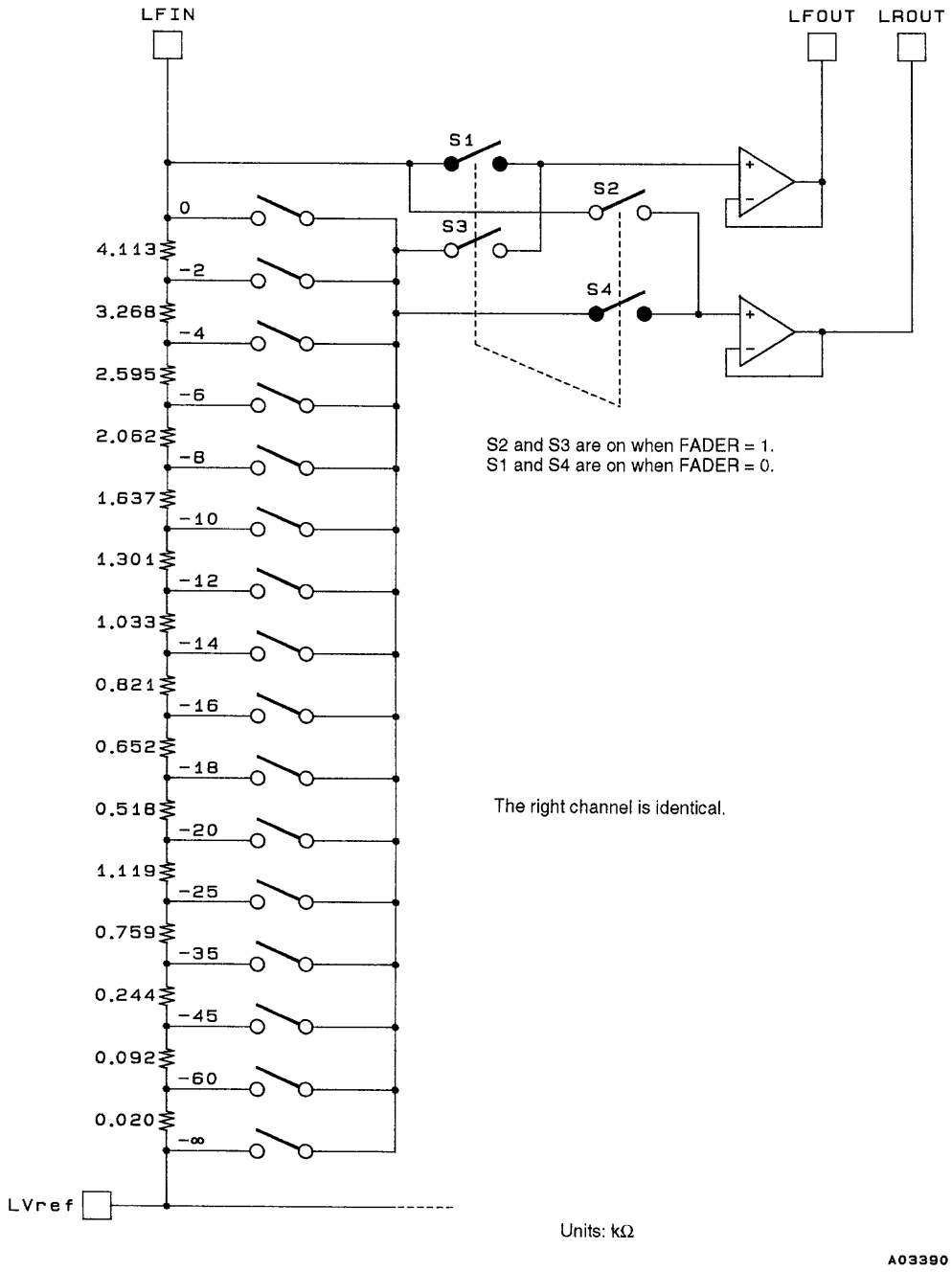
   Note: See the tone block equivalent circuit for the internal resistance.

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.

