Ordering number : ENN6866

CMOS IC

LC75421M

Electronic Volume Controller for Cars

Overview

The LC75421M is an electronic volume controller that enables control of volume, balance, fader, bass/treble + super bass, input switching, and input and output level control functions using only a small number of external components.

Functions

- Volume: 0 dB to –79 dB in 1-dB steps, and –∞ (81 positions)
  Balance function with separate L/R control
- Fader: rear output or front output can be attenuated across 16 positions (in 2-dB steps from 0 dB to -20 dB, 5-dB steps from –20 dB to –25 dB, 10-dB steps from –25 dB to –45 dB, and –60 dB, –∞)
- Bass/treble: A tone control circuit can be configured using an external RC, with 15-position control from 0 dB to ±11.9 dB in 1.7-dB steps possible for both bass and treble
- Input gain: 0 dB to +18.75 dB (1.25-dB steps) amplification is possible for the input signal.
- Output gain: Fader output can be selected among 0 dB, +6.5 dB, and +8.5 dB.
- Input switching: Five input signals can be selected for Left and for Right
- Super bass: Step control with 11 positions is possible, with peaking characteristics (type T)

Features

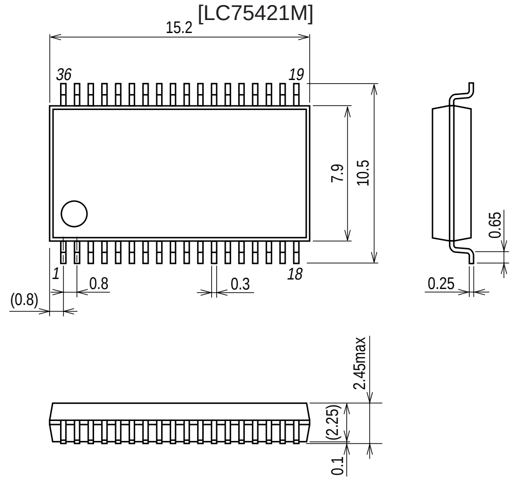
- On-chip buffer amplifier cuts down number of external components
- Low switching noise generated by on-chip switch due to use of silicon gate CMOS process
- On-chip reference voltage circuit for analog ground
- Controls performed with serial input (CCB)

Package Dimensions

unit: mm

3263-MFP36SDJ (375 mil)

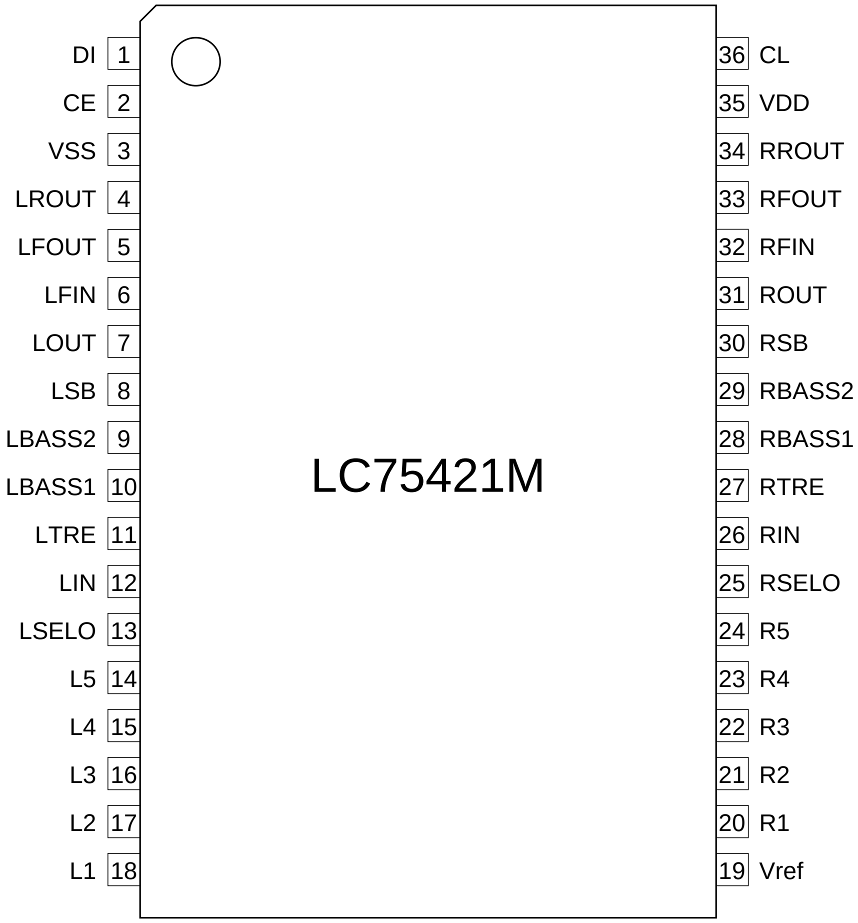
[LC75421M]



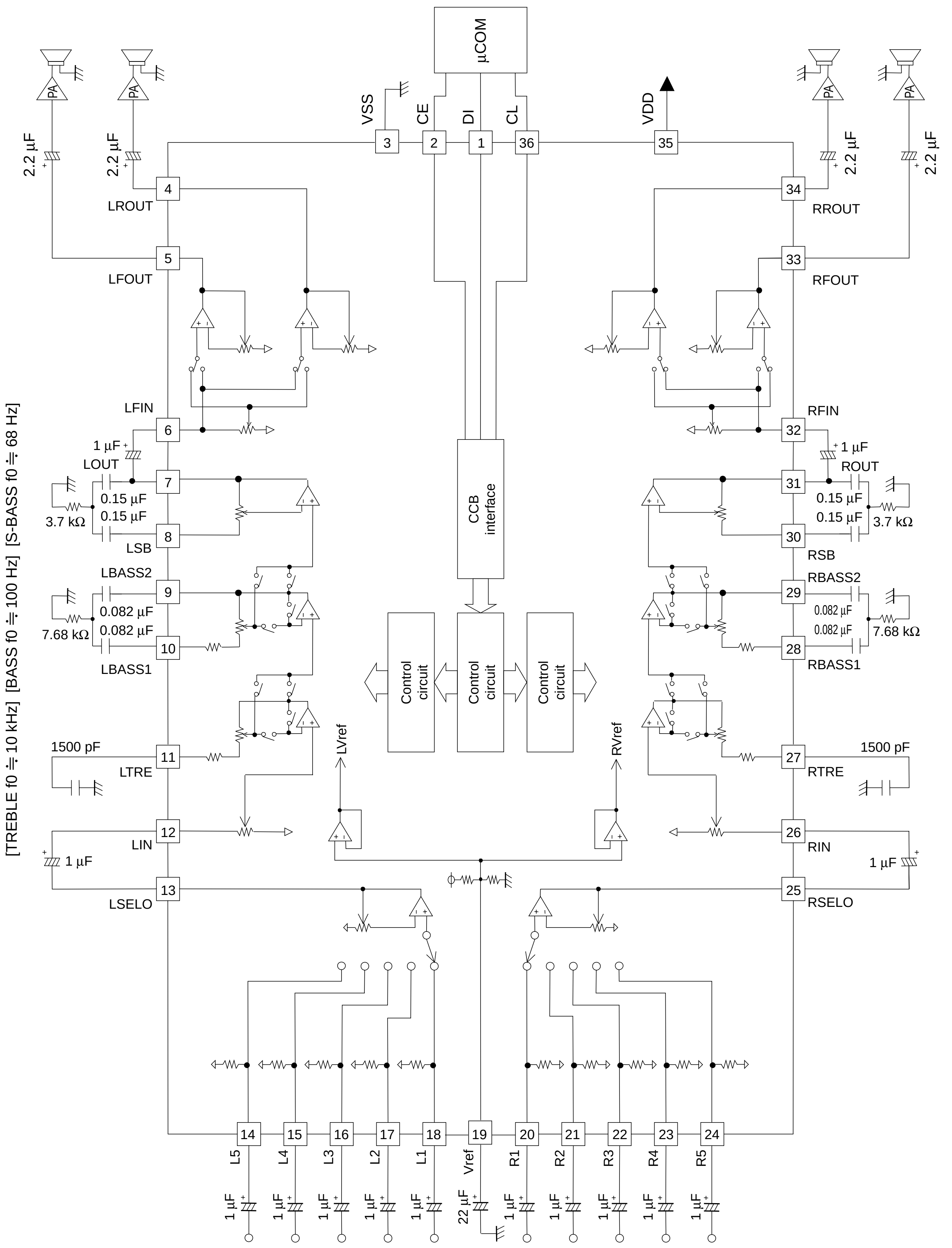
SANYO: MFP36SDJ (375 mil)

