



## **Electronic Volume and Tone Control for Car Stereos**



#### Overview

The LC75374E is an electronic volume and tone control circuit that provides volume, balance, fader, bass and treble, super bass, input switching, and input and output level controls and requires a minimal number of external components to implement these functions.

#### **Functions**

• Volume: 0dB to −79dB (in 1-dB steps) and −∞dB for a total of 81 positions.

A balance function can be implemented by controlling the left and right channels independently.

- Fader: Allows either the rear or the front channel outputs to be attenuated over 16 positions.
  - (0 to −20dB in 2dB steps, −20 to −25dB in a 5dB step, −25 to −45dB in 10dB steps, −60dB, and −∞dB for a total of 16 positions.)
- Bass and treble: NF-type tone control circuits are formed using external CR circuits. The bass and treble can be controlled from 0dB to +11.9dB (in 1.7dB steps) for a total of 15 positions.
- Input gain: The input signal can be amplified by 0dB to +18.75dB (in 1.25dB steps).
- Output gain: The fader output can be set to one of three settings: 0dB, +6.5dB, or +8.5dB.
- Input switching: Both the left and right channels can be selected from one of four inputs.
- Super bass: This circuit provides peaking characteristics (T type characteristics) and 11 position settings.

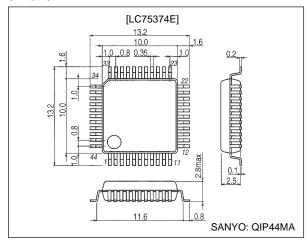
#### **Features**

- On-chip buffer amplifiers minimizes the number of external components.
- Built-in reference voltage generator for the analog ground.
- All controls can be set using the serial data input circuit (CCB).

#### **Package Dimensions**

unit: mm

#### 3148-QIP44MA



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# Specifications Absolute Maximum Ratings at $\mathrm{Ta}=25^{\circ}\mathrm{C},\,V_{SS}=0~V$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V <sub>DD</sub> max	V <sub>DD</sub>	11	V
Maximum input voltage	V <sub>IN</sub> max	CL, DI, CE	$V_{SS} - 0.3$ to $V_{DD} + 0.3$	V
Allowable power dissipation	Pd max	When Ta ≤ 85°C and mounted on a printed circuit board	720	mW
Operating temperature	Topr		-40 to +85	°C
Storage temperature	Tstg		-50 to +125	°C

# Allowable Operating Ranges at $Ta=-40~to~+85^{\circ}C,~V_{SS}=0~V$

Parameter	Cumbal	Conditions	Ratings			- Unit
Parameter	Parameter Symbol Conditions		min	typ	max	Oill
Supply voltage	V <sub>DD</sub>	V <sub>DD</sub>	7.5		9.7	V
High-level input voltage	V <sub>IH</sub>	CL, DI, CE	4.0		$V_{DD}$	V
Low-level input voltage	V <sub>IL</sub>	CL, DI, CE	V <sub>SS</sub>		1.0	V
Input voltage amplitude	V <sub>IN</sub>	CL, DI, CE, LVRIN, RVRIN, L1 to L4, R1 to R4, LFIN, RFIN, LSIN, RSIN	V <sub>SS</sub>		V <sub>DD</sub>	Vp-p
Input pulse width	tφ W	CL	1			μs
Setup time	t <sub>setup</sub>	CL, DI, CE	1			μs
Hold time	t <sub>hold</sub>	CL, DI, CE	1			μs
Operating frequency	fopg	CL			500	kHz

