



LC75345M

Electronic Volume Control System on-Chip



Overview

The LC75345M is an electronic volume system that can control the volume, balance, 2-band equalizer, super bass, and input switching functions by serial data input.

Functions

- Volume: 0 dB to -78 dB (1-dB step) and $-\infty$ (64 positions)
0 dB to -50 dB (1-dB step), -50 dB to -70 dB (2-dB step), -70-dB to -78 dB (4-dB step)
Balance function with separate L/R control
- Treble: ± 10 -dB control in 2-dB steps is possible.
Shelving characteristic.
- Bass: ± 10 -dB control in 2-dB steps is possible. Peaking characteristics.
- Super bass: +10-dB control in 2-dB steps is possible.
Peaking characteristics.
- Selector: 5 input signals can be selected both for L and R
- Input gain: 0 dB to +30 dB (2-dB step) amplification is possible for the input signal.
- General-purpose amp (ATT): 2 on-chip general-purpose amplifiers

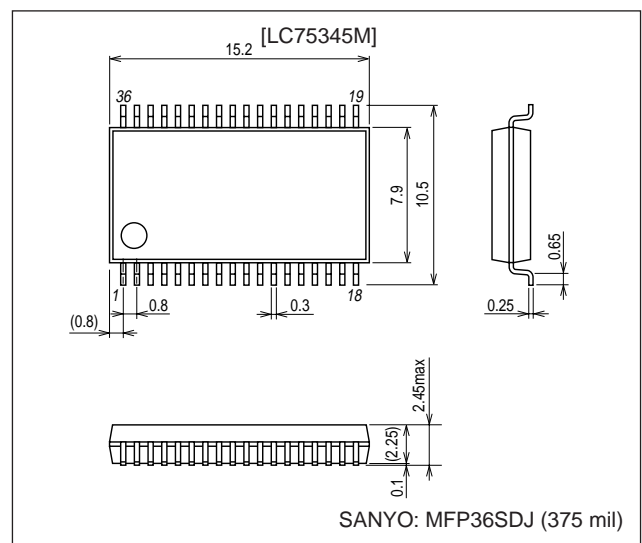
Features

- On-chip buffer amplifier cuts down number of external components
- Low switching noise generated by on-chip switch due to use of silicon gate CMOS process
- On-chip reference voltage circuit for analog ground
- Controls performed with serial data input (CCB)

Package Dimensions

unit: mm

3263-MFP36SDJ (375 mil)



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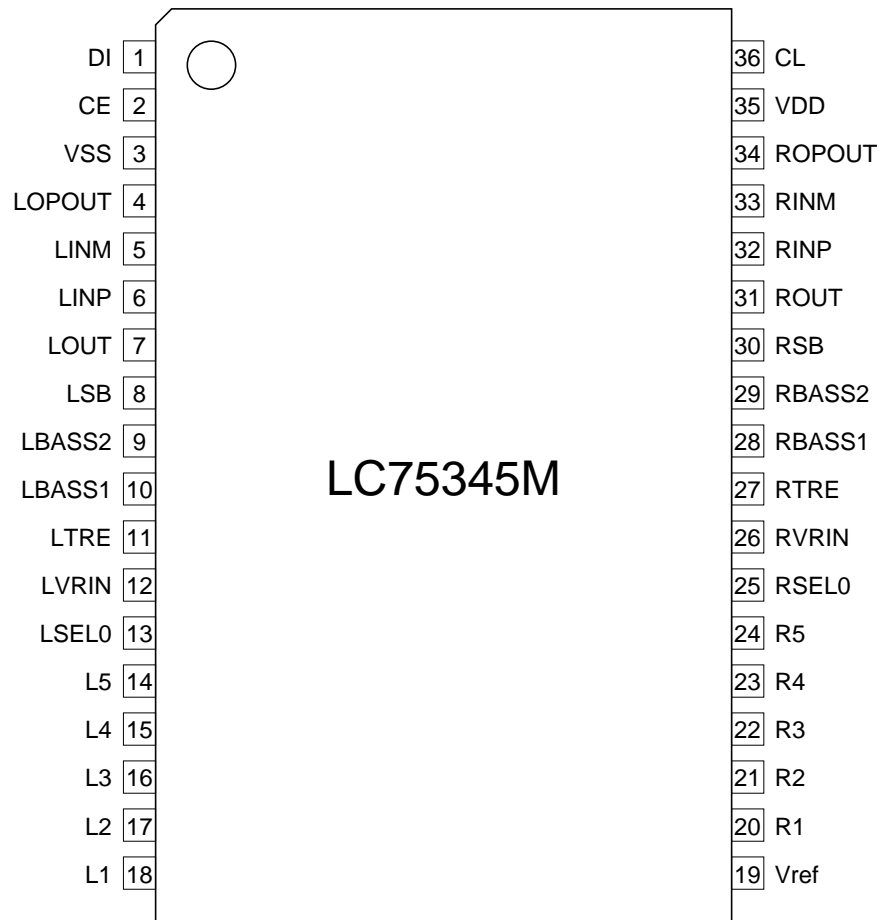
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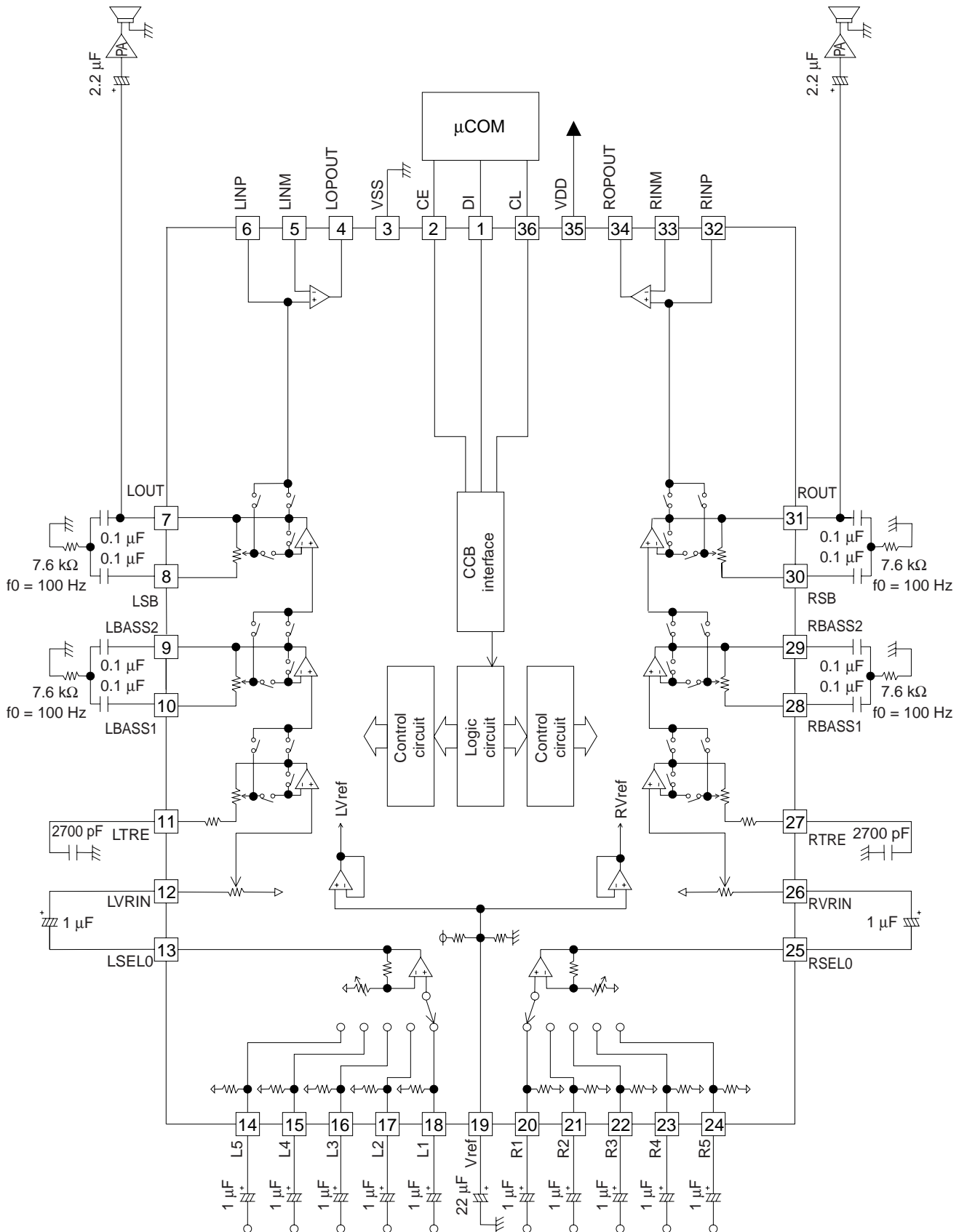
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Pin Assignment



