



LC75341, 75341M

Single-Chip Volume and Tone Control System

Preliminary



Overview

The LC75341 and LC75341M are electronic volume and tone control systems that provide volume, balance, a 2-band equalizer, and input switching functions that can be controlled from serially transferred data.

Functions

- Volume: 0 dB to -79 dB (in 1-dB steps) and $-\infty$, for a total of 81 settings.
The volume can be controlled independently in the left and right channels to implement a balance function.
- Bass boost: Up to +20 dB in 2-dB steps. Peaking characteristics.
- Treble: ± 10 dB in 2-dB steps. Shelving characteristics.
- Selector: One of four sets of left/right inputs can be selected.
- Input gain: The input signal can be boosted by from 0 dB to +30 dB in 2-dB steps.

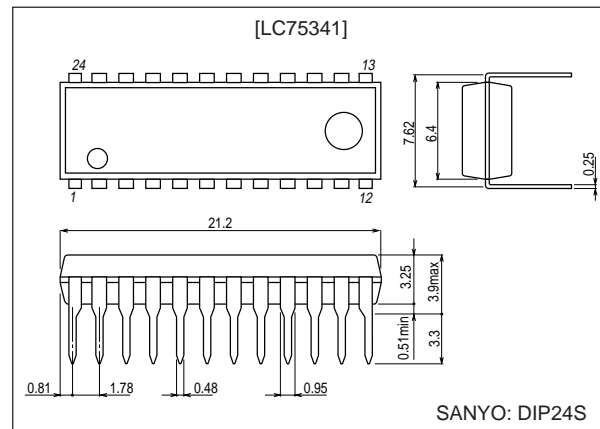
Features

- On-chip buffer amplifiers minimize the number of external components.
- Fabricated in a silicon gate CMOS process to minimize switching noise from internal switches.
- Built-in analog ground reference voltage generation circuit.
- All controls can be set from serially transferred data. Supports the CCB standard.

Package Dimensions

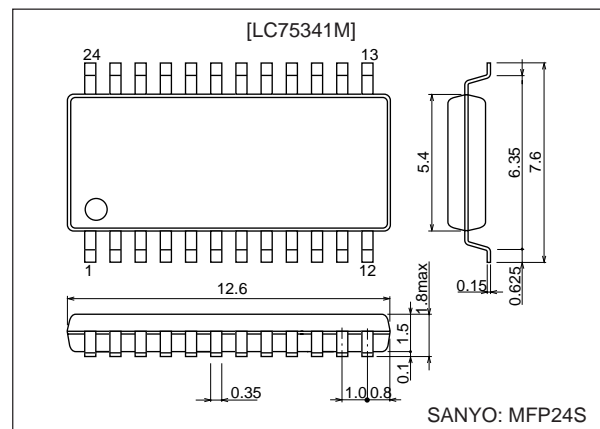
unit: mm

3067-DIP24S



unit: mm

3112-MFP24S



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D2499RM (OT) No. 6270-1/20

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Specifications

Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$, $V_{SS} = 0\text{ V}$

Parameter	Symbol	Pin	Conditions	Ratings	Unit	
Maximum supply voltage	$V_{DD\text{ max}}$	V_{DD}		11	V	
Maximum input voltage	$V_{IN\text{ max}}$	CE, DI, CL, L1 to L4, R1 to R4, LIN, RIN		$V_{SS} - 0.3\text{ to }V_{DD} + 0.3$	V	
Allowable power dissipation	$P_{d\text{ max}}$		$T_a \leq 75^\circ\text{C}$	LC75341	450	mW
			$T_a \leq 75^\circ\text{C}$ with a PCB*	LC75341M	450	
Operating temperature	T_{opr}			-30 to +75	$^\circ\text{C}$	
Storage temperature	T_{stg}			-40 to +125	$^\circ\text{C}$	

Note: * Printed circuit board size: $76.1 \times 114.3 \times 1.6\text{ mm}$, printed circuit board material: glass/epoxy resin

Allowable Operating Ranges at $T_a = -30\text{ to }+75^\circ\text{C}$, $V_{SS} = 0\text{ V}$

Parameter	Symbol	Pin	Conditions	Ratings			Unit
				min	typ	max	
Supply voltage	V_{DD}	V_{DD}		5.0		10	V
High-level input voltage	V_{IH}	CL, DI, CE		2.7		10	V
Low-level input voltage	V_{IL}	CL, DI, CE	$7.5 \leq V_{DD} \leq 10.0$	V_{SS}		1.0	V
			$5.0 \leq V_{DD} < 7.5$	V_{SS}		0.8	
Input voltage amplitude	V_{IN}	CE, DI, CL, L1 to L4, R1 to R4, LIN, RIN		V_{SS}		V_{DD}	Vp-p
Input pulse width	t_{PW}	CL		1			μs
Setup time	t_{setup}	CL, DI, CE		1			μs
Hold time	t_{hold}	CL, DI, CE		1			μs
Operating frequency	f_{opg}	CL				500	kHz

Electrical Characteristics at $T_a = 25^\circ\text{C}$, $V_{DD} = 9\text{ V}$, $V_{SS} = 0\text{ V}$

Input Block

Parameter	Symbol	Pin	Conditions	Ratings			Unit
				min	typ	max	
Maximum input gain	$G_{in\text{ max}}$				+30		dB
Step resolution	G_{step}				+2		dB
Input resistance	R_{in}	L1, L2, L3, L4 R1, R2, R3, R4			50		$\text{k}\Omega$
Clipping level	V_{cl}	LSEL0, RSEL0	THD = 1.0%, $f = 1\text{ kHz}$		2.90		Vrms
Output load resistance	R_l	LSEL0, RSEL0		10			$\text{k}\Omega$

Volume Control Block

Parameter	Symbol	Pin	Conditions	Ratings			Unit
				min	typ	max	
Input resistance	R_{in}	L_{IN}, R_{IN}			50		$\text{k}\Omega$

Bass Band Equalizer Control Block

Parameter	Symbol	Pin	Conditions	Ratings			Unit
				min	typ	max	
Control range	G_{eq}		max.boost	+18	+20	+22	dB
Step resolution	E_{step}			1	2	3	dB
Internal feedback resistance	R_{feed}				66.6		$\text{k}\Omega$

Treble Band Equalizer Control Block

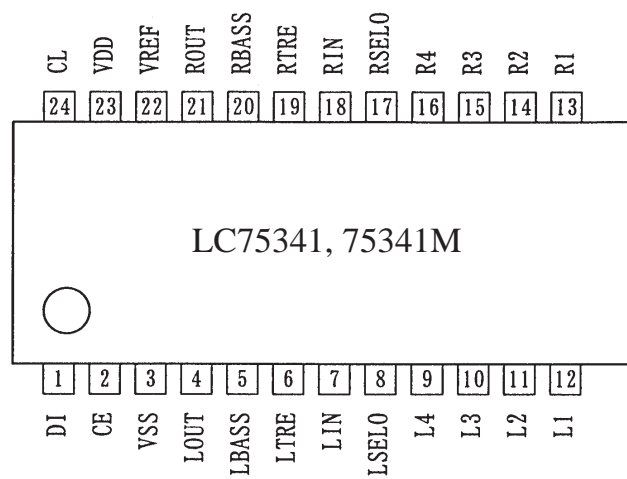
Parameter	Symbol	Pin	Conditions	Ratings			Unit
				min	typ	max	
Control range	G_{eq}		max.boost/cut	± 8	± 10	± 12	dB
Step resolution	E_{step}			1	2	3	dB
Internal feedback resistance	R_{feed}				51.7		$\text{k}\Omega$