# Electrical Characteristics at Ta = 25°C, $V_{DD}$ = 8 V, $V_{SS}$ = 0 V

Parameter	Symbol	Conditions	Ratings			Unit	
Parameter	Symbol	Conditions	min	typ	max	Unit	
[Input Block]							
Maximum input gain	Gin max			+18.75		dB	
Step resolution	Gstep			+1.25		dB	
Output load resistance	RL		10			kΩ	
Output impedance	Ro	LSEL0, RSEL0 : $R_L = 10 \text{ k}\Omega$ , $f = 1 \text{ kHz}$ , $V_{IN} = 1 \text{ Vrms}$		46		Ω	
[Output Block]			•				
Maximum output gain	Gout max			+8.5		dB	
Output load resistance	R <sub>L</sub>		10			kΩ	
Output impedance	Ro	LFOUT, LROUT, RFOUT, RROUT : $R_L$ = 10 k $\Omega$ , f = 1 kHz, $V_{IN}$ = 1 Vrms		35		Ω	
[Volume Control Block]			•				
Step resolution	ATstep			1		dB	
Step error	ATerr	STEP = 0 dB to -20 dB	-1	0	+1	dB	
Step entor	Aleii	STEP = -20 dB to -50 dB	-3	0	+3	dB	
Output load resistance	R <sub>L</sub>		10			kΩ	
Output impedance	R <sub>O</sub>	LTOUT, RTOUT : $R_L = 10 \text{ k}\Omega$ , $f = 1 \text{ kHz}$ , $V_{IN} = 1 \text{ Vrms}$		46		Ω	
[Fader Volume Control Block]							
		STEP = 0 dB to -20 dB		2		dB	
Step resolution	ATstep	STEP = -20 dB to -25 dB		5		dB	
		STEP = -25 dB to -45 dB		10		dB	
Step error	ATerr	STEP = 0 dB to -45 dB	-2	0	+2	dB	
Otop ciror	Aich	STEP = -45 dB to -60 dB	-3	0	+3	dB	
Output load resistance	R <sub>L</sub>		10			kΩ	
Output impedance	R <sub>O</sub>	LFOUT, LROUT, RFOUT, RROUT : $R_L$ = 10 k $\Omega$ , f = 1 kHz, $V_{IN}$ = 1 Vrms		46		Ω	
[Bass and Treble Control Block]							
Bass control range	Gbass	Max. Boost/Cut	±8	±11.9	±13	dB	
Treble control range	Gtre	Max. Boost/Cut	±8	±11.9	±13	dB	
Output load resistance	R <sub>L</sub>		10			kΩ	
Output impedance	R <sub>O</sub>	LTOUT, RTOUT : $R_L = 10 \text{ k}\Omega$ , $f = 1 \text{ k}\Omega$ , $V_{\text{IN}} = 1 \text{ Vrms}$		46		Ω	

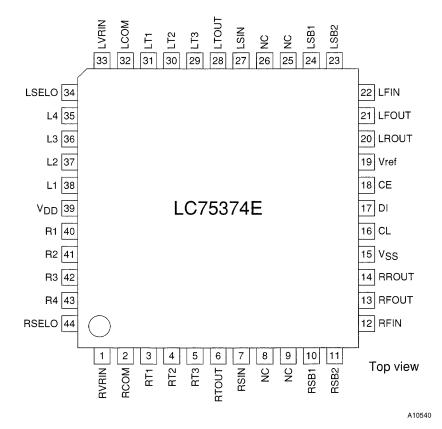
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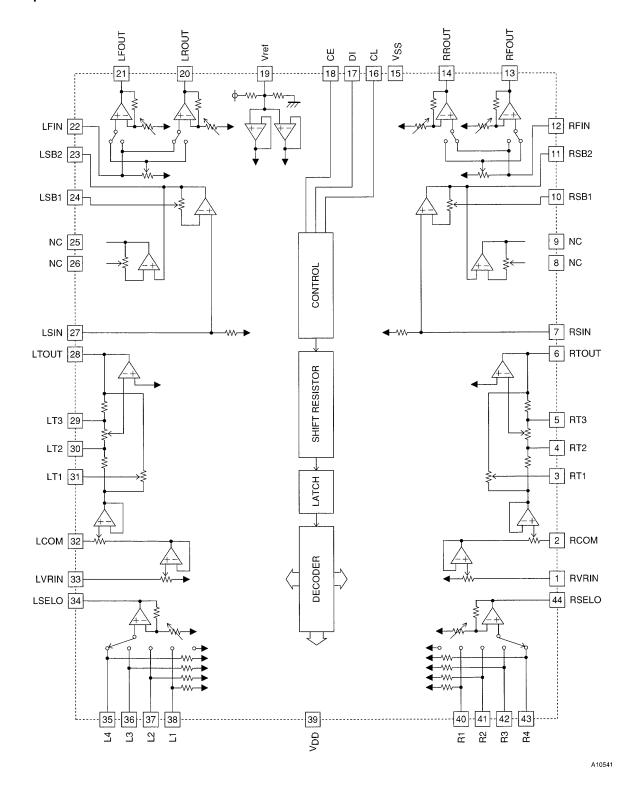
# Electrical Characteristics at $Ta=25^{\circ}C,\,V_{DD}$ = $8~V,\,V_{SS}$ = 0~V