SANYO Electric Co.,Ltd. Semiconductor Company
TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

Pin Assignment



Equivalent Circuit Block Diagram



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}	11	V
Maximum input voltage	V_{IN} max	CE, DI, CL	–0.3 to 11	V
		Input pins other than CE, DI, CL	V_{SS} – 0.3 to V_{DD} + 0.3	
Allowable power dissipation	Pdmax	Ta ≤ 85°C, when mounted on board	550	mW
Operating temperature	Topr		–40 to +85	°C
Storage temperature	Tstg		–50 to +125	°C

Allowable Operating Ranges at Ta = –40 to +85°C, V_{SS} = 0 V

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Supply voltage	V_{DD}	V_{DD}		7.5		10	V
Input high-level voltage	V_{IH}	CL, DI, CE		4.0		10	V
Input low-level voltage	V_{IL}	CL, DI, CE		V_{SS}		1.0	V
Input amplitude voltage	V_{IN}	CL, DI, CE, LIN, RIN, L1 to L5, R1 to R5, LFIN, RFIN		V_{SS}		V_{DD}	Vp-p
Input pulse width	tøW	CL		1			µs
Setup time	tsetup	CL, DI, CE		1			µs
Hold time	thold	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	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Maximum input gain	Ginmax				+18.75		dB
Step resolution	Gstep				+1.25		dB
Input resistance	Rin	L1, L2, L3, L4, L5 R1, R2, R3, R4, R5			50		kΩ
Clipping level	Vcl	LSELO, RSELO	THD = 1.0%, f = 1 kHz		2.90		Vrms
Output load resistance	RL	LSELO, RSELO		10			kΩ

Volume Block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Input resistance	Rin	LIN, RIN			50		kΩ

Fader Volume Block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Step resolution	ATstep		STEP = 0 dB to –20 dB		2		dB
			STEP = –20 dB to –25 dB		5		
			STEP = –25 dB to –45 dB		10		
Step error	ATerr		STEP = 0 dB to –45 dB	–2	0	+2	dB
			STEP = –45 dB to –60 dB	–3	0	+3	
Output load resistance	RL			10			kΩ
Output impedance	R_O	LFOUT, LROUT RFOUT, RROUT	RL = 10 kΩ, f = 1 kHz V_{IN} = 1 Vrms		46		Ω

Bass Band Control Block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Control range	Gbass		MAX. Boost/Cut	±10	±11.9	±14	dB
Step resolution	Estep			1	1.7	3	dB
Internal feedback resistance	Rfeed				56.084		kΩ

Treble Band Control Block

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Control range	Gtre		MAX. Boost/Cut	±10	±11.9	±14	dB
Step resolution	Estep			1	1.7	3	dB
Internal feedback resistance	Rfeed				45.084		kΩ

Super Bass Block (Type T)

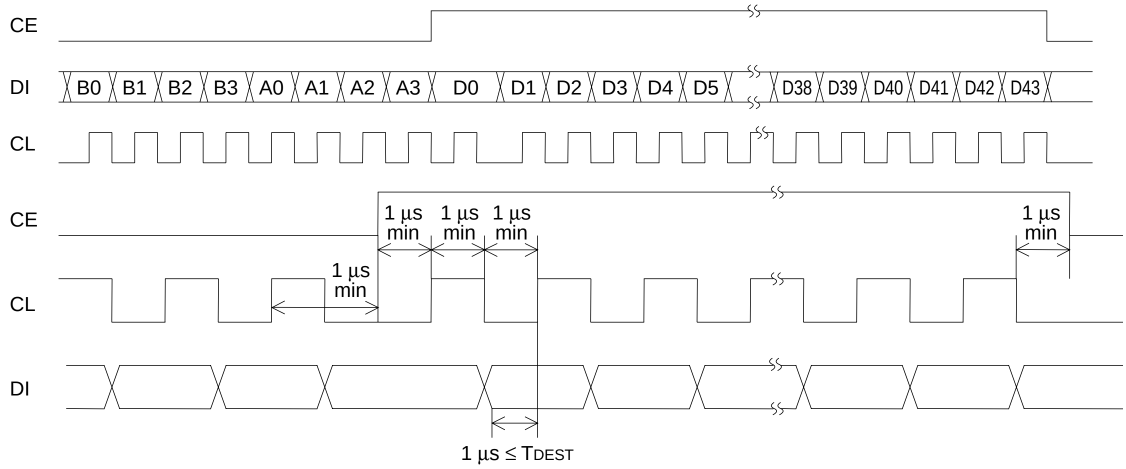
Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
Control range	Crange		MAX. Boost		+20		dB
Step resolution	Estep				+2.0		dB
Internal feedback resistance	Rfeed				66.6		kΩ

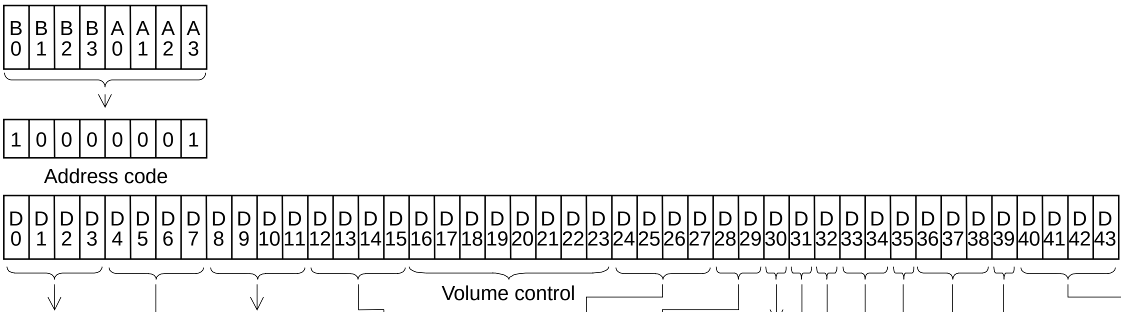
General

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Total harmonic distortion	THD	V_{IN} = 1 Vrms, f = 1 kHz, flat overall		0.003	0.01	%
Crosstalk	CT	V_{IN} = 1 Vrms, f = 1 kHz, flat overall, Rg = 1 kΩ		80.5		dB
Maximum attenuated output	Vomin	V_{IN} = 1 Vrms, f = 1 kHz, main volume –∞		–80		dB
Output noise voltage	VN-1	Fflat overall, (IHF-A), RG = 1 kΩ		8		µV
	VN-2	Flat overall, (DIN-AUDIO), RG = 1 kΩ		10		µV
Input high-level current	I_{IH}	CL, DI, CE V_{IN} = 8 V			10	µA
Input low-level current	I_{IL}	CL, DI, CE V_{IN} = 0 V	–10			µA

Control Timing and Data Format

To control the LC75421M, input specified serial data to the CE, CL, and DI pins.
The data configuration consists of a total of 52 bits broken down into 8 address bits and 44 data bits.





