Ordering number : ENN7053

CMOS IC

LC75412E, 75412W

Electronic Volume Controller for Car Audio Systems

Overview

The LC75412E and 75412W are electronic volume controllers that enable control of volume, balance, fader, bass/treble, loudness, input switching, and input gain 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 1-dB steps from 0 dB to –2 dB, 2-dB steps from –2 dB to –20 dB, 10-dB steps from –20 dB to –30 dB, and –45 dB, –60 dB, –∞)
- Bass/treble: Each band can be controlled in 2-dB steps from ±0 dB to ±18 dB.
- Input gain: 0 dB to +18.75 dB (1.25-dB steps) amplification is possible for the input signal.
- Input switching: Six input signals can be selected for Left and for Right (five are single-ended inputs and one is a differential input.)
- Loudness: A tap is output from the –32 dB position of a volume control resistor ladder. A loudness function can be implemented by connecting an external RC circuit.

Features

- On-chip buffer amplifier cuts down number of external components
- Low switching noise generated by on-chip switch through use of silicon gate CMOS process, for low switching noise when there is no signal
- Low switching noise when there is a signal due to use of on-chip zero-cross switching circuit
- On-chip 1/2 VDD reference voltage circuit
- Controls performed with serial input (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.**

SANYO Electric Co.,Ltd. Semiconductor Company

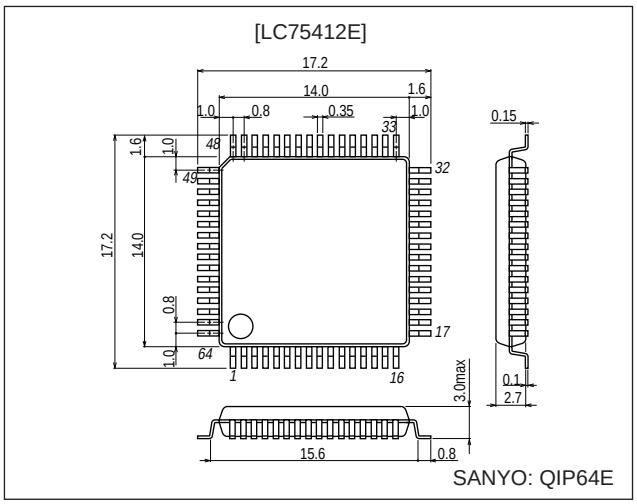
TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