Parameter	Comme hand	Canalitiana	Ratings			l lait
Parameter	Symbol	Conditions	min	typ	max	Unit
[Super-Bass Block] (T type)						
Control range	Crange	Max. Boost		+20		dB
Step resolution	ATstep			+2.0		dB
Output load resistance	$R_L$		10			kΩ
Output impedance	Ro	LSB2, RSB2 : $R_L = 10 \text{ k}\Omega$ , $f = 1 \text{ kHz}$ , $V_{IN} = 1 \text{ Vrms}$		70		Ω
[Overall]						
Total harmonic distortion	THD	V <sub>IN</sub> = 1 Vrms, f = 1 kHz, All controls flat overall		0.003	0.01	%
Crosstalk	CT	$V_{IN}$ = 1 Vrms, f = 1 kHz, All controls flat overall, Rg = 1 k $\Omega$		80.5		dB
Output at maximum attenuation	Vo min	V <sub>IN</sub> = 1 Vrms, f = 1 kHz, Main volume setting: -∞		-80		dB
Output noise voltage	V <sub>N</sub> 1	All controls flat overall, (IHF-A), Rg = 1 kΩ		8		μV
Output hoise voltage	V <sub>N</sub> 2	All controls flat overall, (DIN-AUDIO), Rg = 1 k $\Omega$		10		μV
High-level input voltage	I <sub>IH</sub>	CL, DI, CE, V <sub>IN</sub> = 8 V			10	μA
Low-level input voltage	I <sub>IL</sub>	CL, DI, CE, V <sub>IN</sub> = 0 V	-10			μΑ

### **Pin Assignment**

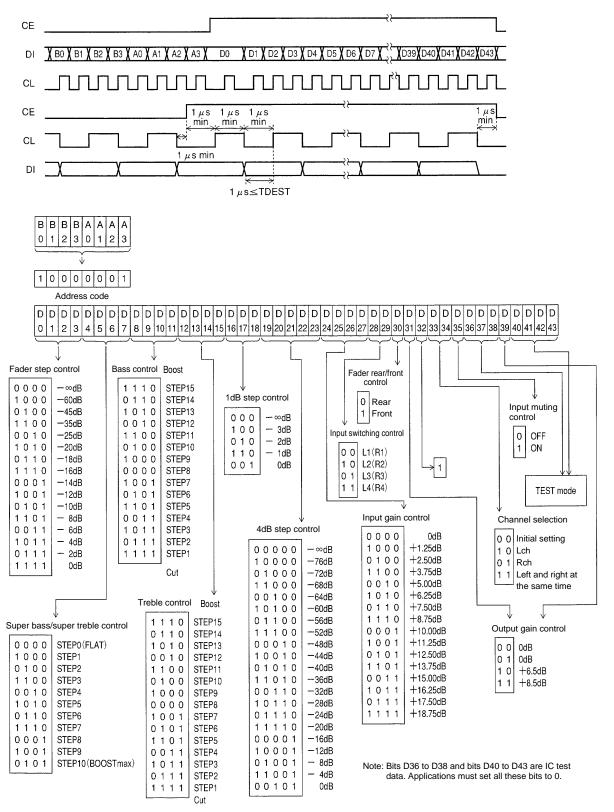


# **Equivalent Circuit**



#### **Control System Timing and Data Format**

Applications must input the stipulated serial data to the CE, CL, and DI pins to control the LC75374E. The data consists of a total of 52 bits, of which 8 bits are address and 44 bits are data.