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Overall Characteristics

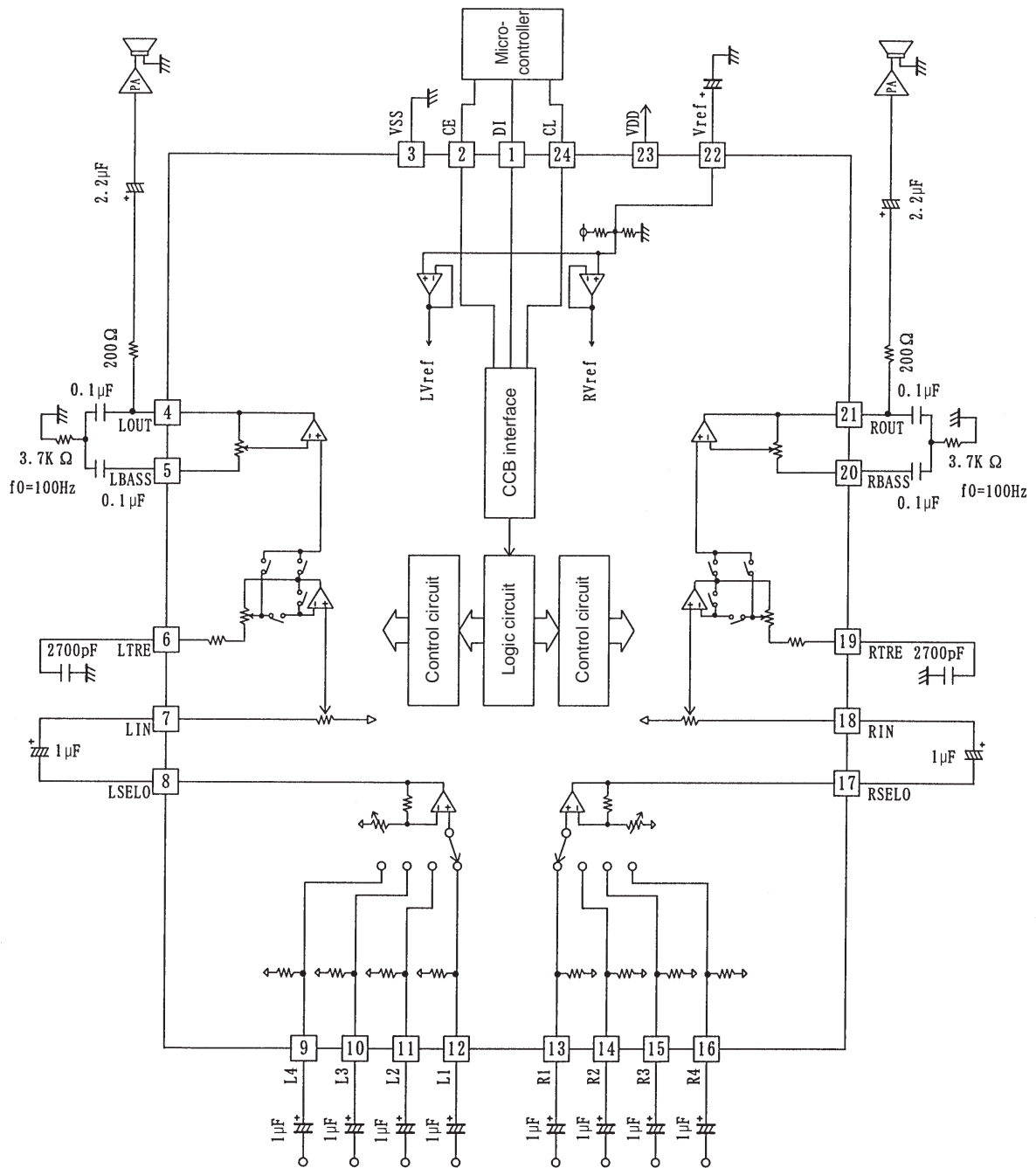
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Total harmonic distortion	THD	$V_{IN} = 1 \text{ Vrms}$, $f = 1 \text{ kHz}$, all flat overall			0.01	%
Crosstalk	CT	$V_{IN} = 1 \text{ Vrms}$, $f = 1 \text{ kHz}$, $R_g = 1 \text{ k}\Omega$, all flat overall	80			dB
Output noise voltage	V_N	All flat overall, 80 kHz, L.P.F		9.3		μV
Maximum attenuation	Vomin	All flat overall, $f = 1 \text{ kHz}$		-90		dB
Current drain	I_{DD}	$V_{DD} - V_{SS} = +10 \text{ V}$		37		mA
High-level input current	I_{IH}	CL, DI, CE: $V_{IN} = 10 \text{ V}$			10	μA
Low-level input current	I_{IL}	CL, DI, CE: $V_{IN} = 0 \text{ V}$	-10			μA

Pin Assignment



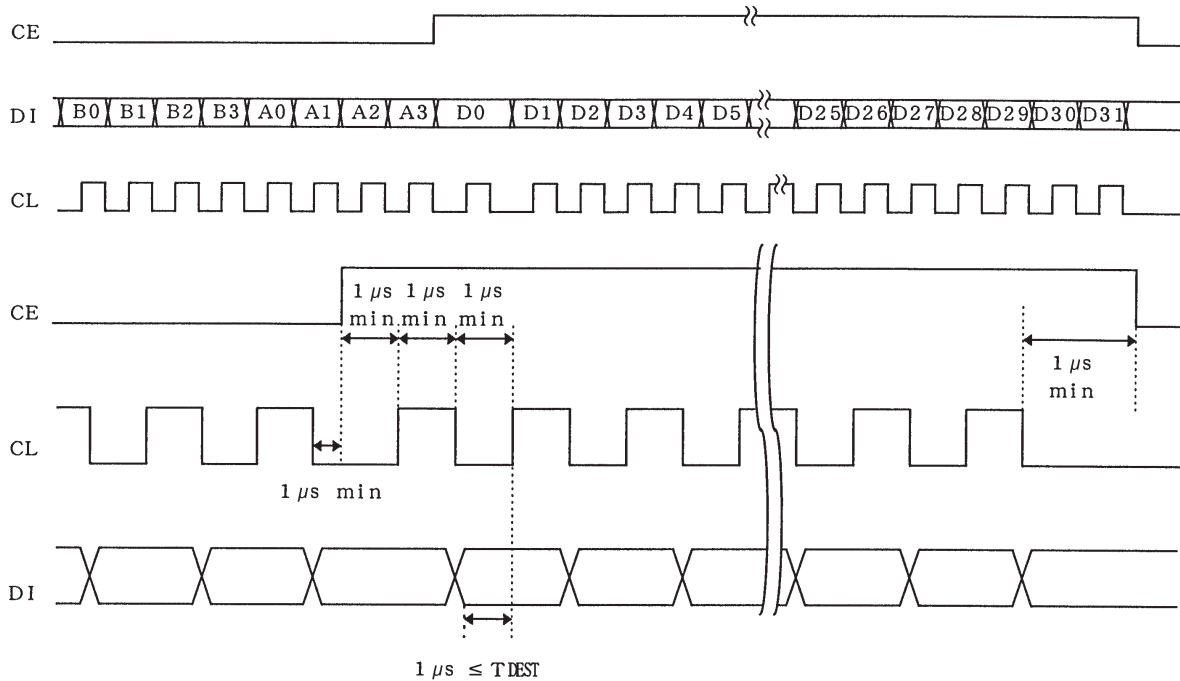
(Top view)