Fader step control

0 0 0 0	–∞ dB
1 0 0 0	–60 dB
0 1 0 0	–45 dB
1 1 0 0	–35 dB
0 0 1 0	–25 dB
1 0 1 0	–20 dB
0 1 1 0	–18 dB
1 1 1 0	–16 dB
0 0 0 1	–14 dB
1 0 0 1	–12 dB
0 1 0 1	–10 dB
1 1 0 1	–8 dB
0 0 1 1	–6 dB
1 0 1 1	–4 dB
0 1 1 1	–2 dB
1 1 1 1	0 dB

Bass control

	Boost
1 1 1 0	STEP15
0 1 1 0	STEP14
1 0 1 0	STEP13
0 0 1 0	STEP12
1 1 0 0	STEP11
0 1 0 0	STEP10
1 0 0 0	STEP9
0 0 0 0	STEP8
1 0 0 1	STEP7
0 1 0 1	STEP6
1 1 0 1	STEP5
0 0 1 1	STEP4
1 0 1 1	STEP3
0 1 1 1	STEP2
1 1 1 1	STEP1
	Cut

Fader rear/front control

0	Rear
1	Front

Input mute switch control

0	OFF
1	ON

TEST mode

Input gain control

0 0 0 0	0 dB
1 0 0 0	+1.25 dB
0 1 0 0	+2.50 dB
1 1 0 0	+3.75 dB
0 0 1 0	+5.00 dB
1 0 1 0	+6.25 dB
0 1 1 0	+7.50 dB
1 1 1 0	+8.75 dB
0 0 0 1	+10.00 dB
1 0 0 1	+11.25 dB
0 1 0 1	+12.50 dB
1 1 0 1	+13.75 dB
0 0 1 1	+15.00 dB
1 0 1 1	+16.25 dB
0 1 1 1	+17.50 dB
1 1 1 1	+18.75 dB

Channel selection

0 0	Initial setting
1 0	Lch
0 1	Rch
1 1	L/R simultaneous

Super bass control

0 0 0 0	STEP0(FLAT)
1 0 0 0	STEP1
0 1 0 0	STEP2
1 1 0 0	STEP3
0 0 1 0	STEP4
1 0 1 0	STEP5
0 1 1 0	STEP6
1 1 1 0	STEP7
0 0 0 1	STEP8
1 0 0 1	STEP9
0 1 0 1	STEP10(BOOST max)

Treble control

	Boost
1 1 1 0	STEP15
0 1 1 0	STEP14
1 0 1 0	STEP13
0 0 1 0	STEP12
1 1 0 0	STEP11
0 1 0 0	STEP10
1 0 0 0	STEP9
0 0 0 0	STEP8
1 0 0 1	STEP7
0 1 0 1	STEP6
1 1 0 1	STEP5
0 0 1 1	STEP4
1 0 1 1	STEP3
0 1 1 1	STEP2
1 1 1 1	STEP1
	Cut

Output gain control

0 0	0 dB
0 1	0 dB
1 0	+6.5 dB
1 1	+8.5 dB

Caution: Be sure to set D36 to D38 and D40 to D43 to "0" for the TEST bit of the IC.

Volume Control

D16	D17	D18	D19	D20	D21	D22	D23	Operation
0	0	1	0	0	1	0	1	0dB
1	1	0	0	0	1	0	1	–1dB
0	1	0	0	0	1	0	1	–2dB
1	0	0	0	0	1	0	1	–3dB
0	0	1	1	1	0	0	1	–4dB
1	1	0	1	1	0	0	1	–5dB
0	1	0	1	1	0	0	1	–6dB
1	0	0	1	1	0	0	1	–7dB
0	0	1	0	1	0	0	1	–8dB
1	1	0	0	1	0	0	1	–9dB
0	1	0	0	1	0	0	1	–10dB
1	0	0	0	1	0	0	1	–11dB
0	0	1	1	0	0	0	1	–12dB
1	1	0	1	0	0	0	1	–13dB
0	1	0	1	0	0	0	1	–14dB
1	0	0	1	0	0	0	1	–15dB
0	0	1	0	0	0	0	1	–16dB
1	1	0	0	0	0	0	1	–17dB
0	1	0	0	0	0	0	1	–18dB
1	0	0	0	0	0	0	1	–19dB
0	0	1	1	1	1	1	0	–20dB
1	1	0	1	1	1	1	0	–21dB
0	1	0	1	1	1	1	0	–22dB
1	0	0	1	1	1	1	0	–23dB
0	0	1	0	1	1	1	0	–24dB
1	1	0	0	1	1	1	0	–25dB
0	1	0	0	1	1	1	0	–26dB
1	0	0	0	1	1	1	0	–27dB
0	0	1	1	0	1	1	0	–28dB
1	1	0	1	0	1	1	0	–29dB
0	1	0	1	0	1	1	0	–30dB
1	0	0	1	0	1	1	0	–31dB
0	0	1	0	0	1	1	0	–32dB
1	1	0	0	0	1	1	0	–33dB
0	1	0	0	0	1	1	0	–34dB
1	0	0	0	0	1	1	0	–35dB
0	0	1	1	1	0	1	0	–36dB
1	1	0	1	1	0	1	0	–37dB
0	1	0	1	1	0	1	0	–38dB
1	0	0	1	1	0	1	0	–39dB
0	0	1	0	1	0	1	0	–40dB
1	1	0	0	1	0	1	0	–41dB
0	1	0	0	1	0	1	0	–42dB
1	0	0	0	1	0	1	0	–43dB
0	0	1	1	0	0	1	0	–44dB
1	1	0	1	0	0	1	0	–45dB
0	1	0	1	0	0	1	0	–46dB
1	0	0	1	0	0	1	0	–47dB
0	0	1	0	0	0	1	0	–48dB
1	1	0	0	0	0	1	0	–49dB
0	1	0	0	0	0	1	0	–50dB