# LC75374E

# **Pin Functions**

Pin No.	Pin	Description	Notes
19	Vref	• Supply voltage generator (0.525 $\times$ V <sub>DD</sub> ) used for the analog ground. A capacitor must be connected between Vref and V <sub>SS</sub> to remove power supply ripple.	LVref RVref A10543
20 21 14 13	LROUT LFOUT RROUT RFOUT	Fader outputs. The front and rear outputs can be attenuated independently.	A10544
22 12	LFIN RFIN	Fader inputs     These inputs must be driven by low-impedance circuits.	VDD → VDD → A10545
24 23 10 11	LSB1 LSB2 RSB1 RSB2	Left channel super bass compensation capacitor connection     Left channel super bass output and compensation capacitor connection     Right channel super bass compensation capacitor connection     Right channel super bass output and compensation capacitor connection	SB1 SIN SIN SIN A10547
22 7	LSIN RSIN	Super bass input     These inputs must be driven by low-impedance circuits.	VDD A10548
28 6	LTOUT RTOUT	Tone control outputs	LVref RVref A10549

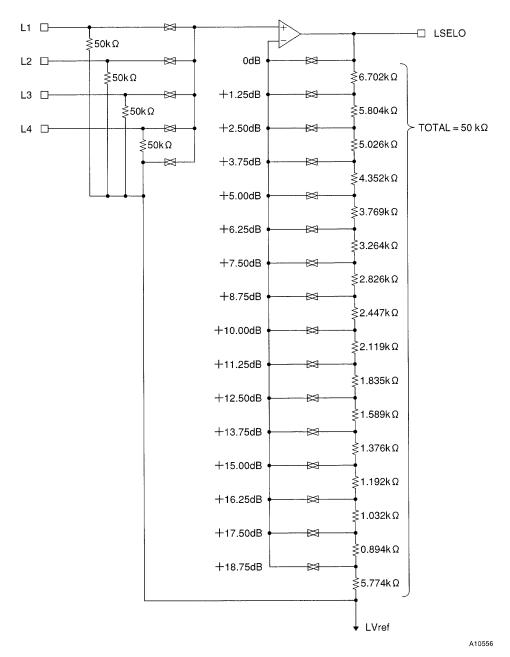
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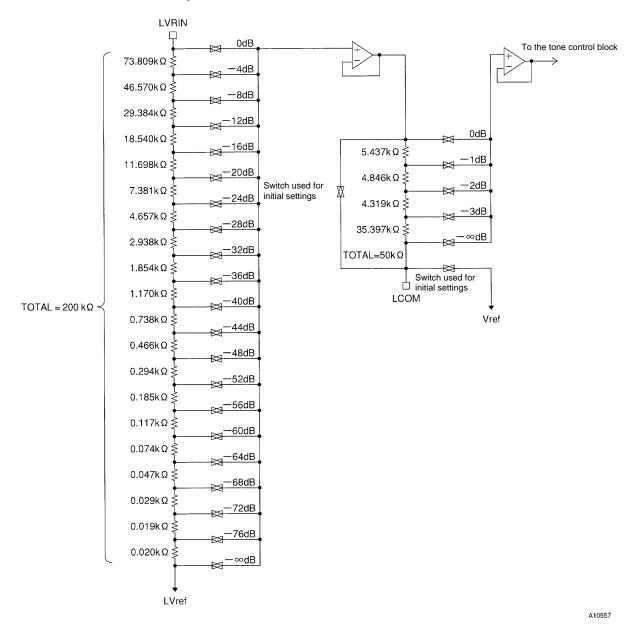
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Pin No.	Pin	Description	Notes
			∘ V <sub>DD</sub>
31 30 29 3	LT1 LT2 LT3 RT1	Tone control circuit bass and treble compensation capacitor connections.  Connect the high band compensation capacitors between the pins T1 and T2.	→ T1  → VDD
5	RT2 RT3	Connect the low band compensation capacitors between the pins T2 and T3.	T2,T3
32 2	LCOM RCOM	1dB volume control common connections	VDD A10551
33 1	LVRIN RVRIN	4dB volume control inputs     These inputs must be driven by low-impedance circuits.	LVref RVref
34 44	LSELO RSELO	Input selector outputs	A10553
38 37 36 35 40 41 42 43	L1 L2 L3 L4 R1 R2 R3 R4	Signal inputs	LVref RVref
39	V <sub>DD</sub>	Power supply	
15	V <sub>SS</sub>	Ground	
16	CL	Serial data and clock inputs used for transferring control data	o ∧DD
18	DI CE	Chip enable input. Data is written into the internal latches and the analog switches operate when this pin goes from high to low. Data transfers are enabled when this pin is high.	A10555
8, 26 9, 25	NC	<ul> <li>Unused pins. These pins must be connected to V<sub>SS</sub>.</li> <li>Unused pins. These pins must be left open.</li> </ul>	