Equivalent Circuit



Control System Timing and Data Format

Applications control the LC75341 and LC75341M by applying the stipulated serial data to the CL, DI, and CE pins. This data consists of a total of 40 bits, of which 8 bits are the address and 32 bits are the data itself.



• Address code (B0 to A3)

The LC75341 and LC75341M have an 8-bit address code, and can be used together with other ICs that support the Sanyo CCB serial bus format.

Address code (LSB)

B0	B1	B2	B3	A0	A1	A2	A3
0	1	0	0	0	0	0	1

 (82HEX)

• Control code allocation

Input switching control (L1, L2, L3, L4, R1, R2, R3, R4)

D0	D1	D2	D3	Operation
0	0	0	0	L1 (R1) ON
1	0	0	0	L2 (R2) ON
0	1	0	0	L3 (R3) ON
1	1	0	0	L4 (R4) ON
0	0	1	0	All switches off
1	0	1	0	All switches off
0	1	1	0	All switches off
1	1	1	0	All switches off

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Input Gain Control

D4	D5	D6	D7	Operation
0	0	0	0	0 dB
1	0	0	0	+2 dB
0	1	0	0	+4 dB
1	1	0	0	+6 dB
0	0	1	0	+8 dB
1	0	1	0	+10 dB
0	1	1	0	+12 dB
1	1	1	0	+14 dB
0	0	0	1	+16 dB
1	0	0	1	+18 dB
0	1	0	1	+20 dB
1	1	0	1	+22 dB
0	0	1	1	+24 dB
1	0	1	1	+26 dB
0	1	1	1	+28 dB
1	1	1	1	+30 dB

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Volume Control

D8	D9	D10	D11	D12	D13	D14	D15	Operation
0	0	0	0	0	0	0	0	0 dB
1	0	0	0	0	0	0	0	-1 dB
0	1	0	0	0	0	0	0	-2 dB
1	1	0	0	0	0	0	0	-3 dB
0	0	1	0	0	0	0	0	-4 dB
1	0	1	0	0	0	0	0	-5 dB
0	1	1	0	0	0	0	0	-6 dB
1	1	1	0	0	0	0	0	-7 dB
0	0	0	1	0	0	0	0	-8 dB
1	0	0	1	0	0	0	0	-9 dB
0	1	0	1	0	0	0	0	-10 dB
1	1	0	1	0	0	0	0	-11 dB
0	0	1	1	0	0	0	0	-12 dB
1	0	1	1	0	0	0	0	-13 dB
0	1	1	1	0	0	0	0	-14 dB
1	1	1	1	0	0	0	0	-15 dB
0	0	0	0	1	0	0	0	-16 dB
1	0	0	0	1	0	0	0	-17 dB
0	1	0	0	1	0	0	0	-18 dB
1	1	0	0	1	0	0	0	-19 dB
0	0	1	0	1	0	0	0	-20 dB
1	0	1	0	1	0	0	0	-21 dB
0	1	1	0	1	0	0	0	-22 dB
1	1	1	0	1	0	0	0	-23 dB
0	0	0	1	1	0	0	0	-24 dB
1	0	0	1	1	0	0	0	-25 dB
0	1	0	1	1	0	0	0	-26 dB
1	1	0	1	1	0	0	0	-27 dB
0	0	1	1	1	0	0	0	-28 dB
1	0	1	1	1	0	0	0	-29 dB
0	1	1	1	1	0	0	0	-30 dB
1	1	1	1	1	0	0	0	-31 dB
0	0	0	0	0	1	0	0	-32 dB
1	0	0	0	0	1	0	0	-33 dB
0	1	0	0	0	1	0	0	-34 dB
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0	0	1	0	0	1	0	0	-36 dB
1	0	1	0	0	1	0	0	-37 dB
0	1	1	0	0	1	0	0	-38 dB
1	1	1	0	0	1	0	0	-39 dB
0	0	0	1	0	1	0	0	-40 dB
1	0	0	1	0	1	0	0	-41 dB
0	1	0	1	0	1	0	0	-42 dB
1	1	0	1	0	1	0	0	-43 dB
0	0	1	1	0	1	0	0	-44 dB
1	0	1	1	0	1	0	0	-45 dB
0	1	1	1	0	1	0	0	-46 dB
1	1	1	1	0	1	0	0	-47 dB
0	0	0	0	1	1	0	0	-48 dB
1	0	0	0	1	1	0	0	-49 dB
0	1	0	0	1	1	0	0	-50 dB

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Volume Control

D8	D9	D10	D11	D12	D13	D14	D15	Operation
1	1	0	0	1	1	0	0	-51 dB
0	0	1	0	1	1	0	0	-52 dB
1	0	1	0	1	1	0	0	-53 dB
0	1	1	0	1	1	0	0	-54 dB
1	1	1	0	1	1	0	0	-55 dB
0	0	0	1	1	1	0	0	-56 dB
1	0	0	1	1	1	0	0	-57 dB
0	1	0	1	1	1	0	0	-58 dB
1	1	0	1	1	1	0	0	-59 dB
0	0	1	1	1	1	0	0	-60 dB
1	0	1	1	1	1	0	0	-61 dB
0	1	1	1	1	1	0	0	-62 dB
1	1	1	1	1	1	0	0	-63 dB
0	0	0	0	0	0	1	0	-64 dB
1	0	0	0	0	0	1	0	-65 dB
0	1	0	0	0	0	1	0	-66 dB
1	1	0	0	0	0	1	0	-67 dB
0	0	1	0	0	0	1	0	-68 dB
1	0	1	0	0	0	1	0	-69 dB
0	1	1	0	0	0	1	0	-70 dB
1	1	1	0	0	0	1	0	-71 dB
0	0	0	1	0	0	1	0	-72 dB
1	0	0	1	0	0	1	0	-73 dB
0	1	0	1	0	0	1	0	-74 dB
1	1	0	1	0	0	1	0	-75 dB
0	0	1	1	0	0	1	0	-76 dB
1	0	1	1	0	0	1	0	-77 dB
0	1	1	1	0	0	1	0	-78 dB
1	1	1	1	0	0	1	0	-79 dB
0	0	0	0	1	0	1	0	-∞ dB