O1901RM (OT) No. 7053-1/21

Package Dimensions

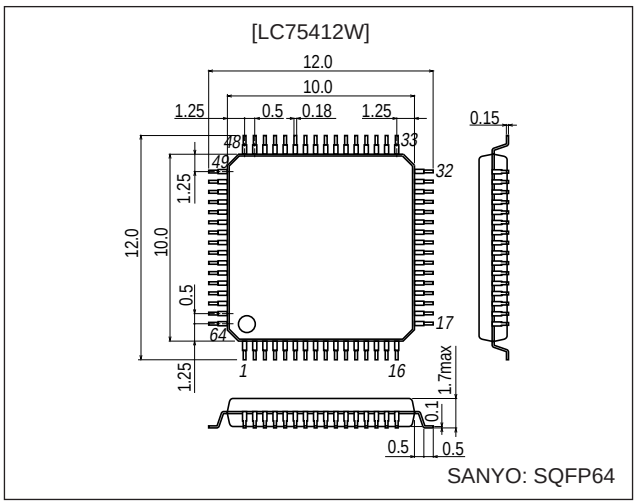
unit: mm

3159-QIP64E

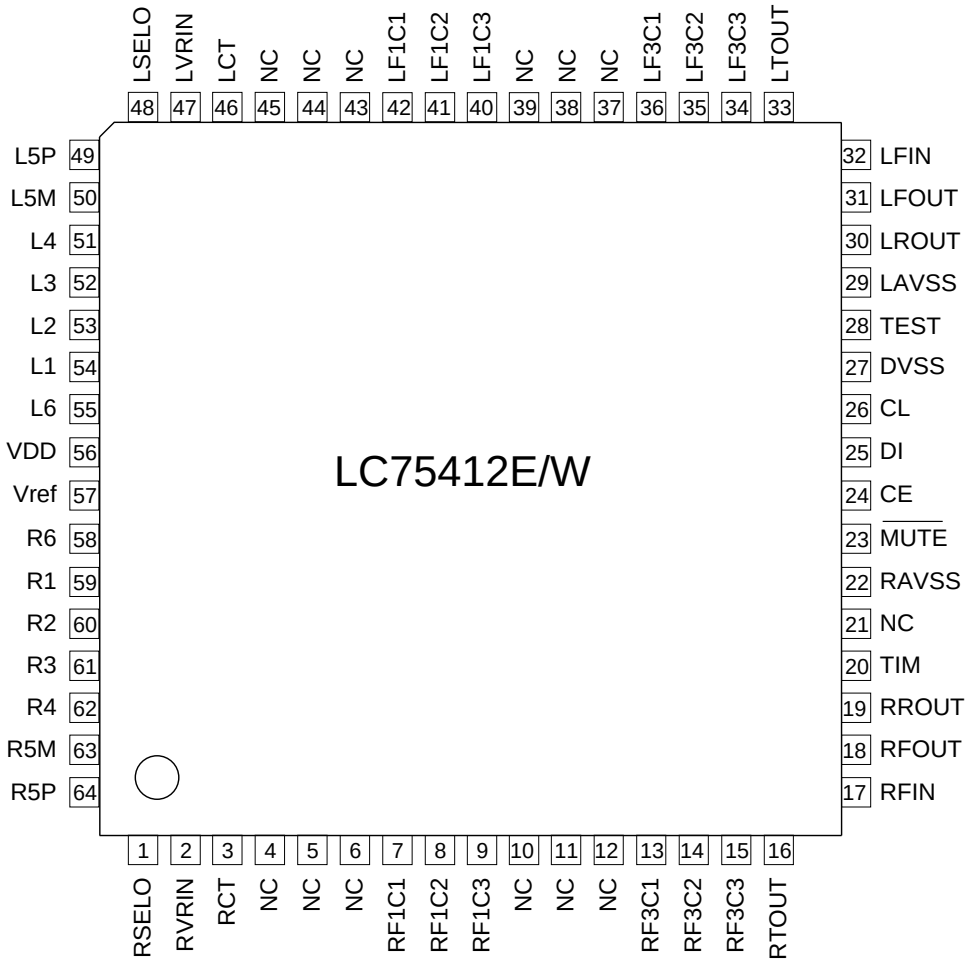


unit: mm

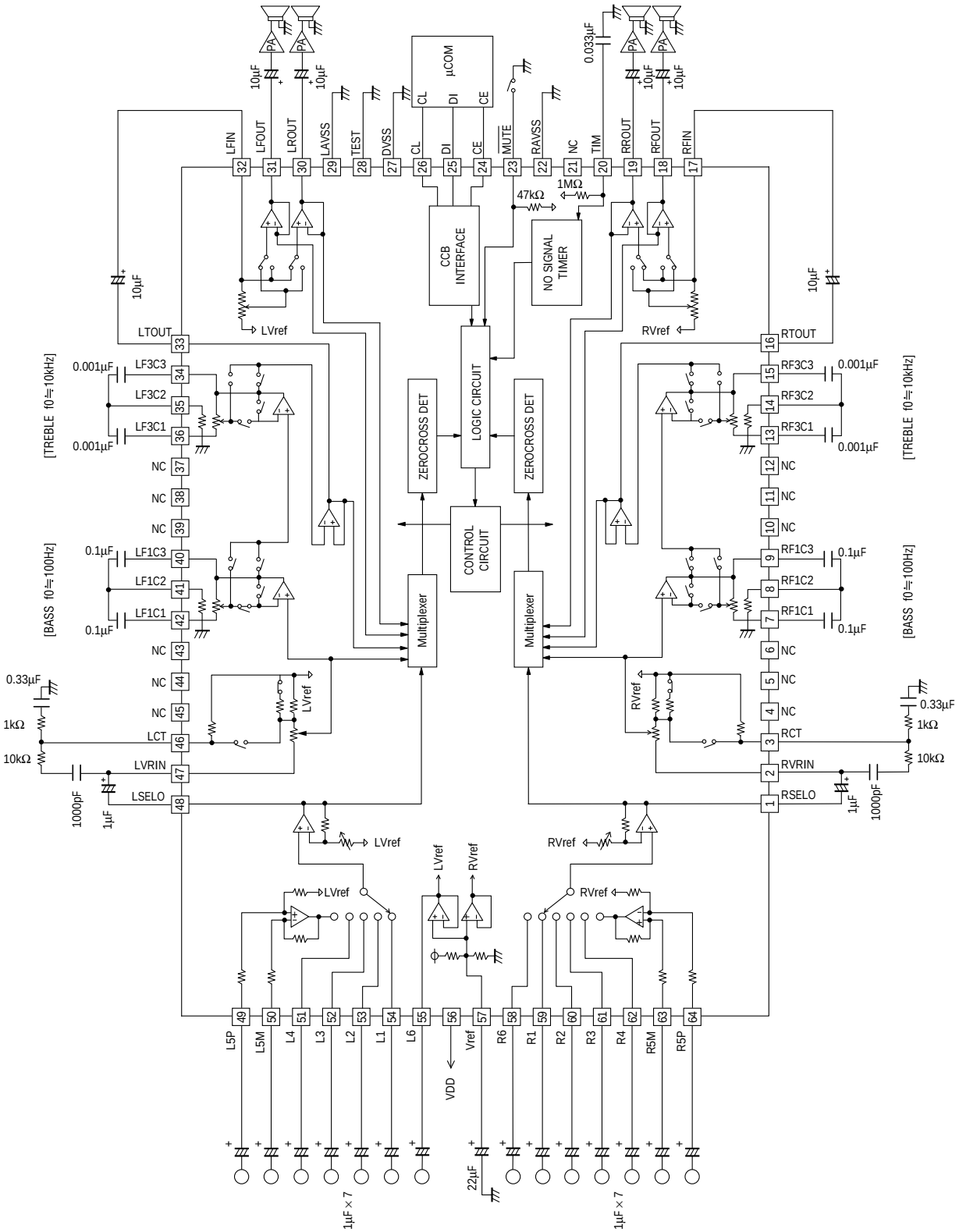
3190-SQFP64



Pin Assignment



Equivalent Circuit Block Diagram/Sample Application Circuit



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	All input pins		V_{SS} – 0.3 to V_{DD} + 0.3	V
Allowable power dissipation	Pd max	Ta ≤ 85°C, when mounted on board	QIP64E	680	mW
			SQFP64	800	
Operating temperature	Topr			–40 to +85	°C
Storage temperature	Tstg			–50 to +125	°C

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

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply voltage	V_{DD}	V_{DD}	6.0		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}		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} = 9 V, V_{SS} = 0 V

Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
[Input block]							
Input resistance	Rin	L1 to L4, L6, R1 to R4, R6		25	50	100	kΩ
Minimum input gain	Ginmin	L1 to L4, L6, R1 to R4, R6		–1	0	+1	dB
Maximum input gain	Ginmax			+16.5	+18.75	+21	dB
Step setting error	ATerr					±0.5	dB
L/R balance	BAL					±0.5	dB
[Volume Block]							
Input resistance	Rvr	LVRIN, RVRIN, loudness off		25	50	100	kΩ
Step setting error	ATerr					±0.5	dB
L/R balance	BAL					±0.5	dB
[Tone block]							
Step setting error	ATerr					±1.0	dB
Bass control range	Gbass		max. boost/cut	±15	±18	±21	dB
Treble control range	Gtre		max. boost/cut	±15	±18	±21	dB
L/R balance	BAL					±0.5	dB