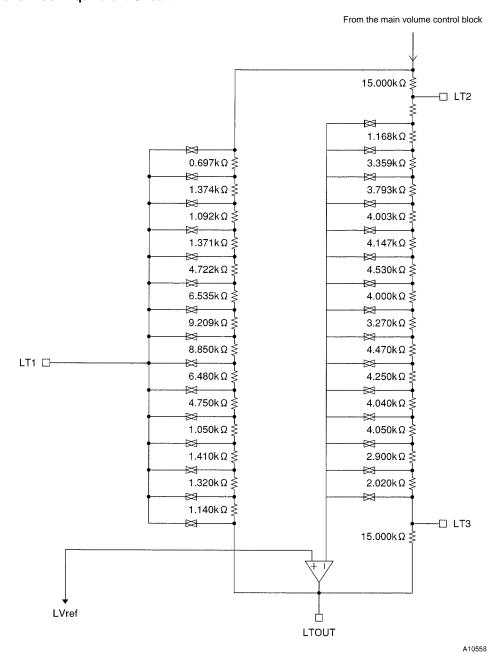
### **Input Block Equivalent Circuit**



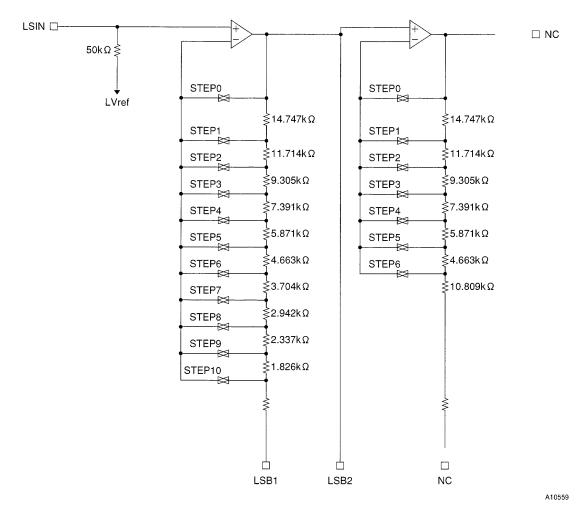
# **Main Volume Control Block Equivalent Circuit**



### **Tone Block Equivalent Circuit**



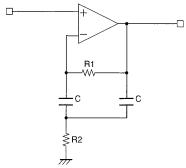
### **Super Bass Block Equivalent Circuit**



#### Sample external constant calculations for the super bass (T type) circuit when full boost is used

The external constants required when full boost is used with the super bass block (T type) are calculated as follows.

• Super bass (T type) equivalent circuit



A10560

- Calculation
- (1) Center frequency

$$f0 = \frac{1}{2 \times \pi \times \sqrt{R1 \times R2 \times C \times C}}$$

(2) Gain

$$G = 20\log \left(1 + \frac{R1}{2 \times R2}\right)$$

(3) Q

$$Q = \frac{C \times C \times R1}{2 \times C} \times \frac{1}{\sqrt{R1 \times R2 \times C \times C}}$$

Sample calculation

Assume:

 $R1 = 64.5 \text{ k}\Omega$ , and

G = 20.65 dB, and

f0 = 72.7 Hz.