Sample Application Circuit



Note: When a general-purpose amp is not used, leave the LINP (RINP) open and connect the LINM (RINM) with the LOPOUT (ROPOUT).

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Specifications

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

Parameter	Symbol	Pin Name	Conditions	Ratings	Unit
Maximum supply voltage	$V_{DD\text{ max}}$	V_{DD}		10.5	V
Maximum input voltage	$V_{IN\text{ max}}$	CE, DI, CL		-0.3 to 10.5	V
		L1 to L5, R1 to R5, LVRIN, RVRIN, LINP, RINP, LINM, RINM		$V_{SS} - 0.3$ to $V_{DD} + 0.3$	V
Allowable power dissipation	P_{dmax}		*1 $T_a \leq 75^\circ\text{C}$, independent IC	520	mW
Operating temperature	T_{opr}			-30 to +75	$^\circ\text{C}$
Storage temperature	T_{stg}			-40 to +125	$^\circ\text{C}$

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

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Supply voltage	V_{DD}	V_{DD}		4.5		9	V
Input high-level voltage	V_{IH}	CL, DI, CE		2.0		9	V
Input low-level voltage	V_{IL}	CL, DI, CE	$7.5 \leq V_{DD} \leq 9$	V_{SS}		0.8	V
			$4.5 \leq V_{DD} \leq 7.5$	V_{SS}		0.3	
Input amplitude voltage	V_{IN}	L1 to L5, R1 to R5, LVRIN, RVRIN, LINP, RINP, LINM, RINM		V_{SS}		V_{DD}	Vp-p
Input pulse width	$t_{\phi W}$	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 $T_a = 25^\circ\text{C}$, $V_{DD} = 8\text{ V}$, $V_{SS} = 0\text{ V}$

Input block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Maximum input gain	G_{inmax}				+30		dB
Step resolution	G_{step}				+2		dB
Input resistance	R_{in}	L1, L2, L3, L4, L5 R1, R2, R3, R4, R5			50		$\text{k}\Omega$
Clipping level	V_{cl}	LSEL0, RSEL0	THD = 1.0%, $f = 1\text{ kHz}$		2.50		Vrms
Output load resistance	R_l	LSEL0, RSEL0		10			$\text{k}\Omega$

Volume block

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

Treble band equalizer control block

Parameter	Symbol	Pin Name	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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Bass band equalizer control block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Control range	Geq		max. boost/cut	±8	±10	±12	dB
Step resolution	Estep			1	2	3	dB
Internal feedback resistance	Rfeed				33.1		kΩ

Super bass band equalizer control block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Control range	Geq		max. boost	+8	+10	+12	dB
Step resolution	Estep			1	2	3	dB
Internal feedback resistance	Rfeed				33.1		kΩ