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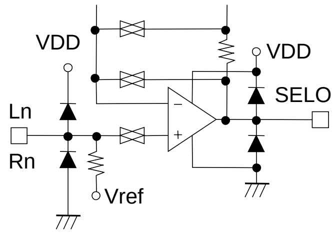
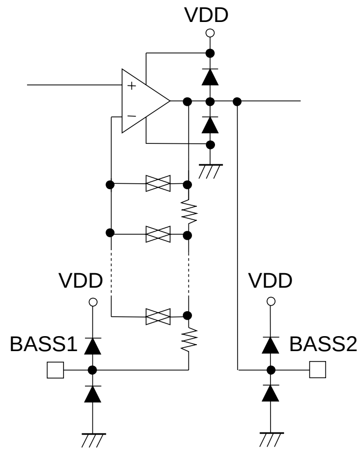
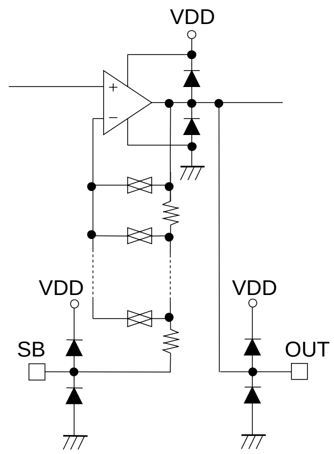
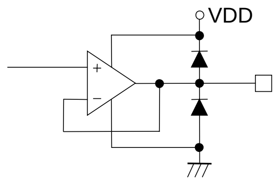
D16	D17	D18	D19	D20	D21	D22	D23	Operation
1	0	0	0	0	0	1	0	–51dB
0	0	1	1	1	1	0	0	–52dB
1	1	0	1	1	1	0	0	–53dB
0	1	0	1	1	1	0	0	–54dB
1	0	0	1	1	1	0	0	–55dB
0	0	1	0	1	1	0	0	–56dB
1	1	0	0	1	1	0	0	–57dB
0	1	0	0	1	1	0	0	–58dB
1	0	0	0	1	1	0	0	–59dB
0	0	1	1	0	1	0	0	–60dB
1	1	0	1	0	1	0	0	–61dB
0	1	0	1	0	1	0	0	–62dB
1	0	0	1	0	1	0	0	–63dB
0	0	1	0	0	1	0	0	–64dB
1	1	0	0	0	1	0	0	–65dB
0	1	0	0	0	1	0	0	–66dB
1	0	0	0	0	1	0	0	–67dB
0	0	1	1	1	0	0	0	–68dB
1	1	0	1	1	0	0	0	–69dB
0	1	0	1	1	0	0	0	–70dB
1	0	0	1	1	0	0	0	–71dB
0	0	1	0	1	0	0	0	–72dB
1	1	0	0	1	0	0	0	–73dB
0	1	0	0	1	0	0	0	–74dB
1	0	0	0	1	0	0	0	–75dB
0	0	1	1	0	0	0	0	–76dB
1	1	0	1	0	0	0	0	–77dB
0	1	0	1	0	0	0	0	–78dB
1	0	0	1	0	0	0	0	–79dB
0	0	0	0	0	0	0	0	–∞dB

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

D28	D29	D32	Operation
0	0	1	L1 (R1) ON
1	0	1	L2 (R2) ON
0	1	1	L3 (R3) ON
1	1	1	L4 (R4) ON
0	0	0	L5 (R5) ON

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	LSELO RSELO	• Input selector output pins	
10 9 28 29	LBASS1 LBASS2 RBASS1 RBASS2	• Bass band filter configuration capacitor and resistor connection pins	
8 7 30 31	LSB LOUT RSB ROUT	• Super bass band filter configuration capacitor and resistor connection pins	
5 4 33 34	LFOUT LROUT RFOUT RROUT	• Fader output pins. The front side and rear side can be attenuated separately. The attenuation is the same for both Left and Right.	

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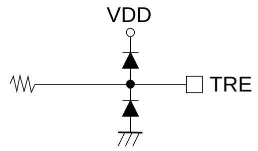
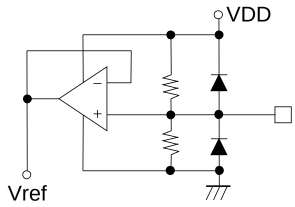
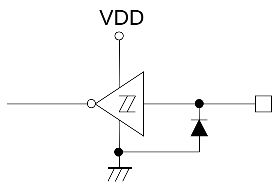
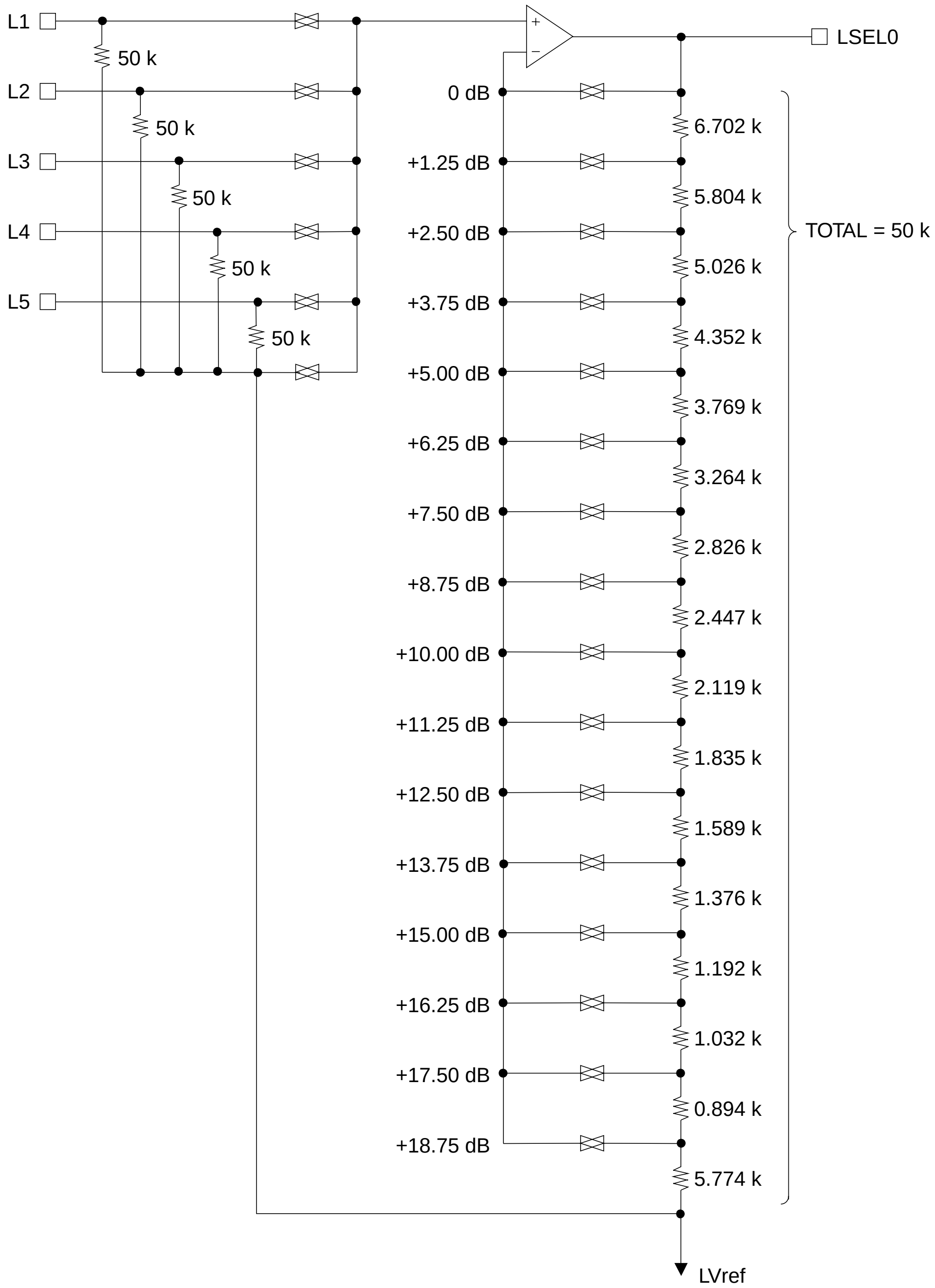
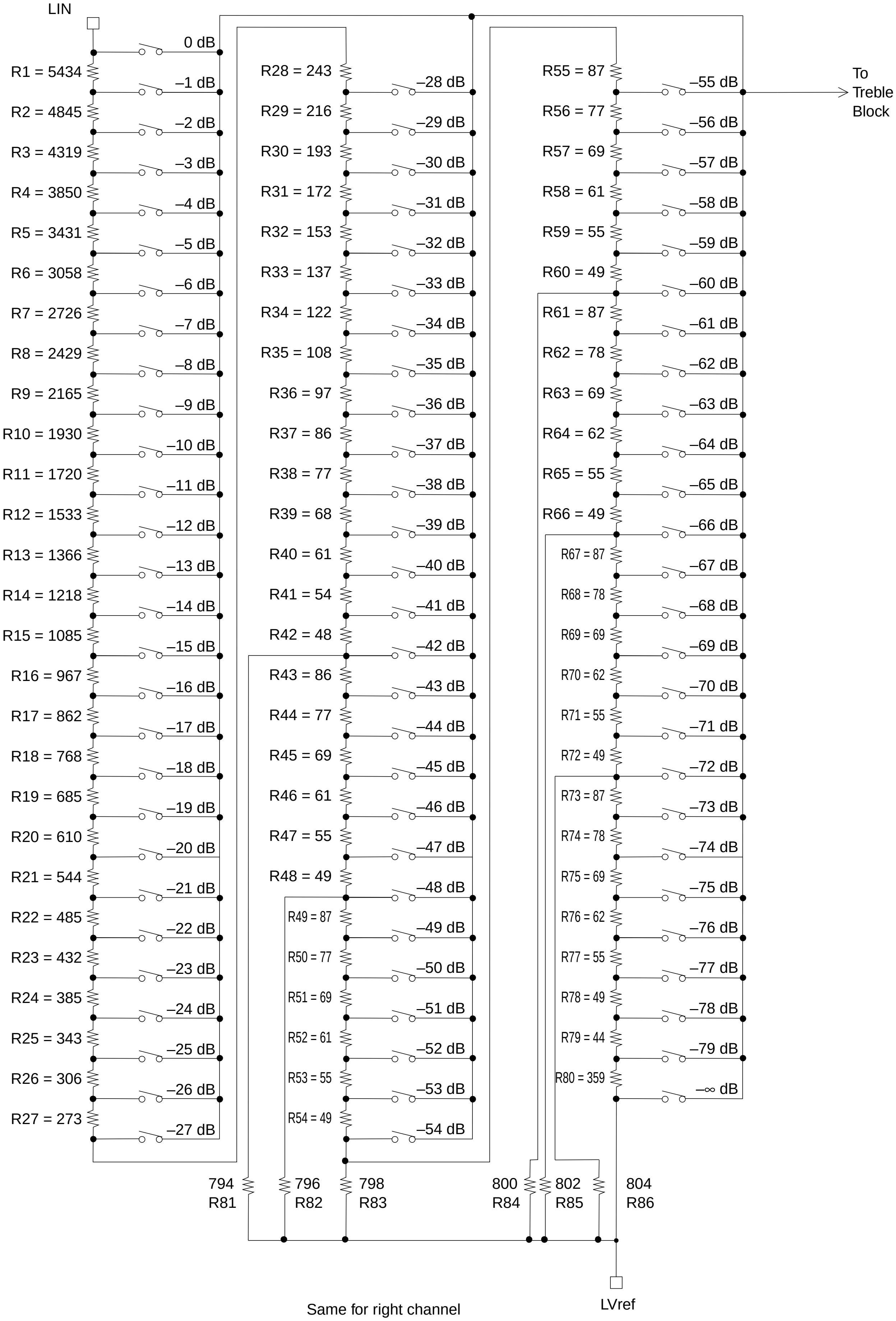
Pin No.	Pin Name	Function	Equivalent circuit
11 27	LTRE RTRE	• Capacitor connection pin for configuring treble filter	
19	Vref	• Connect a capacitor of a few tens of µF between Vref and AV_{SS} (V_{SS}) as a analog ground 0.5 × V_{DD} voltage generator, current ripple countermeasure.	
3	V_{SS}	• Ground pin	
35	V_{DD}	• Power supply pin	
2	CE	• Chip enable pin 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.	
1 36	DI CL	• Serial data pin and clock input pin for control	