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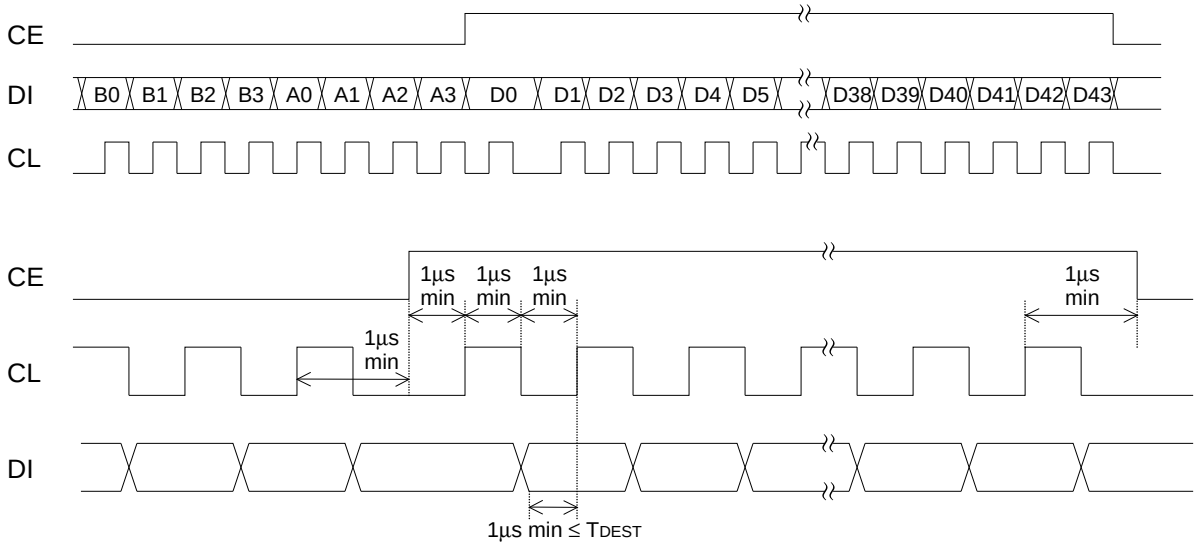
Parameter	Symbol	Pin Name	Conditions	Ratings			Unit
				min	typ	max	
[Fader Block]							
Input resistance	Rfed	LFIN, RFIN		25	50	100	kΩ
Step setting error	ATerr		0dB to –2dB			±0.5	dB
			–2dB to –20dB			±1	dB
			–20dB to –30dB			±2	dB
			–30dB to –60dB			±3	dB
L/R balance	BAL					±0.5	dB
[General]							
Total harmonic distortion	THD (1)	V_{IN} = 0dBV, f = 1 kHz			0.004	0.01	%
	THD (2)	V_{IN} = –10dBV, f = 10 kHz			0.006	0.01	%
Input crosstalk	CT	V_{IN} = 1Vrms, f = 1 kHz		80	88		dB
L/R crosstalk	CT	V_{IN} = 1Vrms, f = 1 kHz		80	88		dB
Maximum attenuated output	Vomin (1)	V_{IN} = 1Vrms, f = 1 kHz		80	88		dB
	Vomin (2)	V_{IN} = 1Vrms, f = 1 kHz INMUTE, fader –∞		90	95		dB
Output noise voltage	V_N (1)	Flat overall, IHF-A filter			5	10	μV
	V_N (2)	Flat overall, 20 to 20 kHzBPF			7	15	μV
Current drain	I_{DD}				55	60	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
Maximum input voltage	V_{CL}	THD = 1%, R_L = 10 kΩ flat overall, f_{IN} = 1 kHz		2.3	2.5		Vrms
Common-mode rejection ratio	CMRR	V_{IN} = 0 dB, f = 1 kHz			70		dB

Control Timing and Data Format

To control the LC75412E and LC75412W 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.



Address code (B0 to A3)

The LC75412E and 75412W use 8-bit address code and can be used in common with ICs that support SANYO's CCB serial bus.