Treble Control

D16	D17	D18	D19	Operation
1	0	1	0	+10 dB
0	0	1	0	+8 dB
1	1	0	0	+6 dB
0	1	0	0	+4 dB
1	0	0	0	+2 dB
0	0	0	0	0 dB
1	0	0	1	-2 dB
0	1	0	1	-4 dB
1	1	0	1	-6 dB
0	0	1	1	-8 dB
1	0	1	1	-10 dB

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Bass Control

D20	D21	D22	D23	D24	D25	Operation
0	1	0	1	0	0	+20 dB
1	0	0	1	0	0	+18 dB
0	0	0	1	0	0	+16 dB
1	1	1	0	0	0	+14 dB
0	1	1	0	0	0	+12 dB
1	0	1	0	0	0	+10 dB
0	0	1	0	0	0	+8 dB
1	1	0	0	0	0	+6 dB
0	1	0	0	0	0	+4 dB
1	0	1	0	0	0	+2 dB
0	0	0	0	0	0	0 dB

Channel Selection

D26	D27	Operation
0	0	
1	0	RCH
0	1	LCH
1	1	Left and right together

Test Mode

D28	D29	D30	D31	Operation
0	0	0	0	
These bits are used for IC testing and must all be set to 0 during normal operation.				

Pin Functions

Pin No.	Pin	Description	Notes
12 11 10 9 13 14 15 16	L1 L2 L3 L4 R1 R2 R3 R4	<ul style="list-style-type: none"> Input signal connections 	
8 17	LSELO RSELO	<ul style="list-style-type: none"> Input selector outputs 	
5 20	LBASS RBASS	<ul style="list-style-type: none"> Connections for the resistors and capacitors that form the bass band filters. 	
4 21	LOUT ROUT	<ul style="list-style-type: none"> These pins are used both as the connections for the resistors and capacitors that form the bass band filters and as the outputs from the bass/treble circuits. 	
6 19	LTRE RTRE	<ul style="list-style-type: none"> Connections for the capacitors that form the treble band filters. 	
7 18	LIN RIN	<ul style="list-style-type: none"> Volume control and equalizer input 	
22	Vref	<ul style="list-style-type: none"> Connection to the $0.5 \times V_{DD}$ voltage generator circuit used as the analog signal ground. Applications must connect a capacitor of about $10 \mu\text{F}$ between this pin and V_{SS} to exclude power supply ripple. 	

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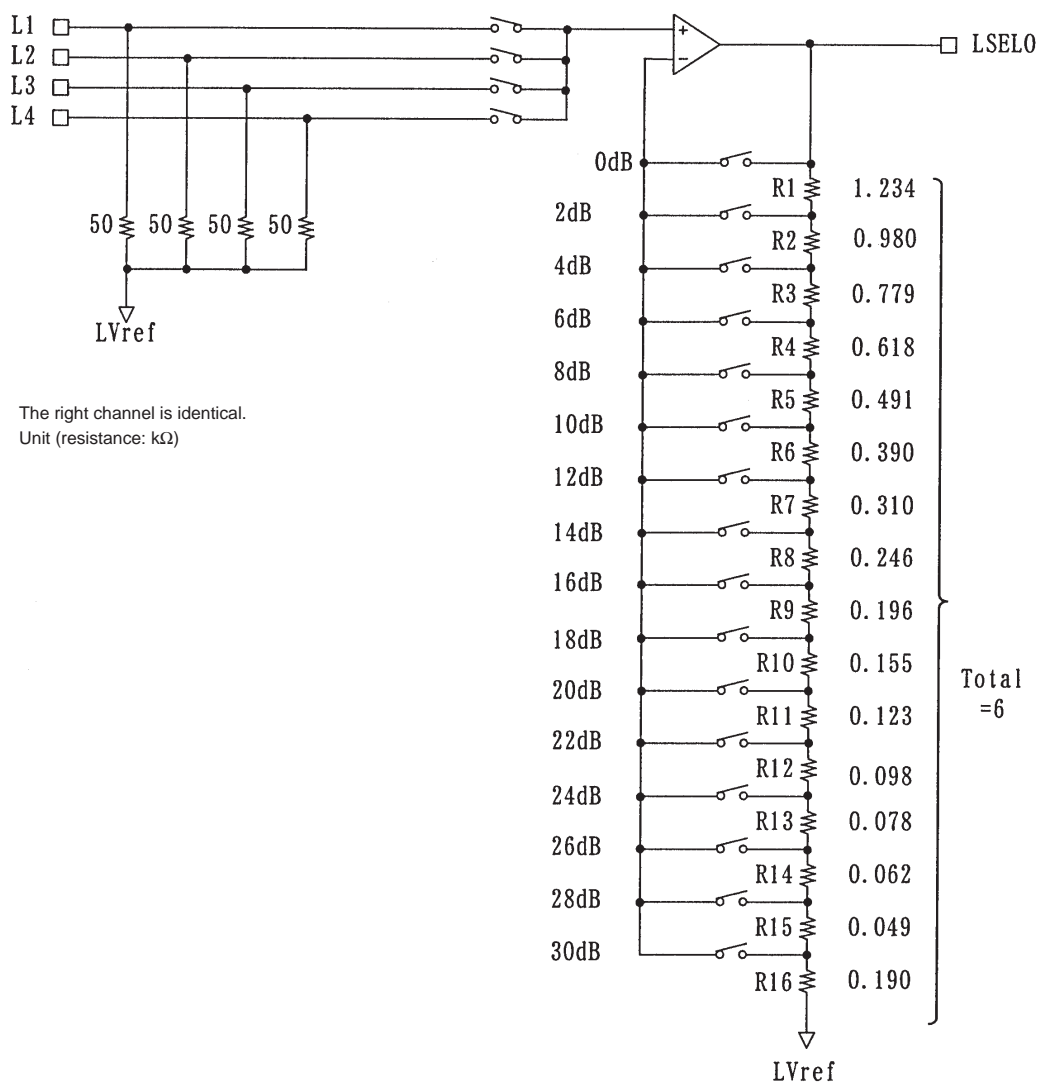
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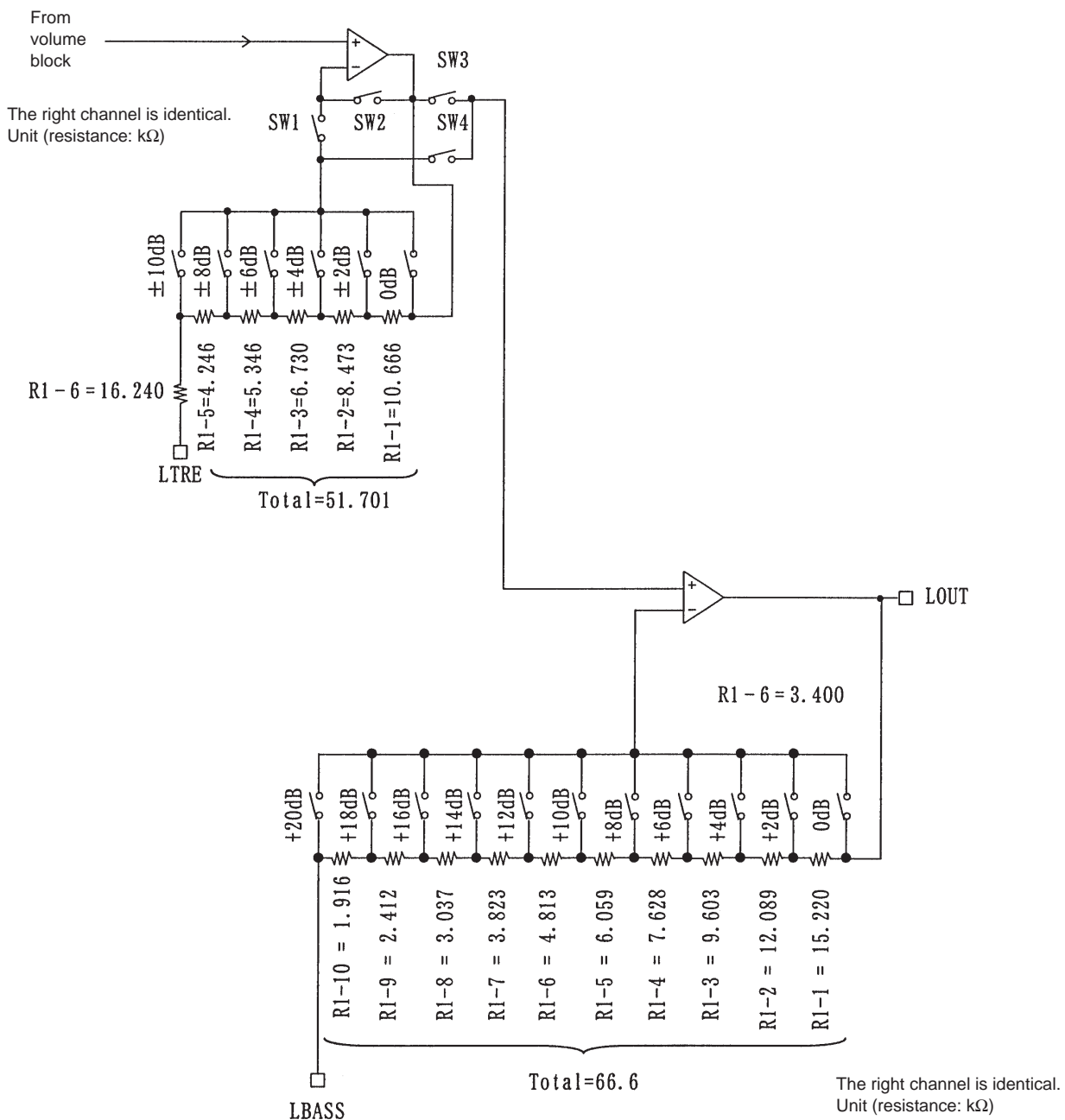
Pin No.	Pin	Description	Notes
3	V _{SS}	• Ground	
23	V _{DD}	• Power supply	
2	CE	• Chip enable Data is written to the internal latch when this pin goes from high to low. The internal analog switches operate at this point. Data transfer is enabled when this pin is high.	
1 24	DI CL	• Serial data and clock inputs used for IC control.	