Equivalent Circuit Input Block Diagram



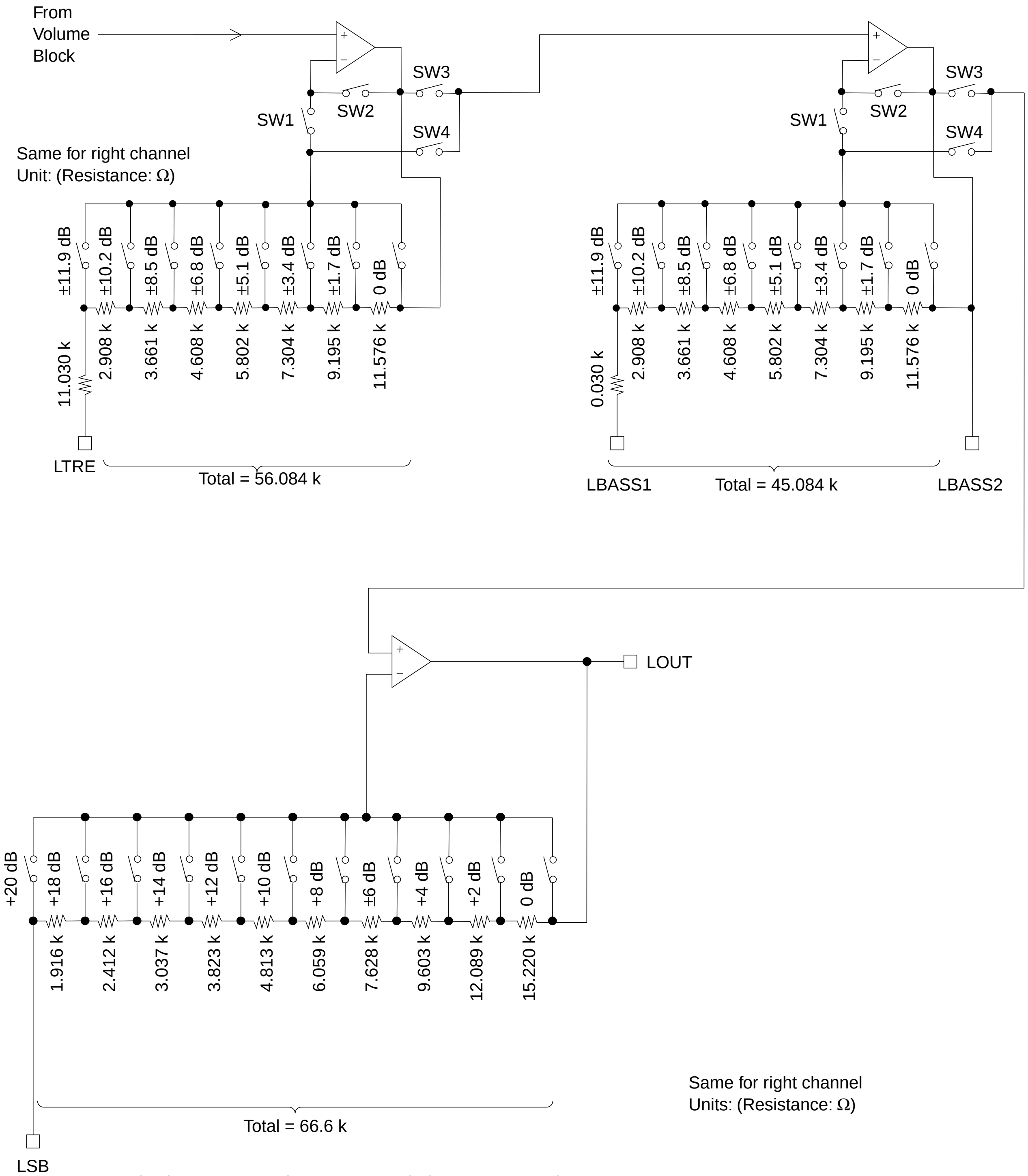
Same for right channel
Unit: (Resistance: Ω)