• Determine R2

Determine R2 from formula (2).

R2 = 
$$\frac{64.5}{2 \times (10.78 - 1)}$$
 ≈ 3.3 (kΩ)

• Determine C

Determine C from formula (1).

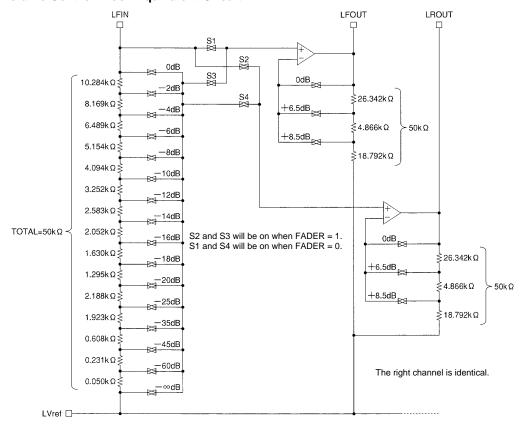
$$C = \frac{1}{\sqrt{R1 \times R2 \times (2 \times \pi \times f0) \times (2 \times \pi \times f0)}} \approx 0.15 \,(\mu \text{F})$$

• Determine Q

Determine Q from formula (3).

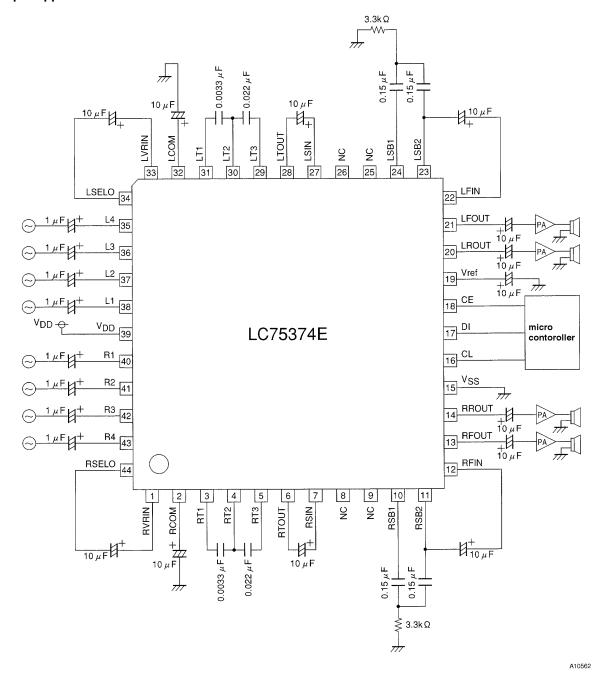
Here, Q will be 2.21.

#### **Fader Volume Control Block Equivalent Circuit**



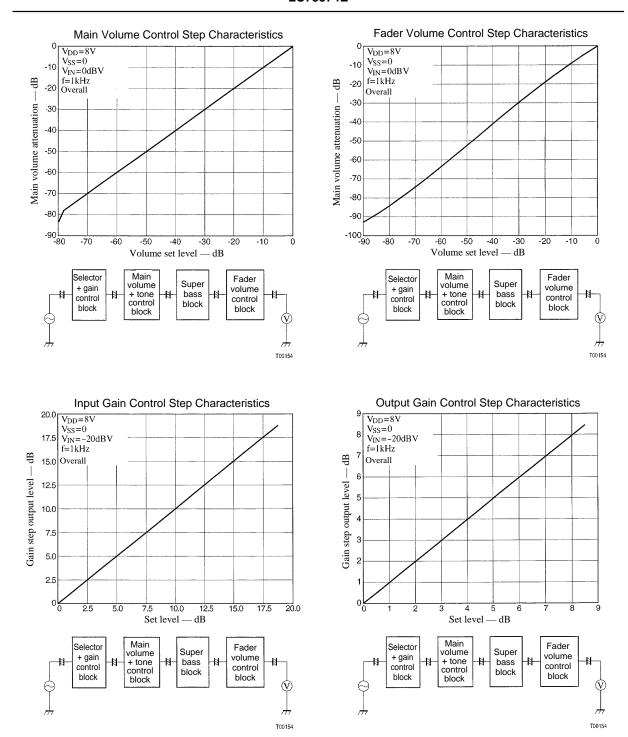
At the point that data corresponding to −∞ is transferred to the 1dB –step main volume control block, S1 and S2 will go to the open state. S3 and S4 will go to the on state at the same time.