Internal Equivalent Circuits

- Selector block equivalent circuit



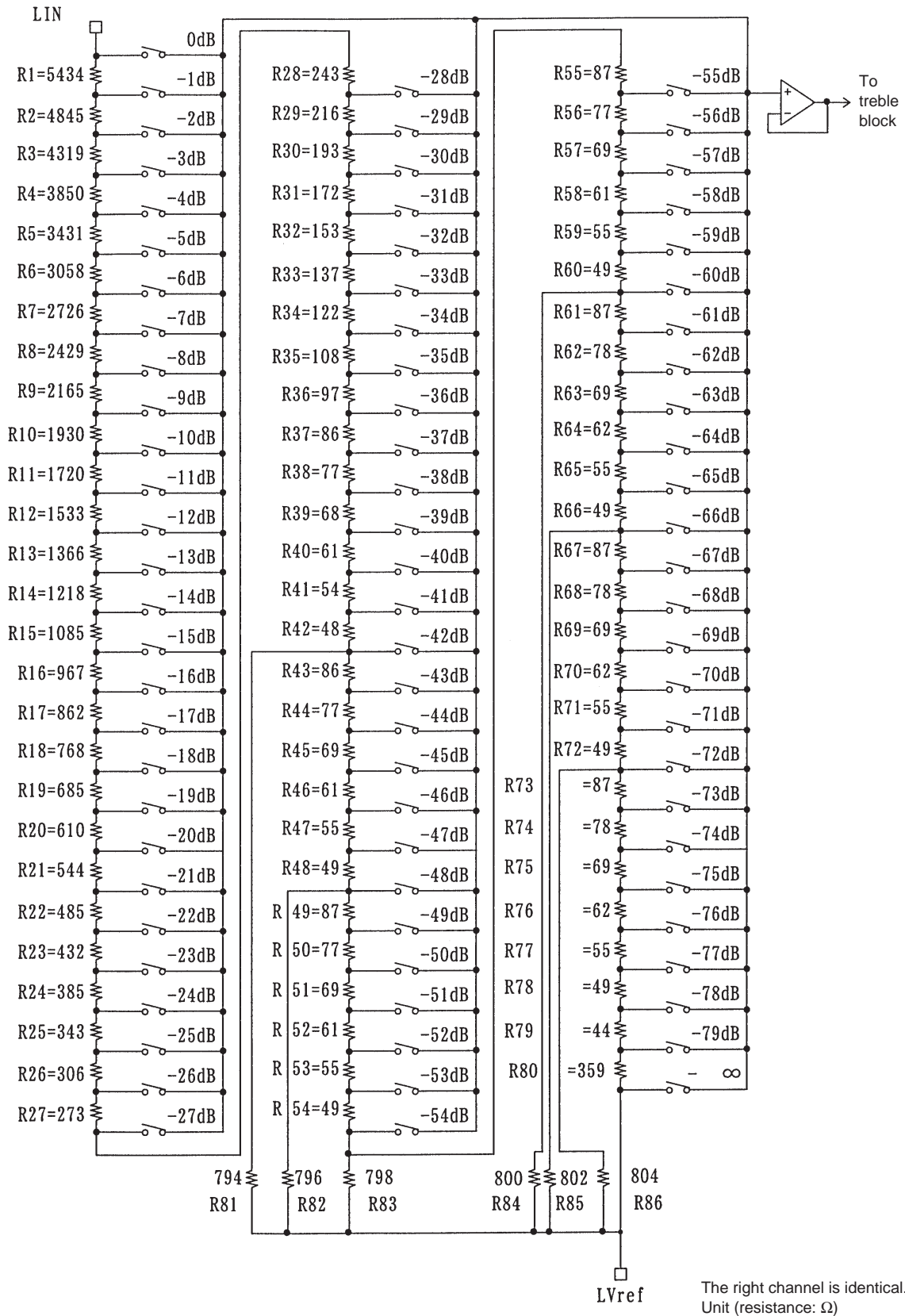
• Treble and bass band block internal equivalent circuit



Set switches SW1 and SW3 to the on position for boost, and set switches SW2 and SW4 to the on position for cut. For a flat (0 dB) response, set the 0dB SW, SW2, and SW3 switches on.