Volume Block Equivalent Circuit Diagram



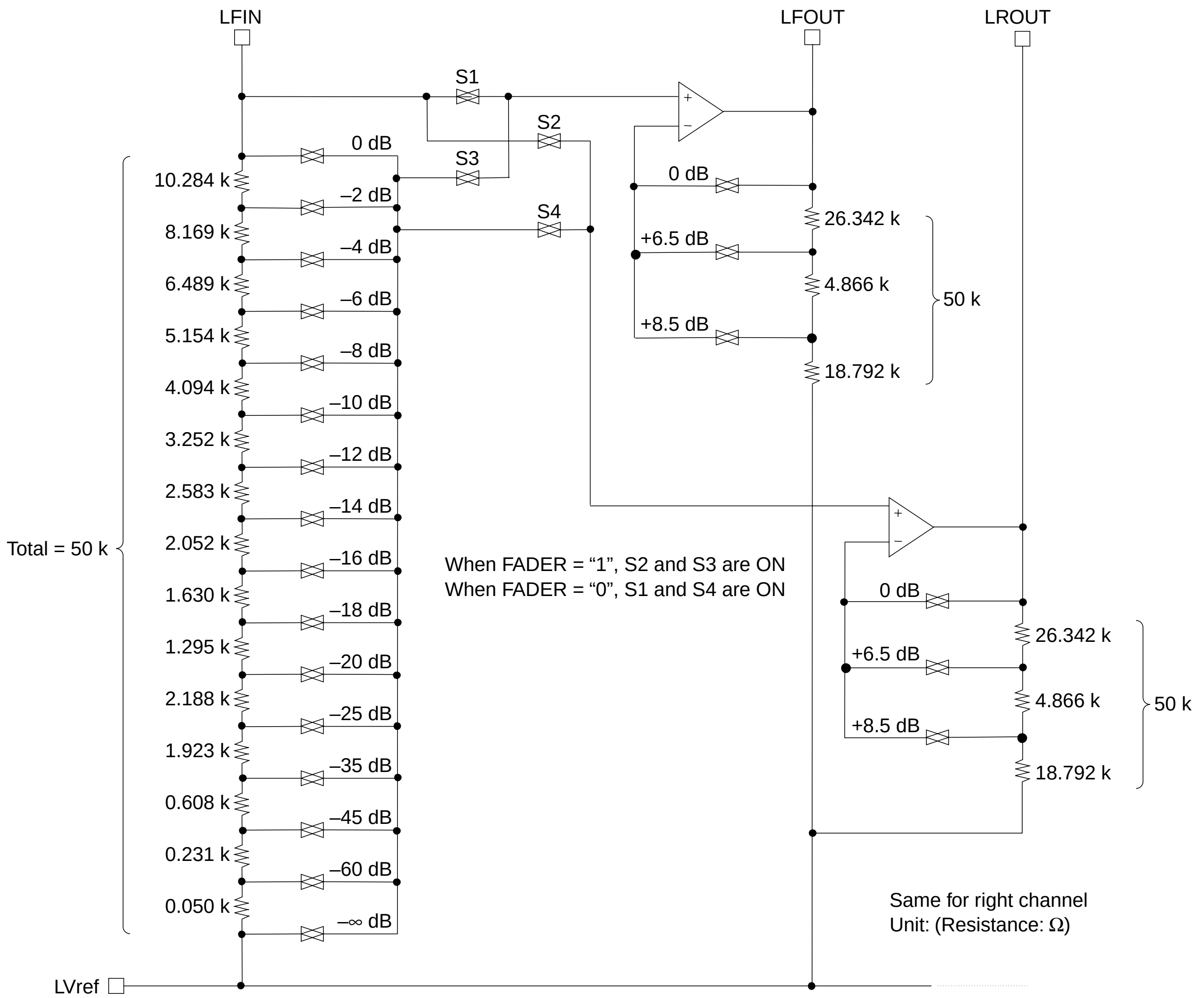
Same for right channel
Unit: (Resistance: Ω)

Treble/Bass/Super Bass Band Block Equivalent Circuit Diagram



During boost, SW1 and SW3 are ON, during cut, SW2 and SW4 are ON,
when 0 dB, 0 dB SW and SW2 and SW3 are ON.

Fader Volume Block Equivalent Circuit Diagram



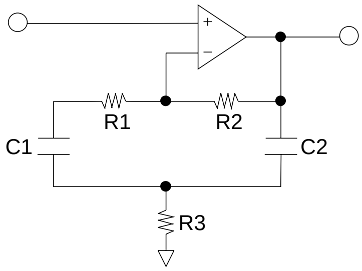
When –∞ data is sent to the main volume, S1 and S2 become open, and S3 and S4 simultaneously become ON.

Tone Circuit Constant Calculation Examples

Super Bass Band Circuit

The equivalent circuit and the formula for calculating the external RC with a mean frequency of 68 Hz are shown below.

- Super bass band equivalent circuit block diagram



- Calculation example

Specification Mean frequency: f0 = 68 Hz
Gain during maximum boost: G = 20 dB
Let us use R1 = 0, R2 = 66.6 kΩ, and C1 = C2 = C.

We obtain R3 from G = 20 dB.

$$G_{+20\ dB} = 20 \times LOG_{10}\left(1 + \frac{R2}{2R3}\right)$$

$$R3 = \frac{R2}{2\left(10^{G+20dB/20} - 1\right)} = \frac{66600}{2 \times (10 - 1)} \neq 3.7\ K\Omega$$

We obtain C from mean frequency f0 = 68 Hz.

$$f0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$

$$C = \frac{1}{2\pi f0\ \sqrt{R3R2}} = \frac{1}{2\pi \times 68\sqrt{66600 \times 3700}} \neq 0.15\ \mu F$$

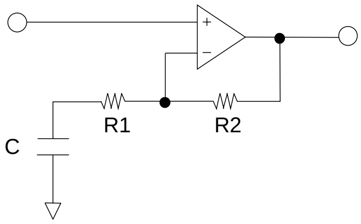
We obtain Q.

$$Q = \frac{R3R2}{2R3}\ \frac{1}{\sqrt{R3R2}} \neq 2.1$$

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 1

Specification Set frequency: f = 10000 Hz

Gain during maximum boost: $G_{+14\,dB}$ = 14 dB

Let us use R1 = 11.030 kΩ and R2 = 45.054 kΩ.

The above constants are inserted in the following formula.

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

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

$$= \frac{1}{2\pi 10000\sqrt{\left(\frac{45054}{5.01-1}\right)^2 - 11030^2}} \neq 6800(pF)$$

Simulation Results

Setting	f = 10 kHz	f = 1 kHz
14 dB	13.95	7.42
12 dB	11.98	6.96
10 dB	10	6.34
8 dB	8	5.5
6 dB	6	4.43
4 dB	4	3.13
2 dB	2	1.64

• Calculation example 2

Specification Set frequency: f = 10000 Hz

Gain during maximum boost: $G_{+11.9\ dB}$ = 11.9 dB

Let us use R1 = 11.030 kΩ and R2 = 45.054 kΩ.

The above constants are inserted in the following formula.