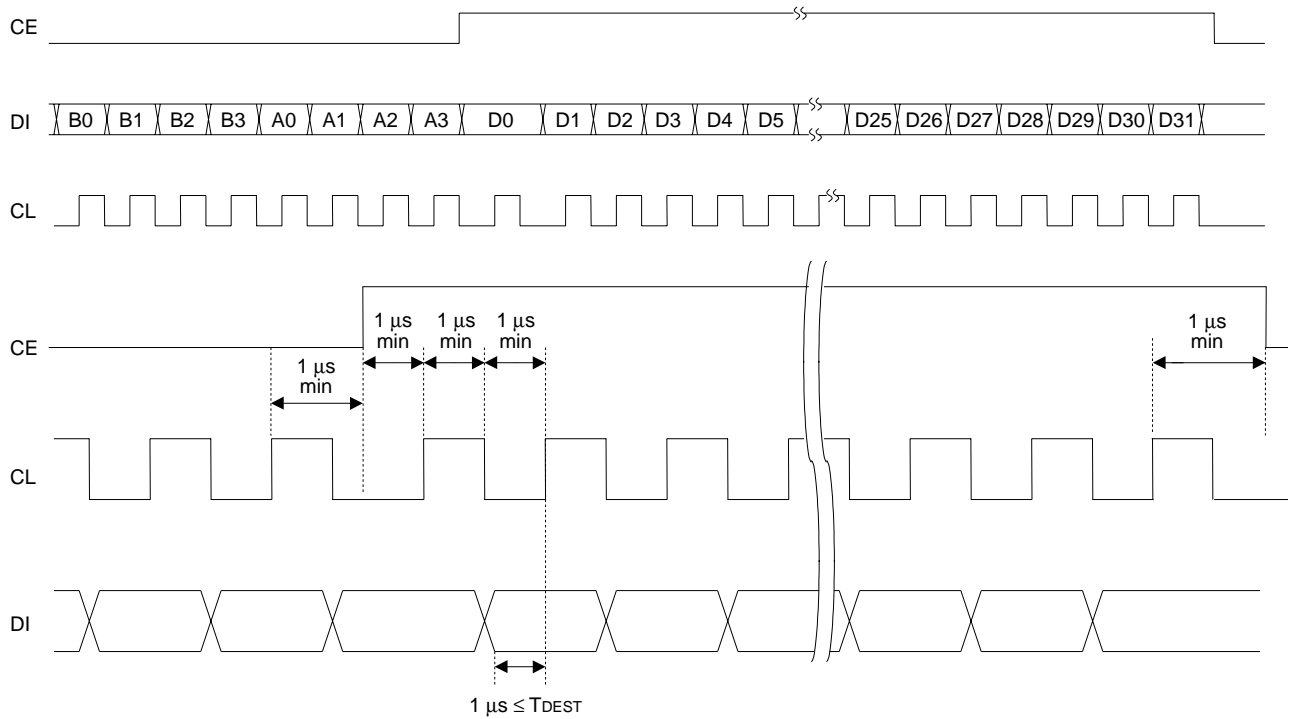
General

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Total harmonic distortion	THD	$V_{IN} = 1 \text{ V}_{rms}$, $f = 1 \text{ KHz}$, total flat overall			0.01	%
Crosstalk	CT	$V_{IN} = 1 \text{ V}_{rms}$, $f = 1 \text{ KHz}$, $R_g = 1 \text{ k}\Omega$, total flat overall	80			dB
Output noise voltage	VN	Flat overall, 80 kHz L.P.F	9.3		μV	
Maximum attenuated output	Vomin	Flat overall, $f = 1 \text{ kHz}$		-90		dB
Current drain	I_{DD}	$V_{DD} - V_{SS} = +9 \text{ V}$		40		mA
Input high-level current	I_{IH}	CL, DI, CE: $V_{IN} = 9 \text{ V}$			10	μA
Input low-level current	I_{IL}	CL, DI, CE: $V_{IN} = 0 \text{ V}$	-10			μA

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Control Timing and Data Format

To control the LC75345M, input specified serial data to the CL, DI, and CE pins. The data configuration consists of a total of 40 bits broken down into 8 address bits and 32 data bits.



- Address Code (B0 to A3)

The LC75345M has an 8-bit address code and common specifications with a SANYO serial bus CCB IC are possible.

Address code (LSB)	B0	B1	B2	B3	A0	A1	A2	A3	(82HEX)
	0	1	0	0	0	0	0	1	

• Control Code Allocation

Input switching control

(L1, L2, L3, L4, L5, R1, R2, R3, R4, R5)

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	L5 (R5) on
1	0	1	0	Analog ground connection
0	1	1	0	Test mode
1	1	1	0	Must not be used in normal operation.

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	Operation
0	0	0	0	0	0	0 dB
1	0	0	0	0	0	-1 dB
0	1	0	0	0	0	-2 dB
1	1	0	0	0	1	-3 dB
0	0	1	0	0	0	-4 dB
1	0	1	0	0	0	-5 dB
0	1	1	0	0	0	-6 dB
1	1	1	0	0	0	-7 dB
0	0	0	1	0	0	-8 dB
1	0	0	1	0	0	-9 dB
0	1	0	1	0	0	-10 dB
1	1	0	1	0	0	-11 dB
0	0	1	1	0	0	-12 dB
1	0	1	1	0	0	-13 dB
0	1	1	1	0	0	-14 dB
1	1	1	1	0	0	-15 dB
0	0	0	0	1	0	-16 dB
1	0	0	0	1	0	-17 dB
0	1	0	0	1	0	-18 dB
1	1	0	0	1	0	-19 dB
0	0	1	0	1	0	-20 dB
1	0	1	0	1	0	-21 dB
0	1	1	0	1	0	-22 dB
1	1	1	0	1	0	-23 dB
0	0	0	1	1	0	-24 dB
1	0	0	1	1	0	-25 dB
0	1	0	1	1	0	-26 dB
1	1	0	1	1	0	-27 dB
0	0	1	1	1	0	-28 dB
1	0	1	1	1	0	-29 dB
0	1	1	1	1	0	-30 dB
1	1	1	1	1	0	-31 dB
0	0	0	0	0	1	-32 dB
1	0	0	0	0	1	-33 dB
0	1	0	0	0	1	-34 dB
1	1	0	0	0	1	-35 dB
0	0	1	0	0	1	-36 dB
1	0	1	0	0	1	-37 dB
0	1	1	0	0	1	-38 dB
1	1	1	0	0	1	-39 dB
0	0	0	1	0	1	-40 dB
1	0	0	1	0	1	-41 dB
0	1	0	1	0	1	-42 dB
1	1	0	1	0	1	-43 dB
0	0	1	1	0	1	-44 dB
1	0	1	1	0	1	-45 dB
0	1	1	1	0	1	-46 dB
1	1	1	1	0	1	-47 dB
0	0	0	0	1	1	-48 dB
1	0	0	0	1	1	-49 dB
0	1	0	0	1	1	-50 dB

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D8	D9	D10	D11	D12	D13	Operation
1	1	0	0	1	1	-52 dB
0	0	1	0	1	1	-54 dB
1	0	1	0	1	1	-56 dB
0	1	1	0	1	1	-58 dB
1	1	1	0	1	1	-60 dB
0	0	0	1	1	1	-62 dB
1	0	0	1	1	1	-64 dB
0	1	0	1	1	1	-66 dB
1	1	0	1	1	1	-68 dB
0	0	1	1	1	1	-70 dB
1	0	1	1	1	1	-74 dB
0	1	1	1	1	1	-78 dB
1	1	1	1	1	1	-∞ dB

Channel selection

D14	D15	Operation
1	0	Right channel
0	1	Left channel
1	1	L/R simultaneous

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

Bass control

D20	D21	D22	D23	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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Super bass control

D24	D25	D26	D27	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

D28 to D31 test mode

(Fixed to 0)

D28	D29	D30	D31	Operation
0	0	0	0	

Pin Functions

Pin No.	Pin Name	Function	Equivalent circuit
18 17 16 15 14 20 21 22 23 24	L1 L2 L3 L4 L5 R1 R2 R3 R4 R5	• Input signal pins	
13 25	LSEL0 RSEL0	• Input selector output pins	
10 9 28 29 8 30	LBASS1 LBASS2 RBASS1 RBASS2 LSB RSB	• Capacitor and resistor connection pins for configuring filter, used for bass and super bass band	
7 31	LOUT ROUT	• ATT + equalizer output pins/Capacitor connection pins used to configure super bass filter	
12 26	LVRIN RVRIN	• Volume input pins	
11 27	LTRE RTRE	• Capacitor connection pins for configuring treble band filter	