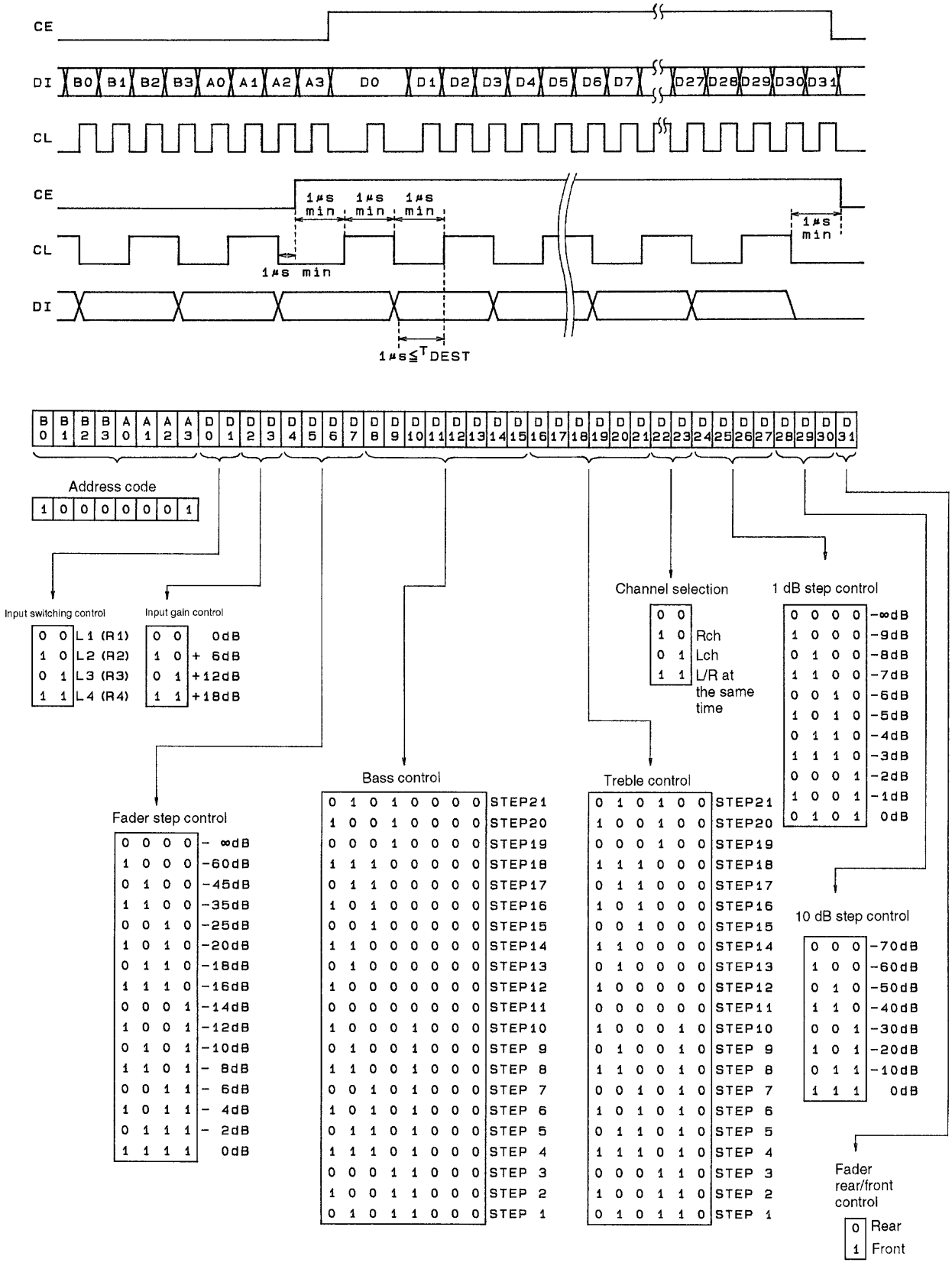
Fader Volume Control Equivalent Circuit



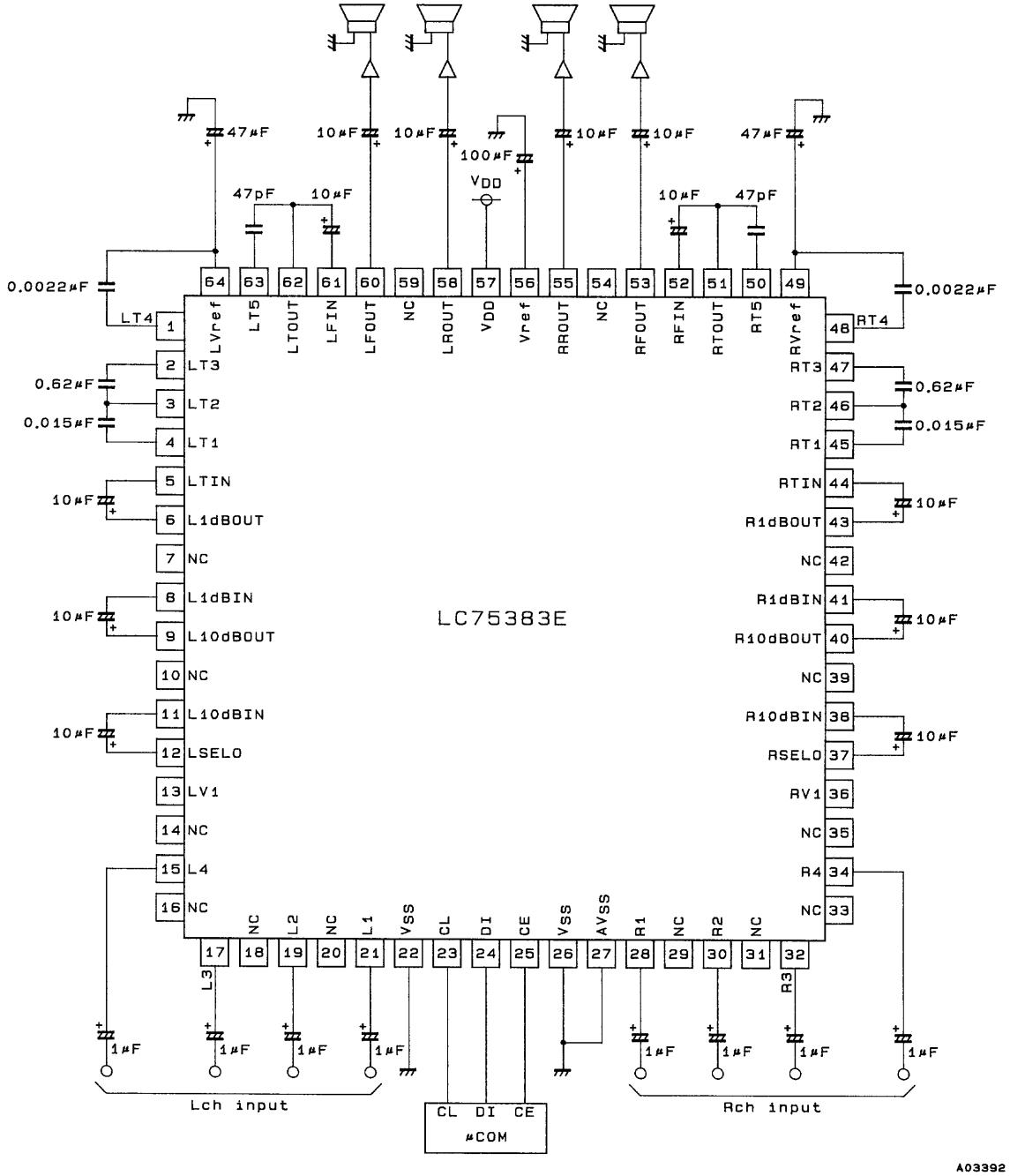
When the main volume 1dBSTEP setting is set to the data value for –∞, S1 and S2 will be open and at the same time S3 and S4 will be on.

Control System Timing and Data Format

The LC75383E is controlled by inputting the stipulated serial data to the CE, CL and DI pins. The data structure consists of a total of 40 bits, of which 8 bits are address and 32 bits are setting data.