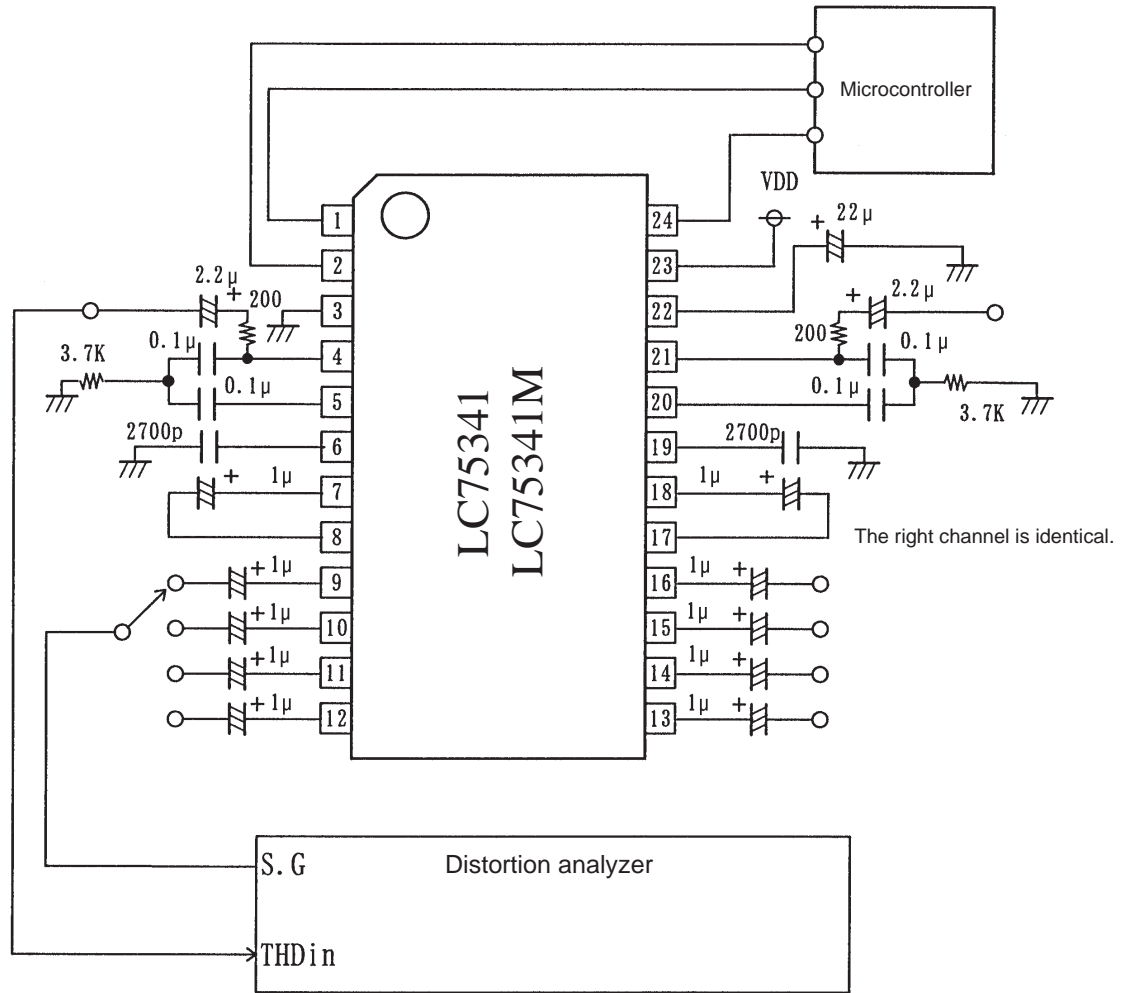
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- Volume block internal equivalent circuit



Test Circuits

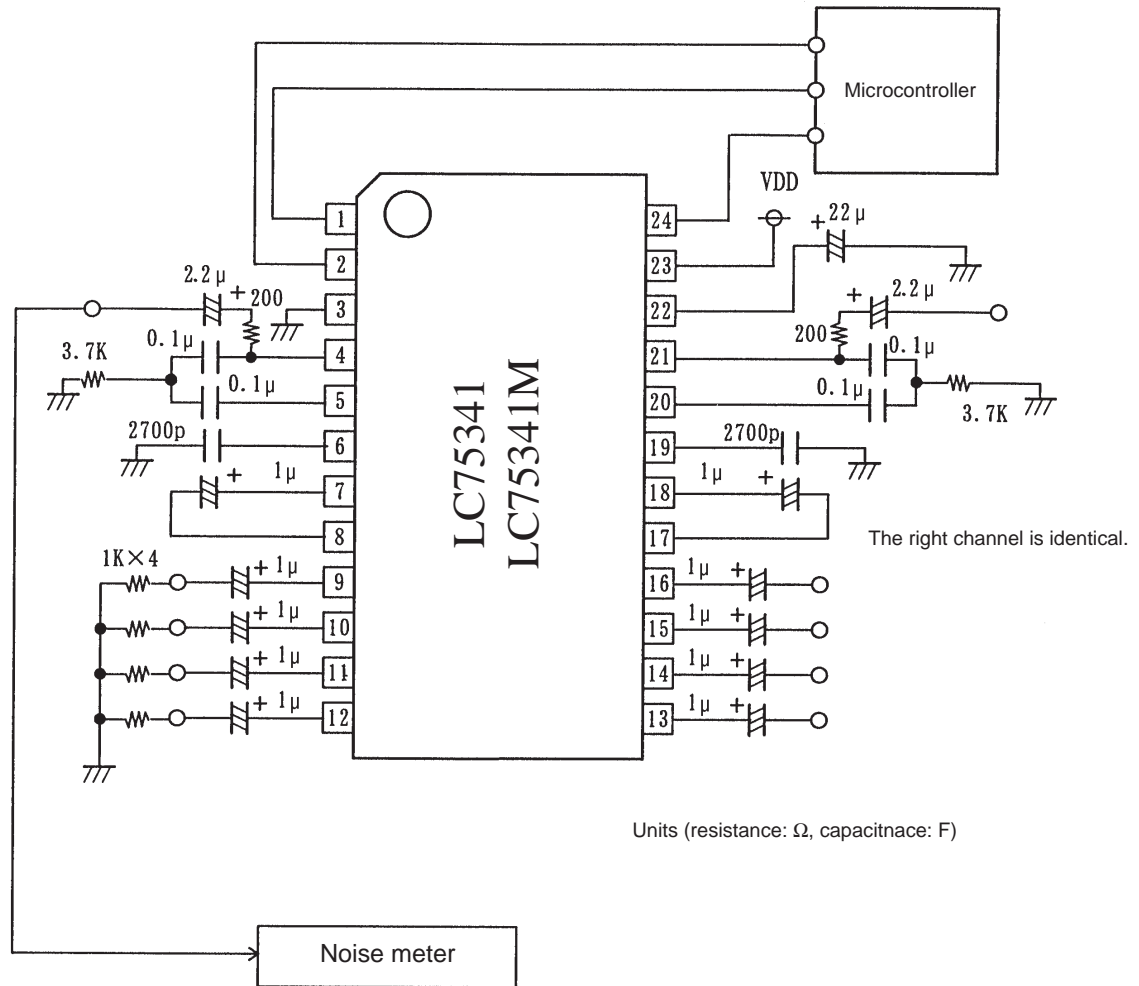
- Total harmonic distortion



Units (resistance: Ω, capacitance: F)