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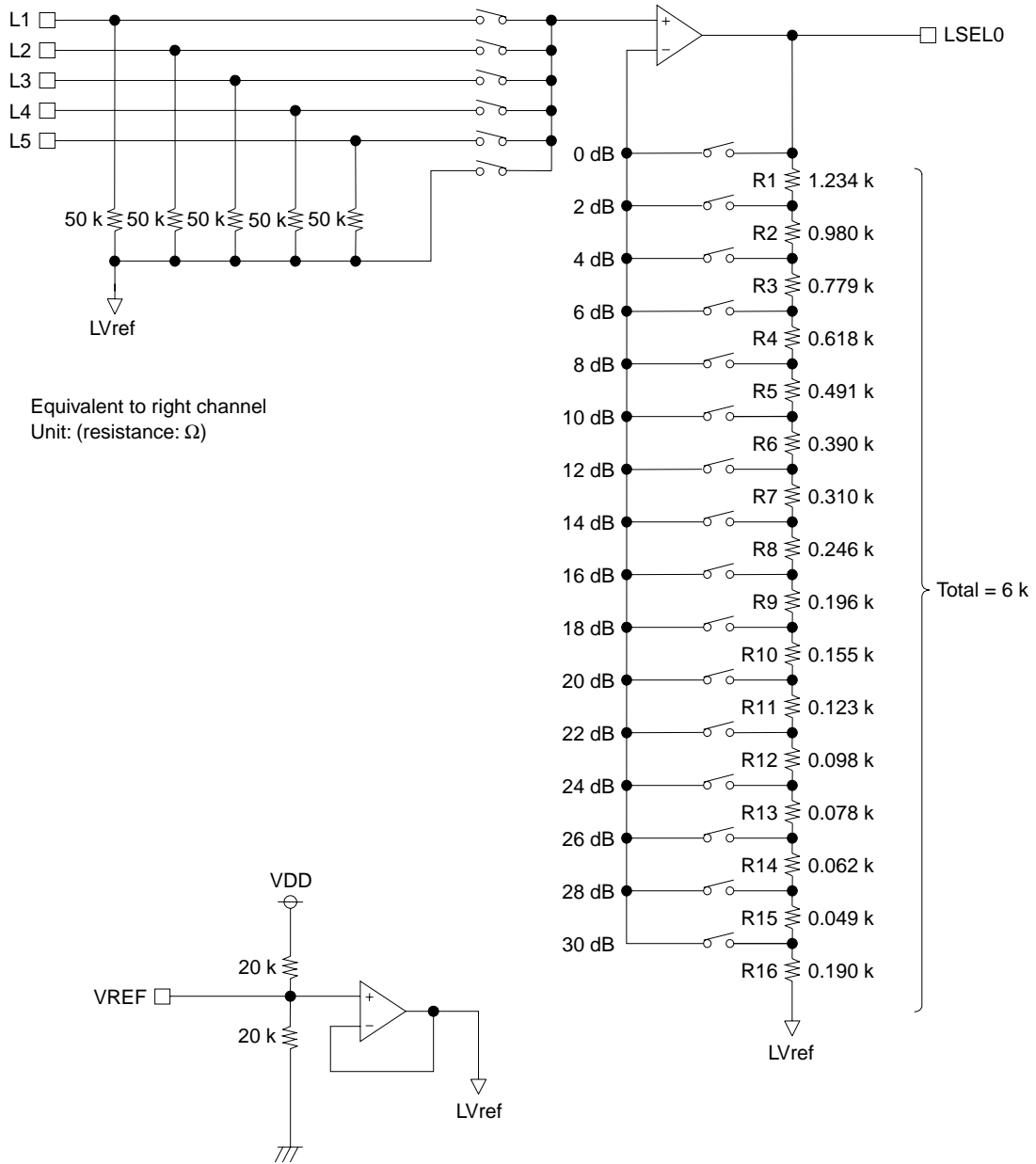
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Pin No.	Pin Name	Function	Equivalent circuit
19	Vref	<ul style="list-style-type: none"> Connect a capacitor of a few tens of μF between Vref and AV_{SS} (V_{SS}) as a analog ground $0.5 \times V_{\text{DD}}$ voltage generator, current ripple countermeasure. 	
3	V _{SS}	<ul style="list-style-type: none"> Ground pin 	
35	V _{DD}	<ul style="list-style-type: none"> Power supply pin 	
2	CE	<ul style="list-style-type: none"> Chip enable pin <p>Data is written to the internal latch and the analog switches are operated when the level changes from high to low. Data transfer is enabled when the level is high.</p>	
1 36	DI CL	<ul style="list-style-type: none"> Serial data pins and clock input pin for control 	
6 32	LINP RINP	<p>Non-inverted input pins of general-purpose op-amp</p> <p>When not used, leave open.</p>	
5 33	LINM RINM	<p>Inverted input pins of general-purpose op-amp.</p> <p>When not used, connect these pins to the L(R) OPOUT Pins.</p> <p>(Connected between pin 5 and pin 4)</p> <p>(Connected between pin 33 and pin 34)</p>	
4 34	LOPOUT ROPOUT	<p>General-purpose op-amp output pins.</p> <p>When not used, connect these pins to the L(R) INM pins.</p> <p>(Connected between pin 5 and pin 4)</p> <p>(Connected between pin 33 and pin 34)</p>	