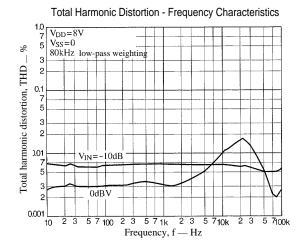
#### **Sample Application Circuit**

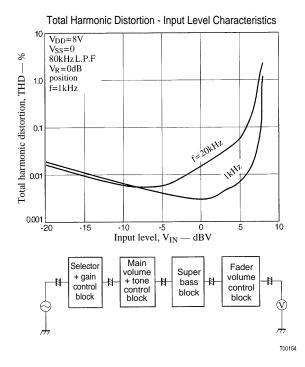


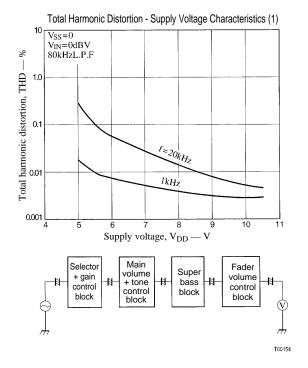
## **Usage Notes**

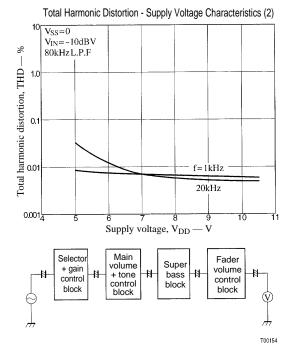
- The internal analog switches are in undefined states when power is first applied. Applications must therefore use external circuits to mute the output until control data has been transferred.
- When setting up the initial data after power is first applied, applications must first transfer a set of IC initialization data. This initialization data consists of an address field of (10000001) and a data field of all zeros (D0 to D43 = 0). Applications must only send the actual initial data after this initialization data has been sent.
- Applications must either cover the CL, DI, and CE lines with the ground pattern or use shielded cables for these lines to prevent the high-frequency digital signals that are transmitted over these lines from entering the analog signal system.

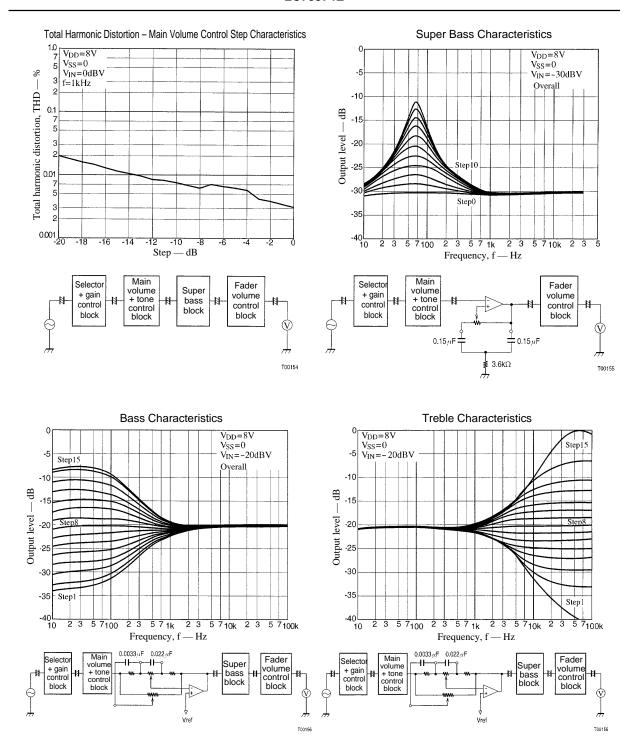












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