Address Code

(LSB)

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

(81HEX)

Control code allocation

Input Switching Control

D0	D1	D2	Setting	Setting
0	0	0	L1 (R1)	
1	0	0	L2 (R2)	
0	1	0	L3 (R3)	
1	1	0	L4 (R4)	
0	0	1	L5 (R5)	
1	0	1	L6 (R6)	

D3	Bit for IC testing: Normally set to 0

Input Gain Control

D4	D5	D6	D7	Operation
0	0	0	0	0dB
1	0	0	0	+1.25dB
0	1	0	0	+2.50dB
1	1	0	0	+3.75dB
0	0	1	0	+5.00dB
1	0	1	0	+6.25dB
0	1	1	0	+7.50dB
1	1	1	0	+8.75dB
0	0	0	1	+10.0dB
1	0	0	1	+11.25dB
0	1	0	1	+12.5dB
1	1	0	1	+13.75dB
0	0	1	1	+15.0dB
1	0	1	1	+16.25dB
0	1	1	1	+17.5dB
1	1	1	1	+18.75dB

Volume Control (0 to –40dB)

D8	D9	D10	D11	D12	D13	D14	D15	Operation
0	0	0	0	0	0	0	0	0dB
1	0	0	0	0	0	0	0	–1dB
0	1	0	0	0	0	0	0	–2dB
1	1	0	0	0	0	0	0	–3dB
0	0	1	0	0	0	0	0	–4dB
1	0	1	0	0	0	0	0	–5dB
0	1	1	0	0	0	0	0	–6dB
1	1	1	0	0	0	0	0	–7dB
0	0	0	1	0	0	0	0	–8dB
1	0	0	1	0	0	0	0	–9dB
0	1	0	1	0	0	0	0	–10dB
1	1	0	1	0	0	0	0	–11dB
0	0	1	1	0	0	0	0	–12dB
1	0	1	1	0	0	0	0	–13dB
0	1	1	1	0	0	0	0	–14dB
1	1	1	1	0	0	0	0	–15dB
0	0	0	0	1	0	0	0	–16dB
1	0	0	0	1	0	0	0	–17dB
0	1	0	0	1	0	0	0	–18dB
1	1	0	0	1	0	0	0	–19dB
0	0	1	0	1	0	0	0	–20dB
1	0	1	0	1	0	0	0	–21dB
0	1	1	0	1	0	0	0	–22dB
1	1	1	0	1	0	0	0	–23dB
0	0	0	1	1	0	0	0	–24dB
1	0	0	1	1	0	0	0	–25dB
0	1	0	1	1	0	0	0	–26dB
1	1	0	1	1	0	0	0	–27dB
0	0	1	1	1	0	0	0	–28dB
1	0	1	1	1	0	0	0	–29dB
0	1	1	1	1	0	0	0	–30dB
1	1	1	1	1	0	0	0	–31dB
0	0	0	0	0	1	0	0	–32dB
1	0	0	0	0	1	0	0	–33dB
0	1	0	0	0	1	0	0	–34dB
1	1	0	0	0	1	0	0	–35dB
0	0	1	0	0	1	0	0	–36dB
1	0	1	0	0	1	0	0	–37dB
0	1	1	0	0	1	0	0	–38dB
1	1	1	0	0	1	0	0	–39dB
0	0	0	1	0	1	0	0	–40dB

Volume Control (–41 to –∞dB)