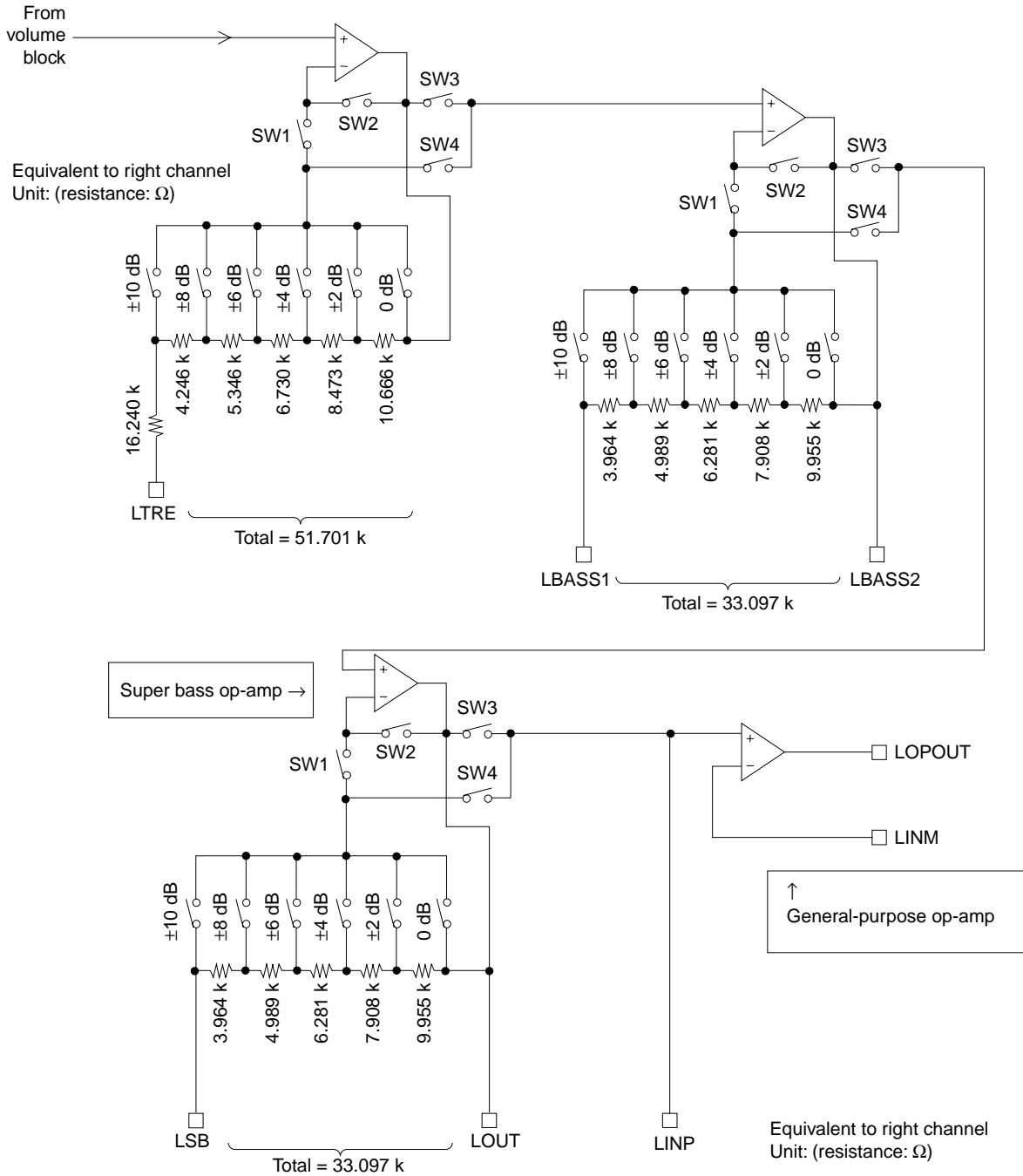
Equivalent Circuit

- Selector Block/Reference Voltage Generator



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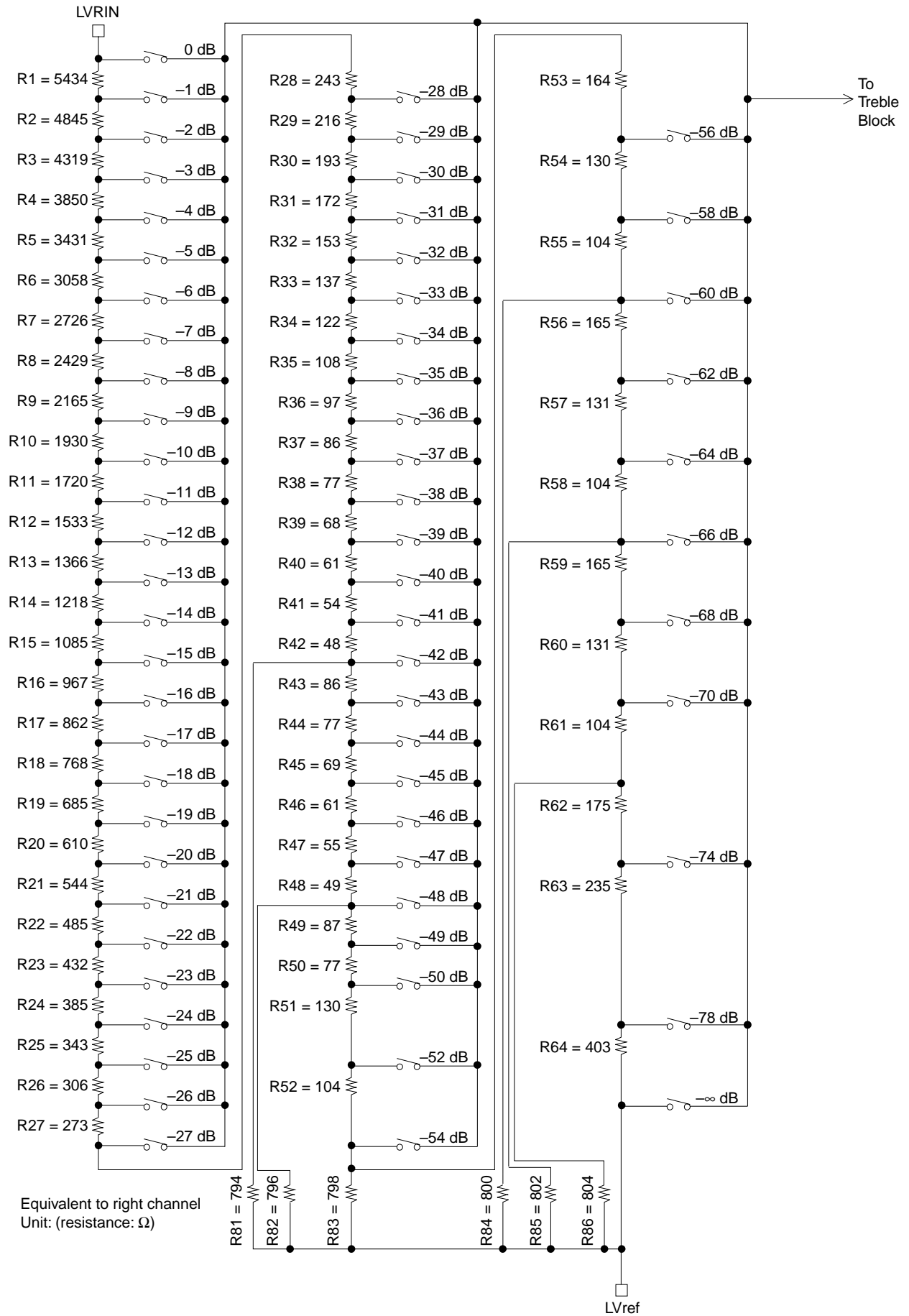
• Treble/Bass/Super Bass Band Multi-Purpose Op Amp



During boost, SW1 and SW3 are on, during cut, SW2 and SW4 are on, when 0 dB, 0dB SW and SW2 and SW3 are on. SW3, SW4 of super bass block are always off.