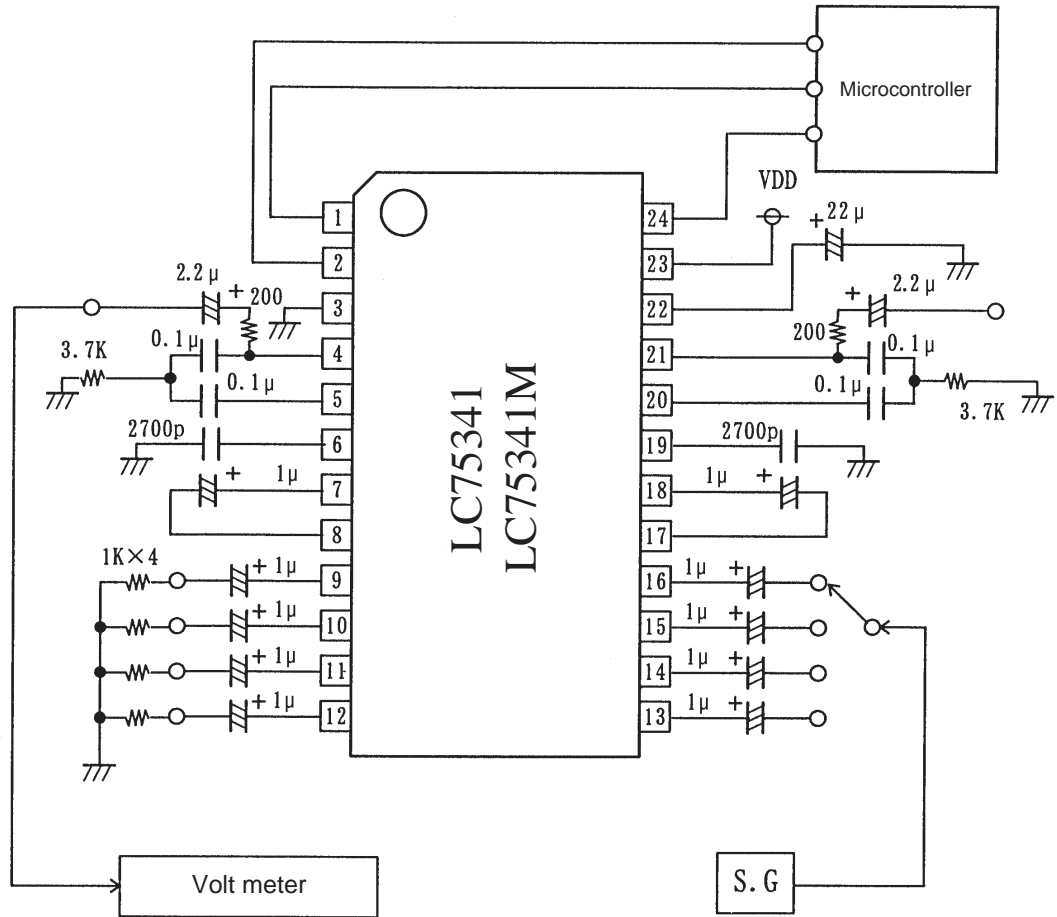
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- Output noise voltage



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- Crosstalk

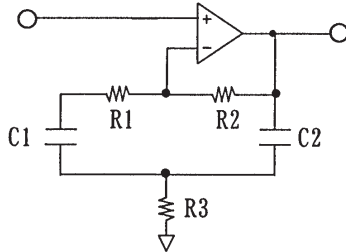


Units (resistance: Ω, capacitance: F)

Bass Band Circuit

This section presents the equivalent circuit and the calculations for the external capacitors and resistors used to achieve a center frequency of 100 Hz.

- Bass band equivalent circuit



- Sample calculation

Specifications Center frequency: $f_0 = 100 \text{ Hz}$
 Gain at maximum boost: $G = 20 \text{ dB}$
 Let $R_1 = 0$, $R_2 = 66.6 \text{ k}\Omega$, and $C_1 = C_2 = C$.

- (1) Determine R_2 from the fact that $G = 20 \text{ dB}$.

$$G_{+20\text{dB}} = 20 \times \text{LOG}_{10} \left(1 + \frac{R_2}{2R_3} \right)$$

$$R_3 = \frac{R_2}{2(10^{G_{+20\text{dB}}/20} - 1)} = \frac{66000}{2 \times (10 - 1)} \approx 3.7 \text{ k}\Omega$$

- (2) Determine C from the fact that the center frequency $f_0 = 100 \text{ Hz}$.

$$f_0 = \frac{1}{2\pi \sqrt{R_3 R_2 C_1 C_2}}$$

$$C = \frac{1}{2\pi f_0 \sqrt{R_3 R_2}} = \frac{1}{2\pi \times 100 \sqrt{66000 \times 3700}} \approx 0.1 \mu\text{F}$$

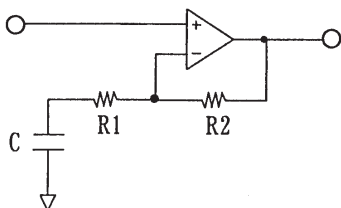
- (3) Determine Q .

$$Q = \frac{R_3 R_2}{2R_3} \cdot \frac{1}{\sqrt{R_3 R_2}} \approx 2.1$$

- Treble band circuit

The treble band circuit provides shelving characteristics.

This section presents the equivalent circuit in boost mode and the formulas used to calculate the external component values.