D8	D9	D10	D11	D12	D13	D14	D15	Operation
1	0	0	1	0	1	0	0	–41dB
0	1	0	1	0	1	0	0	–42dB
1	1	0	1	0	1	0	0	–43dB
0	0	1	1	0	1	0	0	–44dB
1	0	1	1	0	1	0	0	–45dB
0	1	1	1	0	1	0	0	–46dB
1	1	1	1	0	1	0	0	–47dB
0	0	0	0	1	1	0	0	–48dB
1	0	0	0	1	1	0	0	–49dB
0	1	0	0	1	1	0	0	–50dB
1	1	0	0	1	1	0	0	–51dB
0	0	1	0	1	1	0	0	–52dB
1	0	1	0	1	1	0	0	–53dB
0	1	1	0	1	1	0	0	–54dB
1	1	1	0	1	1	0	0	–55dB
0	0	0	1	1	1	0	0	–56dB
1	0	0	1	1	1	0	0	–57dB
0	1	0	1	1	1	0	0	–58dB
1	1	0	1	1	1	0	0	–59dB
0	0	1	1	1	1	0	0	–60dB
1	0	1	1	1	1	0	0	–61dB
0	1	1	1	1	1	0	0	–62dB
1	1	1	1	1	1	0	0	–63dB
0	0	0	0	0	0	1	0	–64dB
1	0	0	0	0	0	1	0	–65dB
0	1	0	0	0	0	1	0	–66dB
1	1	0	0	0	0	1	0	–67dB
0	0	1	0	0	0	1	0	–68dB
1	0	1	0	0	0	1	0	–69dB
0	1	1	0	0	0	1	0	–70dB
1	1	1	0	0	0	1	0	–71dB
0	0	0	1	0	0	1	0	–72dB
1	0	0	1	0	0	1	0	–73dB
0	1	0	1	0	0	1	0	–74dB
1	1	0	1	0	0	1	0	–75dB
0	0	1	1	0	0	1	0	–76dB
1	0	1	1	0	0	1	0	–77dB
0	1	1	1	0	0	1	0	–78dB
1	1	1	1	0	0	1	0	–79dB
	1	1	1	1	1	1	0	–∞

Tone Control

D16	D17	D18	D19	D40	Bass
D24	D25	D26	D27	D41	Treble
1	1	0	0	1	+18dB
0	1	0	0	1	+16dB
1	0	0	0	1	+14dB
0	1	1	0	0	+12dB
1	0	1	0	0	+10dB
0	0	1	0	0	+8dB
1	1	0	0	0	+6dB
0	1	0	0	0	+4dB
1	0	0	0	0	+2dB
0	0	0	0	0	0dB
1	0	0	1	0	–2dB
0	1	0	1	0	–4dB
1	1	0	1	0	–6dB
0	0	1	1	0	–8dB
1	0	1	1	0	–10dB
0	1	1	1	0	–12dB
1	0	0	1	1	–14dB
0	1	0	1	1	–16dB
1	1	0	1	1	–18dB

D20	D21	D22	D23		
0	0	0	0		Set to 0

Fader Volume Control

D28	D29	D30	D31	Operation
0	0	0	0	0dB
1	0	0	0	–1dB
0	1	0	0	–2dB
1	1	0	0	–4dB
0	0	1	0	–6dB
1	0	1	0	–8dB
0	1	1	0	–10dB
1	1	1	0	–12dB
0	0	0	1	–14dB
1	0	0	1	–16dB
0	1	0	1	–18dB
1	1	0	1	–20dB
0	0	1	1	–30dB
1	0	1	1	–45dB
0	1	1	1	–60dB
1	1	1	1	–∞

Channel Selection Control

D32	D33	Operation
0	0	
1	0	RCH
0	1	LCH
1	1	L/R simultaneously

Fader Rear/Front Control

D34	Setting
0	Rear
1	Front

Loudness Control

D35	Setting
0	OFF
1	ON

Zero-Cross Control

D36	D37	Setting
0	0	Data write through zero-cross detection
1	1	Zero-cross detection stopped (data write at falling edge of CE)

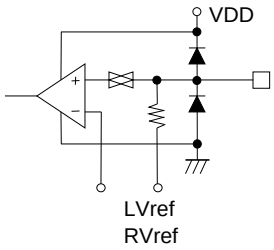
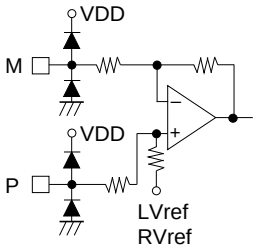
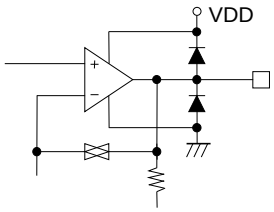
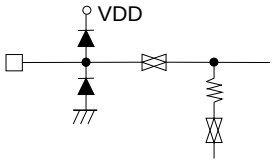
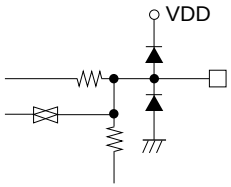
Zero-Cross Signal Detection Block Control

D38	D39	Setting
0	0	Selector
1	0	Volume
0	1	Tone
1	1	Fader

Test Mode Control

D42	D43	Setting
0	0	For IC testing. Always set to 0.