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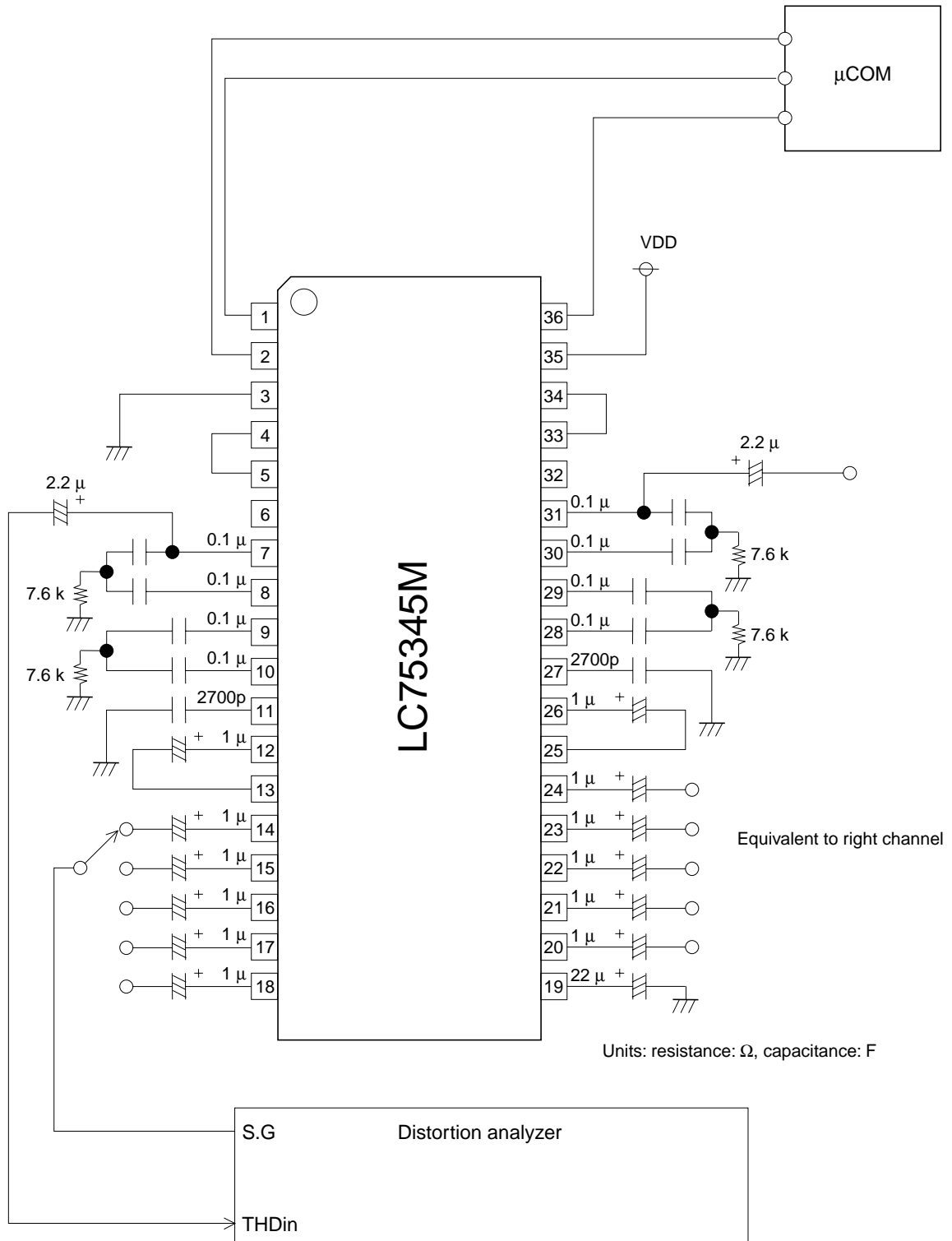
• Volume Block



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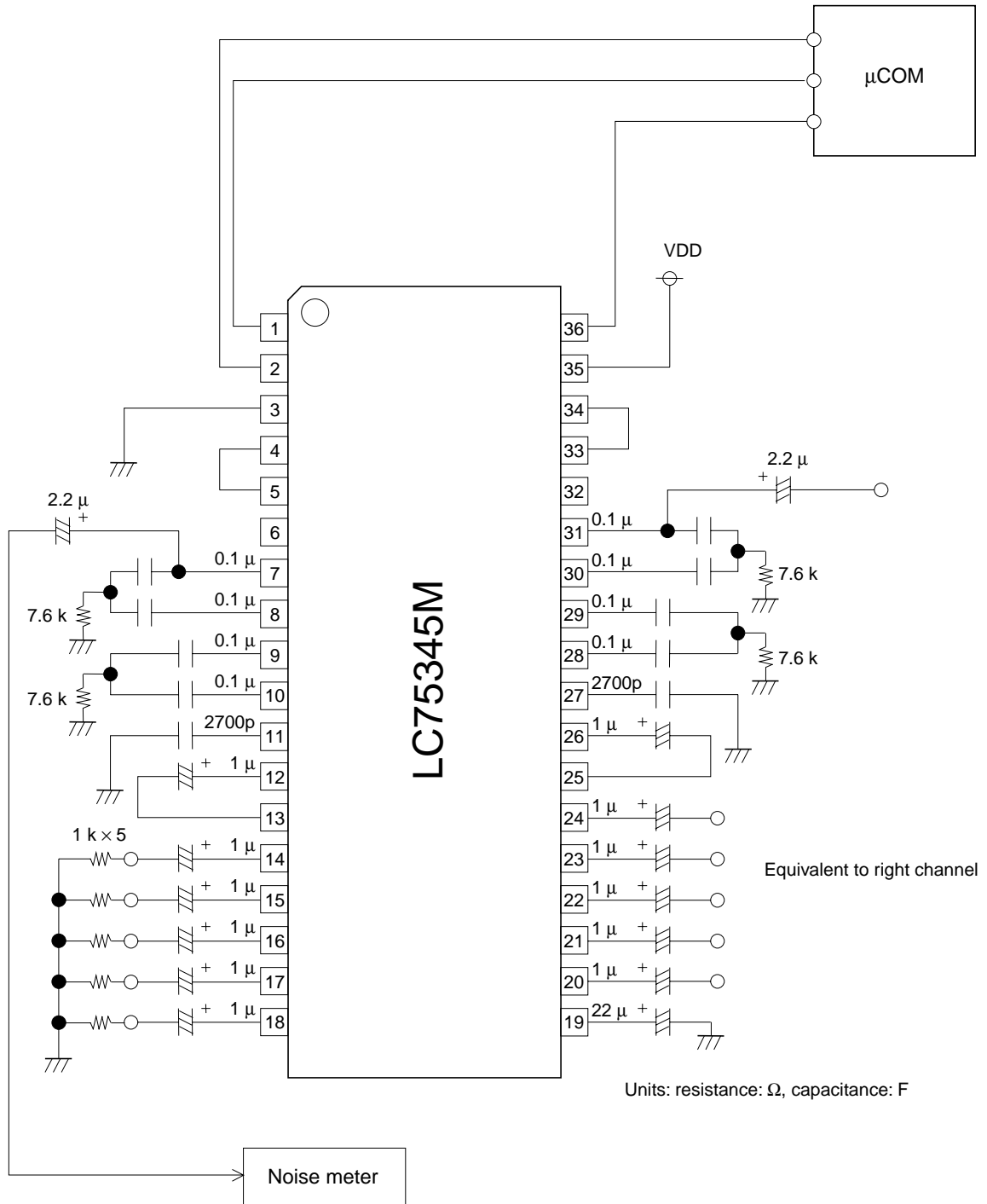
Test Circuit