Sample Application Circuit

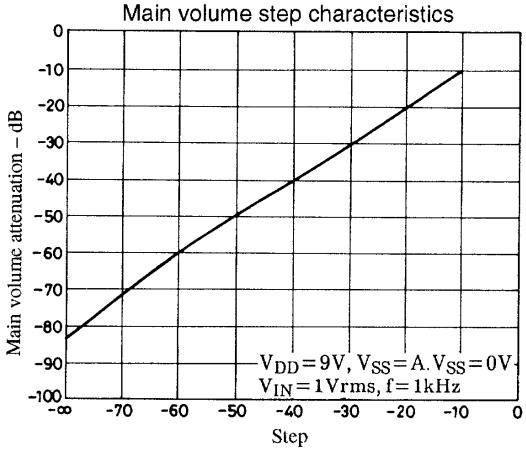


Usage Notes

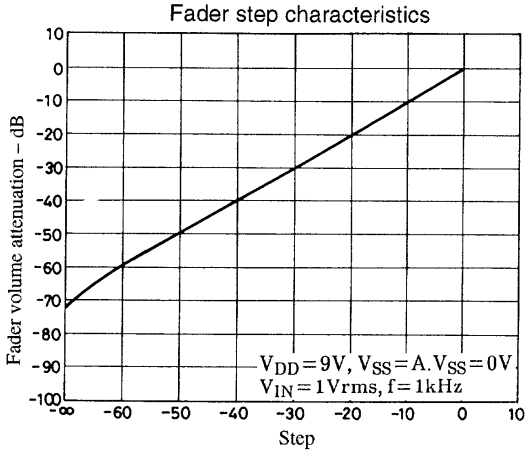
1. The states of the internal analog switches are undefined when power is first applied. Muting should be applied externally until control data has been transferred and stored.

2. The signal lines for the CL, DI and CE pins should either be covered by the pattern ground or be formed from shielded cable to prevent the high-frequency digital signals transmitted over these lines from entering the analog system.

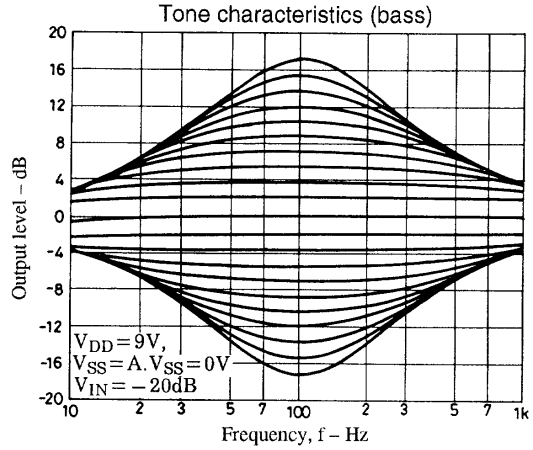
Main volume step characteristics



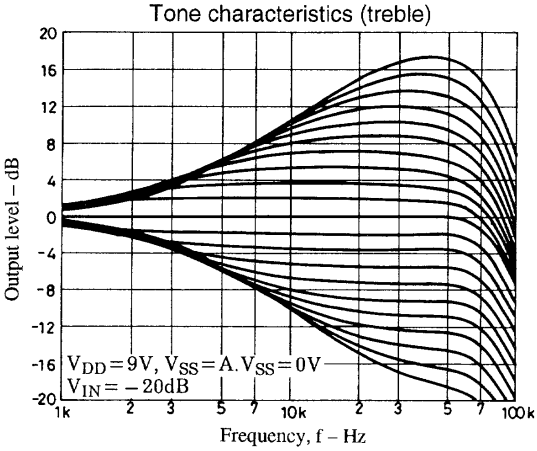
Fader step characteristics



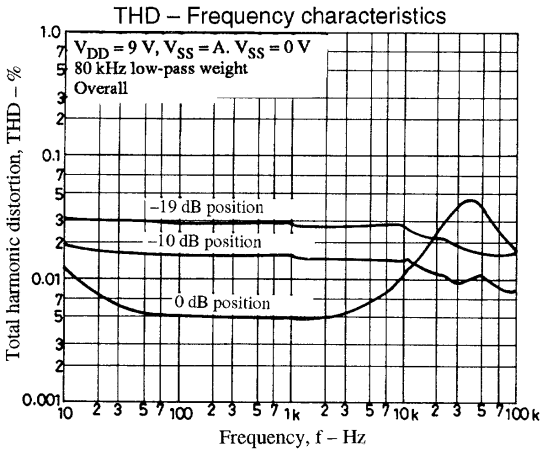
Tone characteristics (bass)



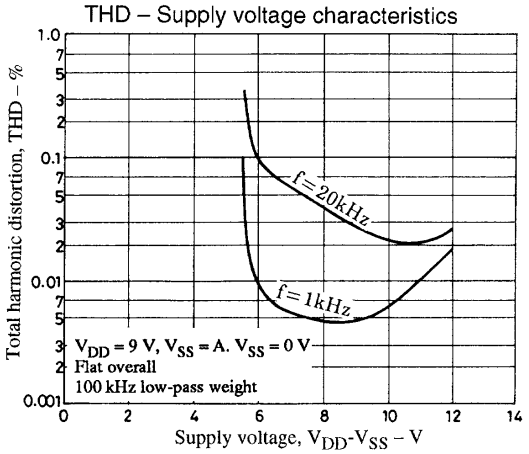
Tone characteristics (treble)



THD – Frequency characteristics



THD – Supply voltage characteristics



THD – Input level characteristics