Pin Functions

Pin Name	Pin No.	Function	Equivalent circuit
L1 L2 L3 L4 L6 R1 R2 R3 R4 R6	54 53 52 51 55 59 60 61 62 58	• Single-end input pins	
L5M L5P R5M R5P	50 49 63 64	• Differential input pins	
LSEL0 RSEL0	48 1	• Input selector output pins	
LCT RCT	46 3	• Loudness pins. Connect high-pass compensation RC between LCT (RCT) and LVRIN (RVRIN), and connect low-pass compensation RC between LCT (RCT) and GND.	
LVRIN RVRIN	47 2	• Volume and equalizer input pins.	

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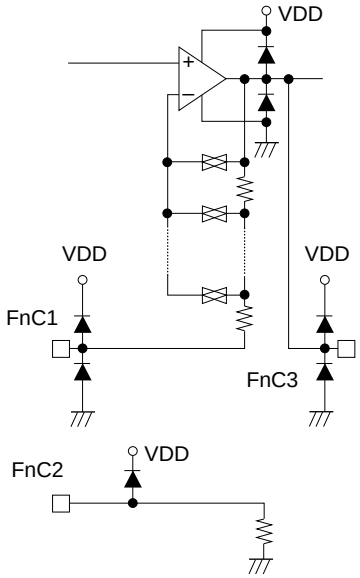
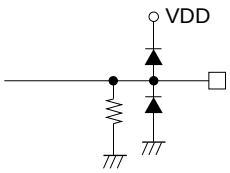
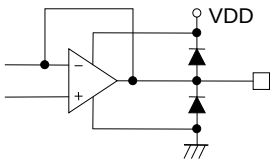
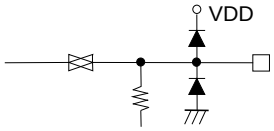
Pin Name	Pin No.	Function	Equivalent circuit
LF1C1 LF1C2 LF1C3 RF1C1 RF1C2 RF1C3	42 41 40 7 8 9	• Equalizer F1 band filter configuration capacitor connection pins. Connect capacitor between LF1C1 (RF1C1) and LF1C2 (RF1C2) LF1C2 (RF1C2) and LF1C3 (RF1C3)	
LF3C1 LF3C2 LF3C3 RF3C1 RF3C2 RF3C3	36 35 34 13 14 15	• Equalizer F3 band filter configuration capacitor connection pins. Connect capacitor between LF3C1 (RF3C1) and LF3C2 (RF3C2) LF3C2 (RF3C2) and LF3C3 (RF3C3)	
NC NC NC NC NC NC NC NC NC NC NC NC	45 44 43 39 38 37 21 10 11 12 5 4 3	• No connect pin	
TEST	28	• Dedicated IC test pin. • Normally this pin is used connected to GND.	
LTOUT RTOUT	33 16	• Equalizer output pins	
LFIN RFIN	32 17	• Fader block input pins • Drive at low impedance.	