- Total Harmonic Distortion



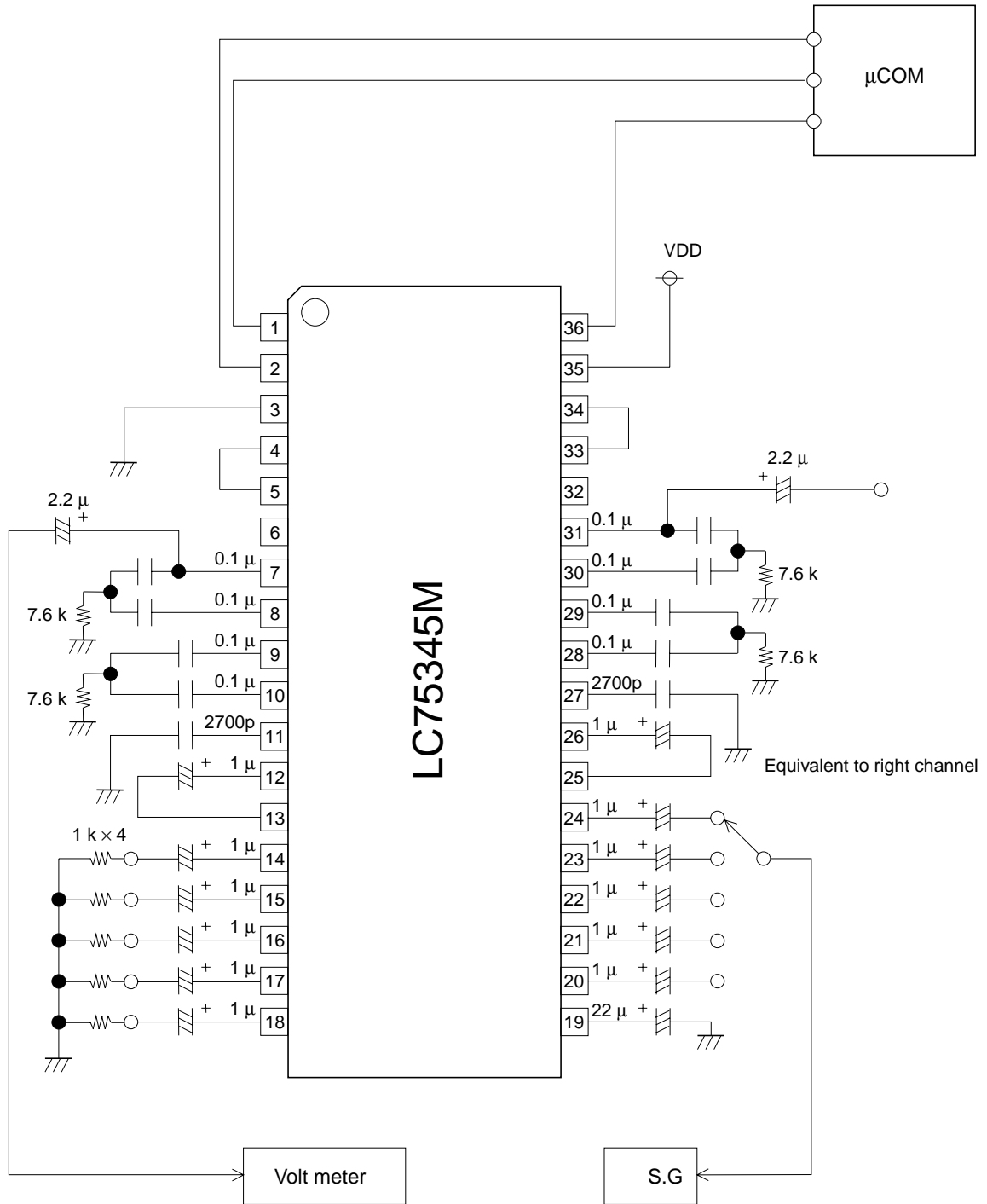
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• Output Noise Voltage



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- Crosstalk



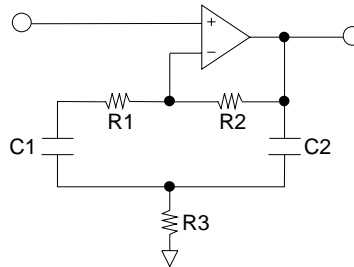
Units: resistance: Ω , capacitance: F

Calculation of External Equalizer Constant

Bass/Super Bass Circuit

The equivalent circuit and the formula for calculating the external RC with a mean frequency of 100 Hz are shown below.

- Bass/super bass band equivalent circuit block diagram



- Calculation example

Specification Mean frequency: $f_0 = 100 \text{ Hz}$

Gain during maximum boost: $G = 10 \text{ dB}$

Using $R_1 = 0$, $R_2 = 33.097 \text{ k}\Omega$, and $C_1 = C_2 = C$,

We obtain R_2 from $G = 10 \text{ dB}$.

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

$$R_3 = \frac{R_2}{2(10^{G+10\text{dB}/20} - 1)} = \frac{33097}{2 \times (3.162 - 1)} \approx 7.6 \text{ K}\Omega$$

We obtain C from mean frequency $f_0 = 100 \text{ Hz}$.

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

$$C = \frac{1}{2\pi f_0 \sqrt{R_3 R_2}} = \frac{1}{2\pi \times 100 \sqrt{33097 \times 7600}} \approx 0.01 \mu\text{F}$$

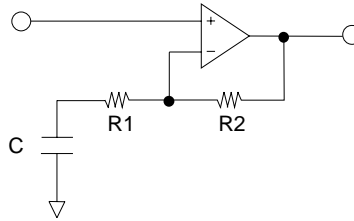
We obtain Q .

$$Q = \frac{R_3 R_2}{2R_3} \frac{1}{\sqrt{R_3 R_2}} \approx 1.04$$

Treble Band Circuit

The shelving characteristics can be obtained for the treble band.

The equivalent circuit and calculation formula during boost are indicated below.