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

$$C = \frac{1}{2\pi f\sqrt{\left(\frac{R2}{10^{11.9/20} - 1}\right)^2 - R1^2}}$$

$$= \frac{1}{2\pi 10000\sqrt{\left(\frac{45054}{3.94-1}\right)^2 - 11030^2}} \neq 1500(pF)$$

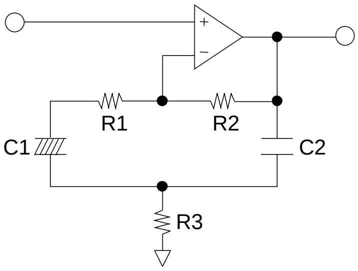
Simulation Results

Setting	f = 10 kHz	f = 1 kHz
11.9 dB	11.92	0.00
10.2 dB	10.64	0.00
8.5 dB	9.17	0.00
6.8 dB	7.52	0.00
5.1 dB	5.74	0.00
3.4 dB	3.88	0.00
1.7 dB	1.96	0.00

Bass Shelving Circuit

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

- Bass band equivalent circuit diagram



- Calculation example 1

Specification Mean frequency: f0 = 40 Hz

Gain during maximum boost: $G_{+14\ dB}$ = 14 dB

Let us use R1 = 0 kΩ, R2 = 45.054 kΩ, C1 = 2.2 µF, and C1 >> C2.

We obtain R3 from G = 14 dB.

$$G_{+14\ dB} = 20 \times LOG_{10}\left(\frac{R2 + R3}{R3}\right)$$

$$R3 = \frac{R2}{10^{G/20} - 1} = \frac{45054}{5.01 - 1} \neq 11\ K\Omega$$

We obtain C2 from mean frequency f0 = 40 Hz.

$$f0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$

$$C2 = \frac{1}{(2\pi f0)^2\ R2R3C1} = \frac{1}{(2\pi \times 40)^2 \times 45054 \times 11000 \times (2.2 \times 10^{-6})} \neq 0.015\ \mu F$$

Simulation Results

Setting	f = 100 Hz	f = 1 kHz
14 dB	13.55	3.65
12 dB	11.73	3.51
10 dB	9.8	3.31
8 dB	7.89	3
6 dB	5.94	2.55
4 dB	3.97	1.92
2 dB	1.99	1.07

- Calculation example 2
  Specification Mean frequency: f0 = 40 Hz
  Gain during maximum boost: G = 12 dB
  Let us use R1 = 0 kΩ, R2 = 45.054 kΩ, C1 = 2.2 uF, and C1 >> C2.

We obtain R3 from G = 12 dB.

$$G_{+12\ dB} = 20 \times LOG_{10} \left(\frac{R2 + R3}{R3} \right)$$

$$R3 = \frac{R2}{10^{G/20} - 1} = \frac{45054}{3.98 - 1} \neq 15\ K\Omega$$

We obtain C2 from mean frequency f0 = 40 Hz.

$$f\,0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$

$$C2 = \frac{1}{(2\pi f0)^2\ R2R3C1} = \frac{1}{(2\pi \times 40)^2 \times 45054 \times 15000 \times (2.2 \times 10^{-6})} \neq 0.01\ \mu F$$

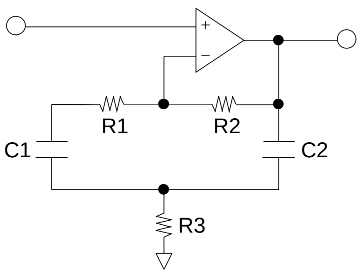
Simulation Results

Setting	f = 100 Hz	f = 1 kHz
14 dB	11.73	4.27
12 dB	10.29	4.07
10 dB	8.74	3.78
8 dB	7.11	3.38
6 dB	5.41	2.82
4 dB	3.65	2.09
2 dB	1.85	1.15

(4) Bass Peaking Circuit

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

- Bass band equivalent circuit diagram



- Calculation example

Specification Mean frequency: f0 = 100 Hz
Gain during maximum boost: G = 11.9 dB
Let us use R1 = 0, R2 = 45.084 kΩ, and C1 = C2 = C.

We obtain R3 from G = 11.9 dB.

$$G_{+11.9\ dB} = 20 \times LOG_{10}\left(1 + \frac{R2}{2R3}\right)$$

$$R3 = \frac{R2}{2\left(10^{11.9dB/20} - 1\right)} = \frac{45084}{2 \times (3.936 - 1)} \neq 7.68\ K\Omega$$

We obtain C from mean frequency f0 = 100 Hz.

$$f0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$

$$C = \frac{1}{2\pi f0\sqrt{R3R2}} = \frac{1}{2\pi \times 100\sqrt{45084 \times 7680}} \neq 0.082\ \mu F$$

We obtain Q.

$$Q = \frac{R3R2}{2R3} \bullet \frac{1}{\sqrt{R3R2}} \neq 1.66$$

Simulation Results

Setting	f = 100 Hz	f = 1 kHz
11.9 dB	11.88	0.00
10.2 dB	10.38	0.00
8.5 dB	8.79	0.00
6.8 dB	7.14	0.00
5.1 dB	5.42	0.00
3.4 dB	3.66	0.00
1.7 dB	1.85	0.00

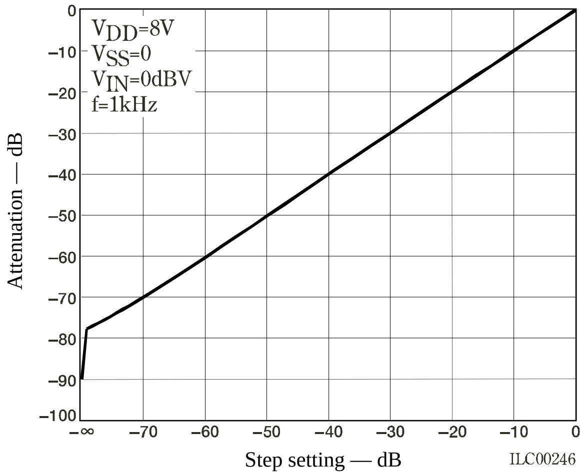
Usage Cautions

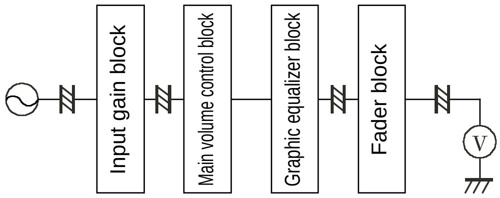
(1) Upon power application, the internal analog switch status is undefined. Use an external countermeasure such as muting until data is set.

(2) When performing initial data setting after applying power, send the initial data once, and then send the initial setting data.

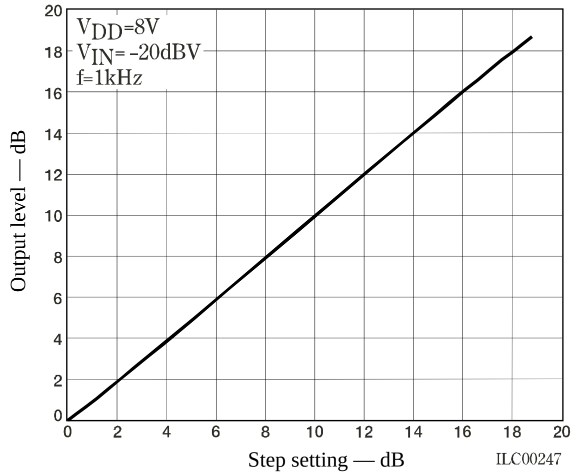
(3) To ensure that the digital frequency signal sent to the CL, DI, and CE pins do not spill over to the analog signal block, either guard these signal lines with a ground pattern, or perform transmission using shielded wires.