- Sample calculation

Specifications - Set frequency: $f = 26,000$ Hz

Gain at maximum boost: $G_{+10dB} = 10$ dB

Let $R1 = 16.240$ k Ω , $R2 = 35.461$ K Ω ,

Substitute the above constants into the following formulas.

$$G = 20 \times \text{LOG}_{10} \left(1 + \frac{R2}{\sqrt{R1^2 + (1 / \omega C)^2}} \right)$$

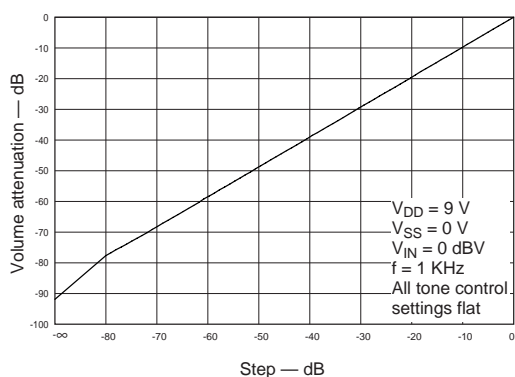
$$C = \frac{1}{2\pi f \sqrt{\left(\frac{R2}{10^{G/20} - 1} \right)^2 - R1^2}}$$

$$= \frac{1}{2\pi 26000 \sqrt{\left(\frac{35461}{3.16 - 1} \right)^2 - 16240^2}} \approx 2700 \text{ (pF)}$$

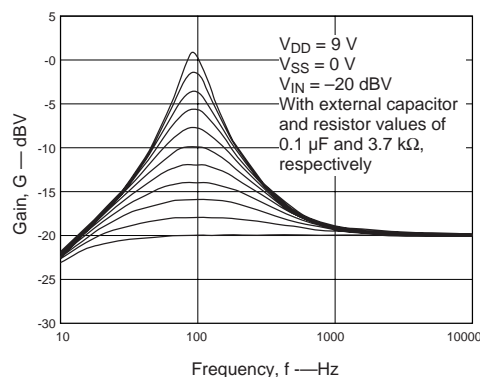
Usage Notes

- When power is first applied, the states of the internal analog switches will be undefined. Applications must provide external muting until the control data has been transferred and the switches set to appropriate states.
- Applications should transfer both the left and right channel initial settings data before releasing the muting function when initializing this IC after first applying power.
- Applications should cover the CL, DI, and CE pin lines with the ground pattern, or should use shielded cables for these lines to prevent the high-frequency digital signals transmitted over these lines from entering analog signal system.
- When the oscillation occurs, connect a resistor of at least 200 Ω to LOUT and ROUT pins.

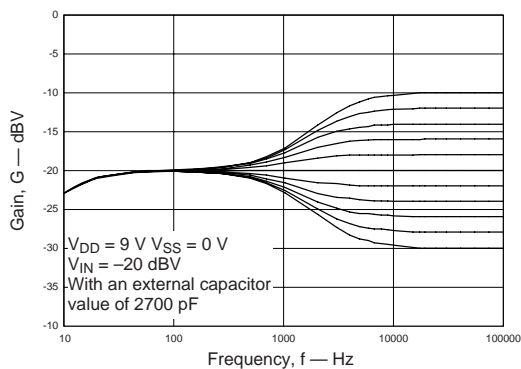
Volume Control Step Characteristics



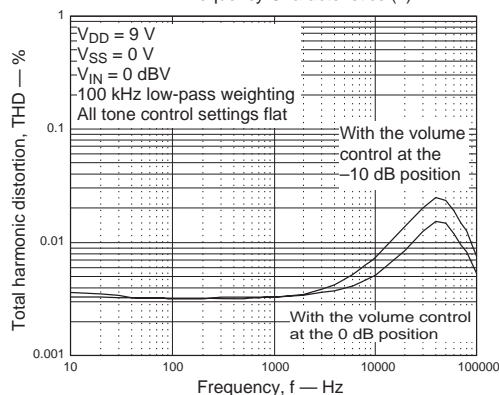
Bass Control Frequency Characteristics



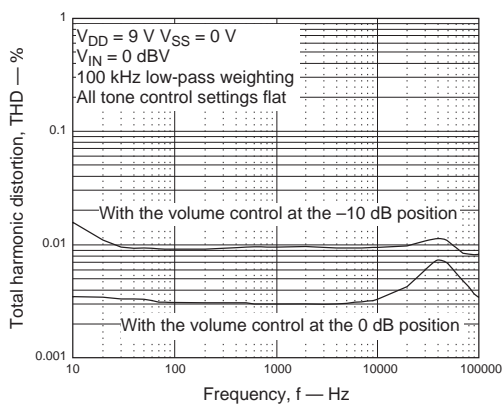
Treble Control Frequency Characteristics



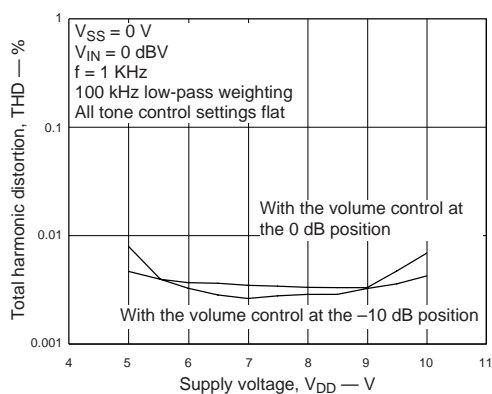
THD - Frequency Characteristics (1)



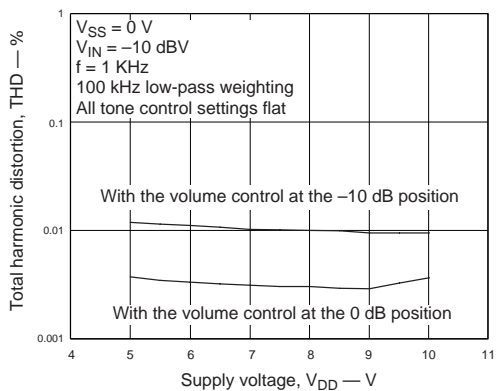
THD - Frequency Characteristics (2)



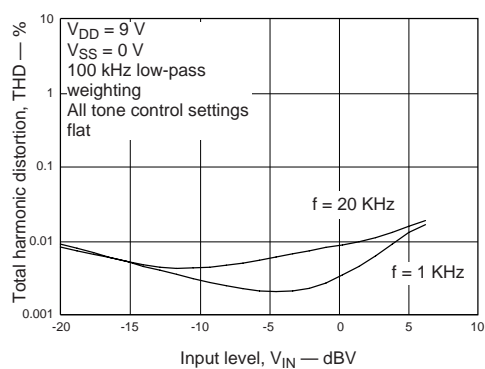
THD - Supply Voltage Characteristics (1)

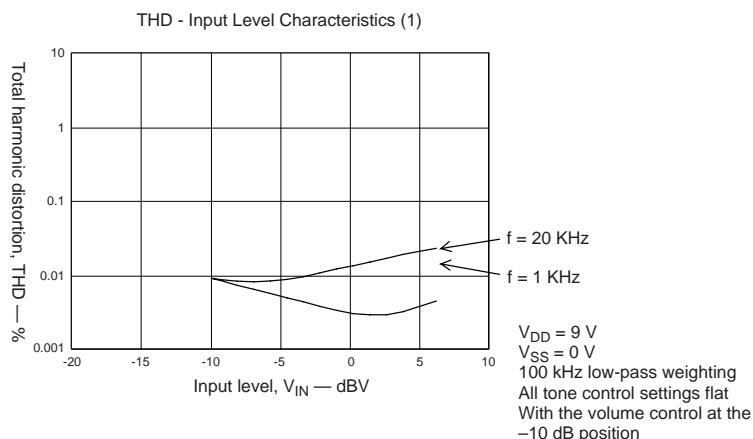


THD - Supply Voltage Characteristics (2)



THD - Input Level Characteristics (1)





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