• Calculation example

Specification Set frequency: $f = 26000 \text{ Hz}$

Gain during maximum boost: $G_{+10 \text{ dB}} = 10 \text{ dB}$

Using $R1 = 16.240 \text{ k}\Omega$ and $R2 = 35.461 \text{ k}\Omega$, and inserting the above values in the following formula, we

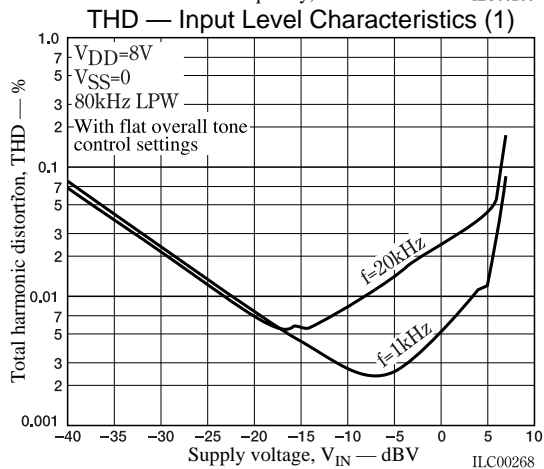
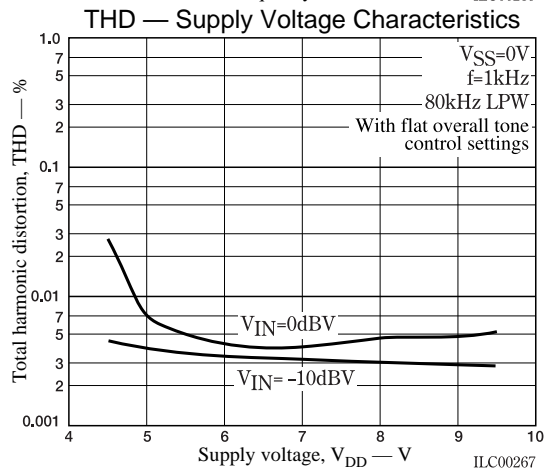
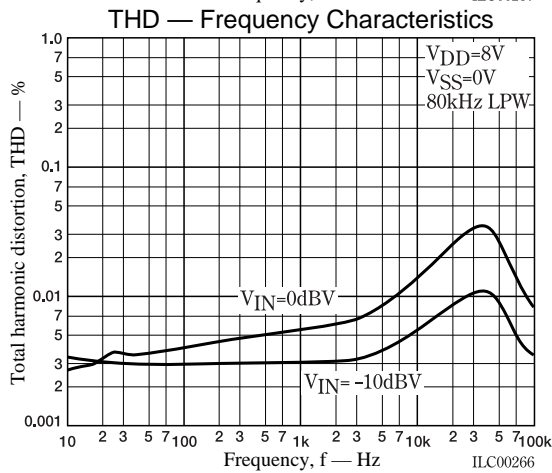
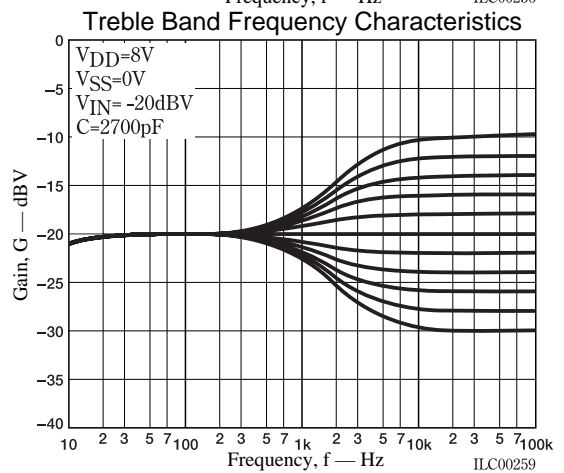
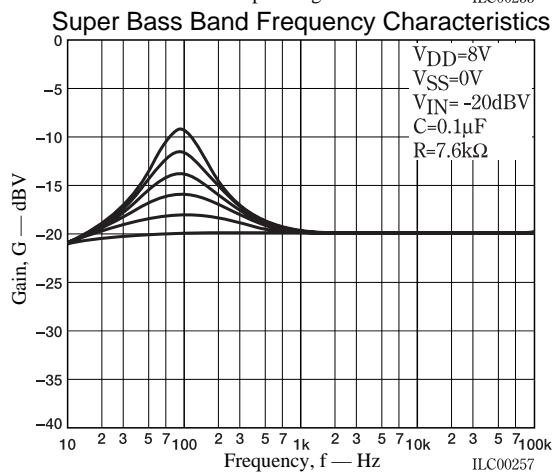
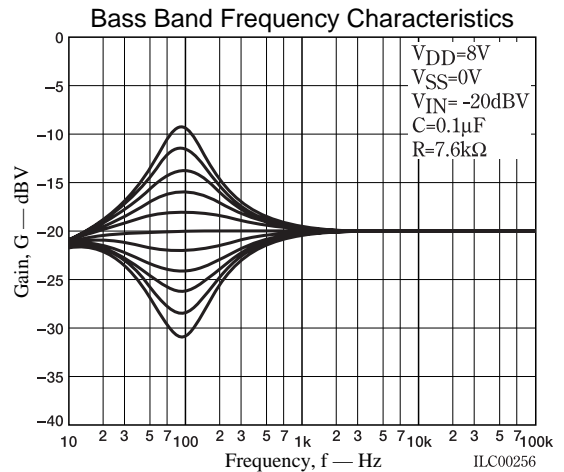
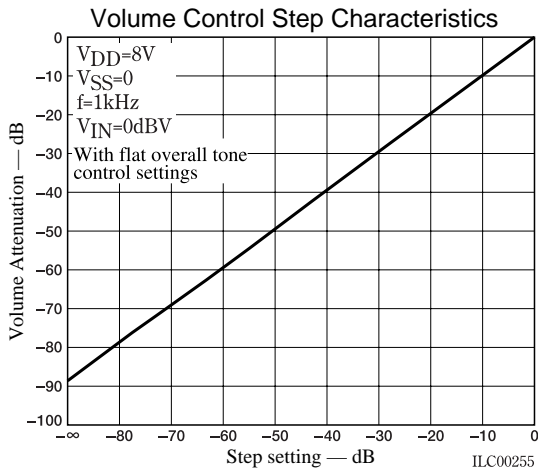
$$G = 20 \times \text{LOG}_{10} \left(1 + \frac{R2}{\sqrt{R1^2 + (1 / \omega C)^2}} \right)$$

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

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

Usage Cautions

- Upon power application, the internal analog switch status is undefined. Use an external countermeasure such as muting until data is set.
- When performing initial setting after applying power, send the initial setting data for the left and right channels prior to canceling mute.
- To ensure that the high-frequency digital signals sent to the CL, DI, and CE pins do not spill over to the analog signal block, either guard these signal lines with a ground pattern, or perform transmission using shielded wires.



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