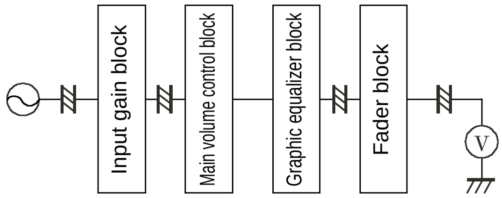
Main Volume Control Step Characteristics



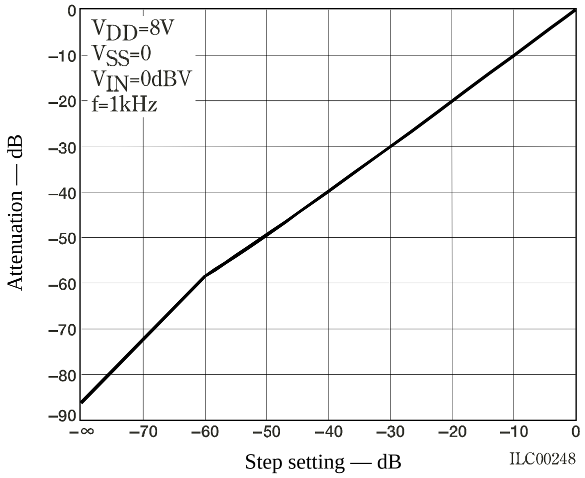


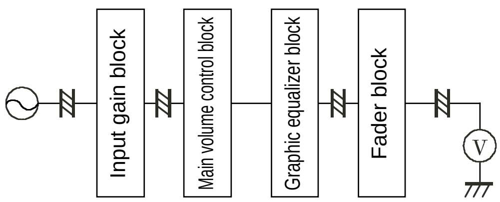
Input Gain Step Characteristics



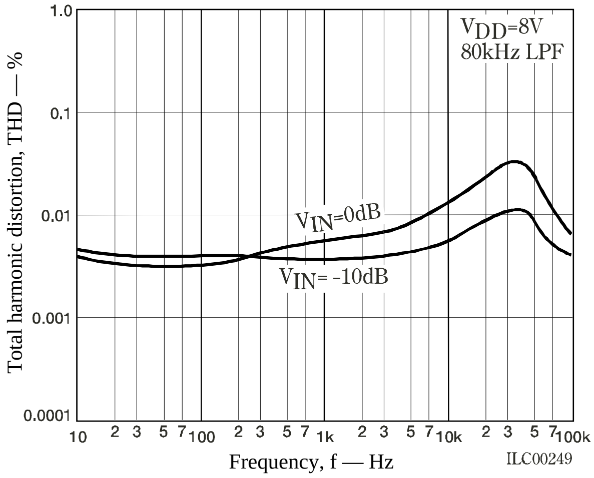


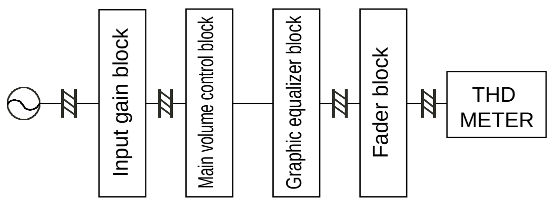
Fader Step Characteristics



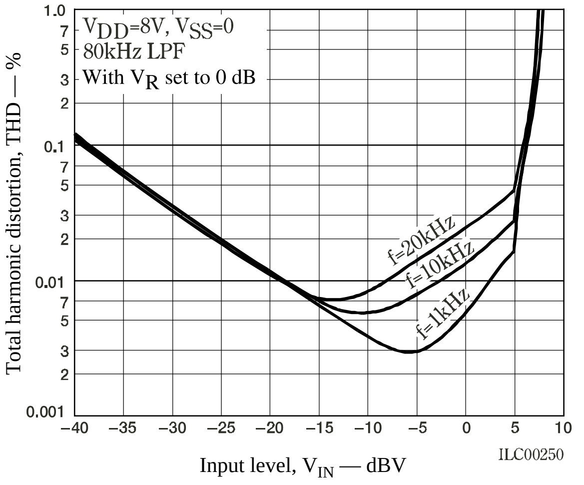


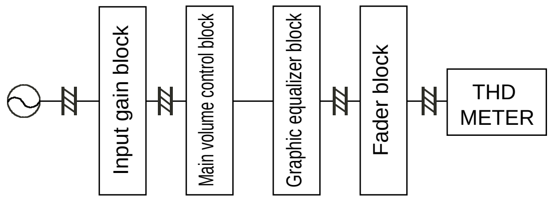
THD — Frequency Characteristics



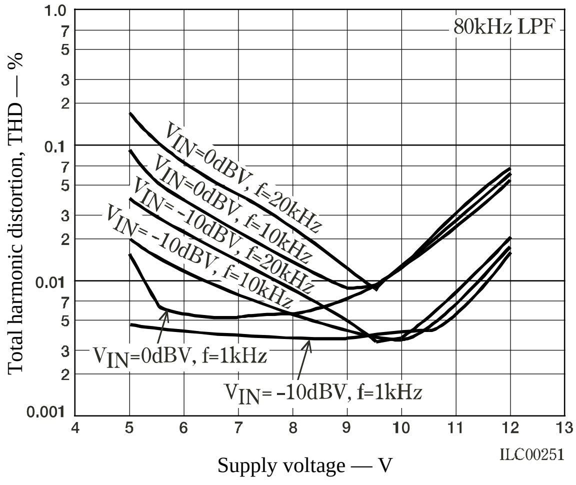


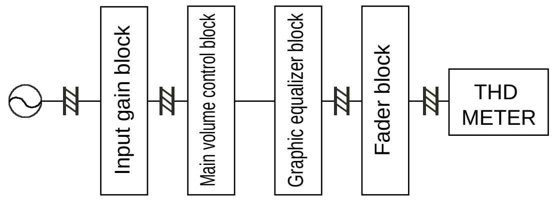
THD — Input Level Characteristics



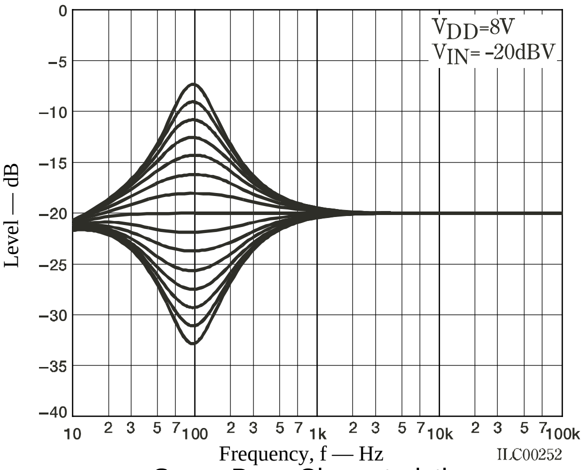


THD — Supply Voltage Characteristics

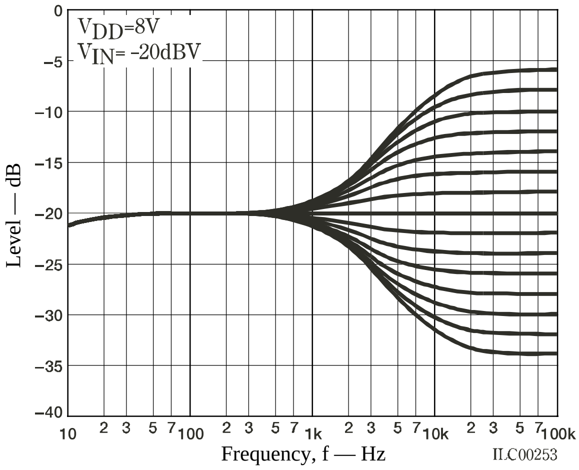




Bass Control Characteristics



Treble Control Characteristics



Super Bass Characteristics