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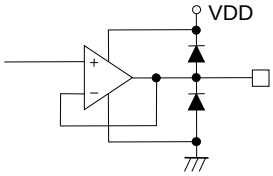
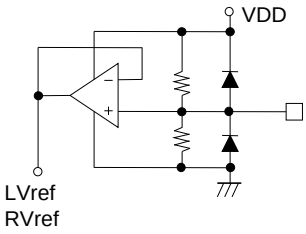
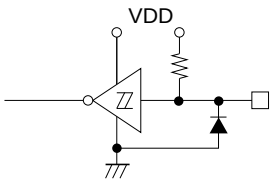
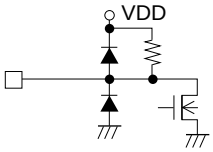
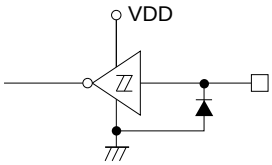
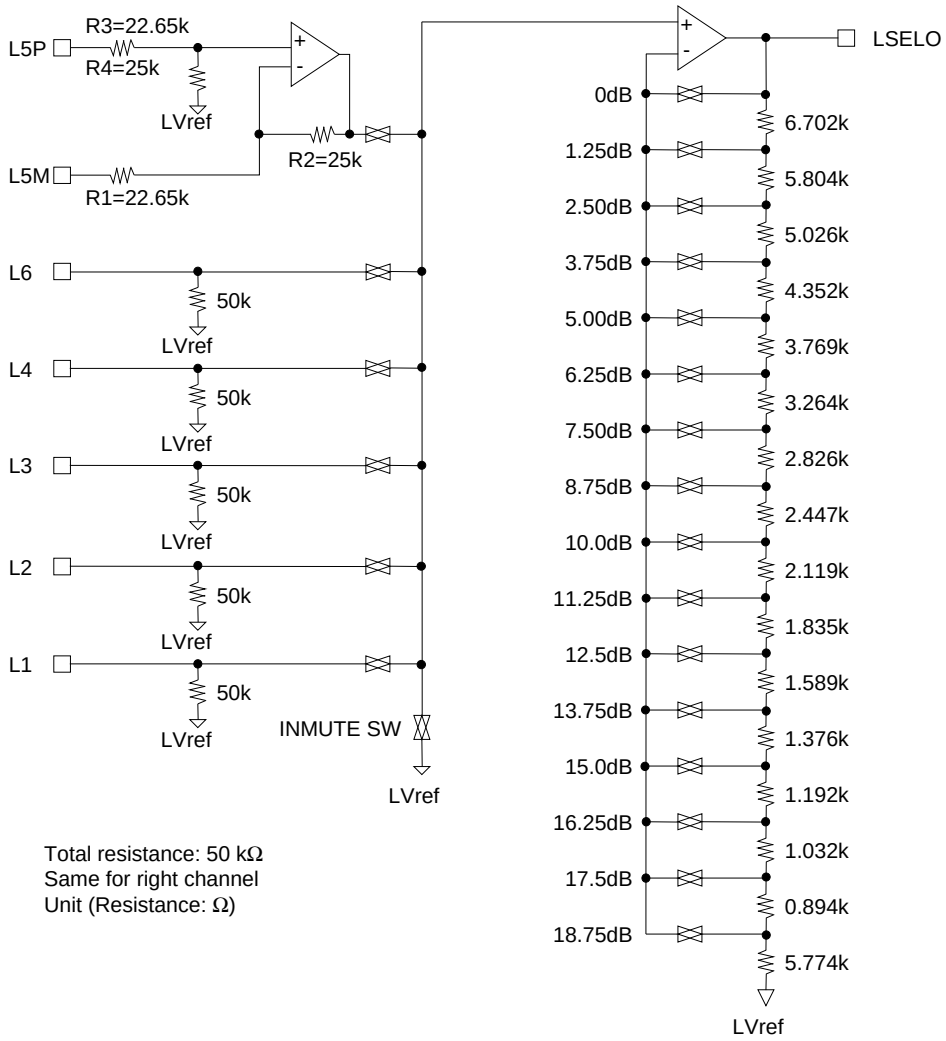
Pin Name	Pin No.	Function	Equivalent circuit
LFOUT LROUT RFOUT RROUT	31 30 18 19	• Fader output pins. Attenuation is possible separately for the front end and rear end. The attenuation amount is the same for L and R.	
Vref	57	• Connect a capacitor of a few tens of µF between Vref and AVSS (VSS) as a VDD/2 voltage generator, current ripple countermeasure.	
VDD	56	• Power supply pin	
DVSS	27	• Logic system ground pin	
LAVSS RAVSS	29 22	• Analog system ground pins	
$\overline{\text{MUTE}}$	23	• External muting control pin • Setting this pin to V_{SS} level sets forcibly fader volume block to –∞ level.	
TIM	20	• Timer pin when there is no signal in the zero-cross circuit. Forcibly set data when there is no zero-cross signal, from the time the data is set until the timer ends.	
CL DI	26 25	• Input pin for serial data and clock used for control	
CE	24	• 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.	

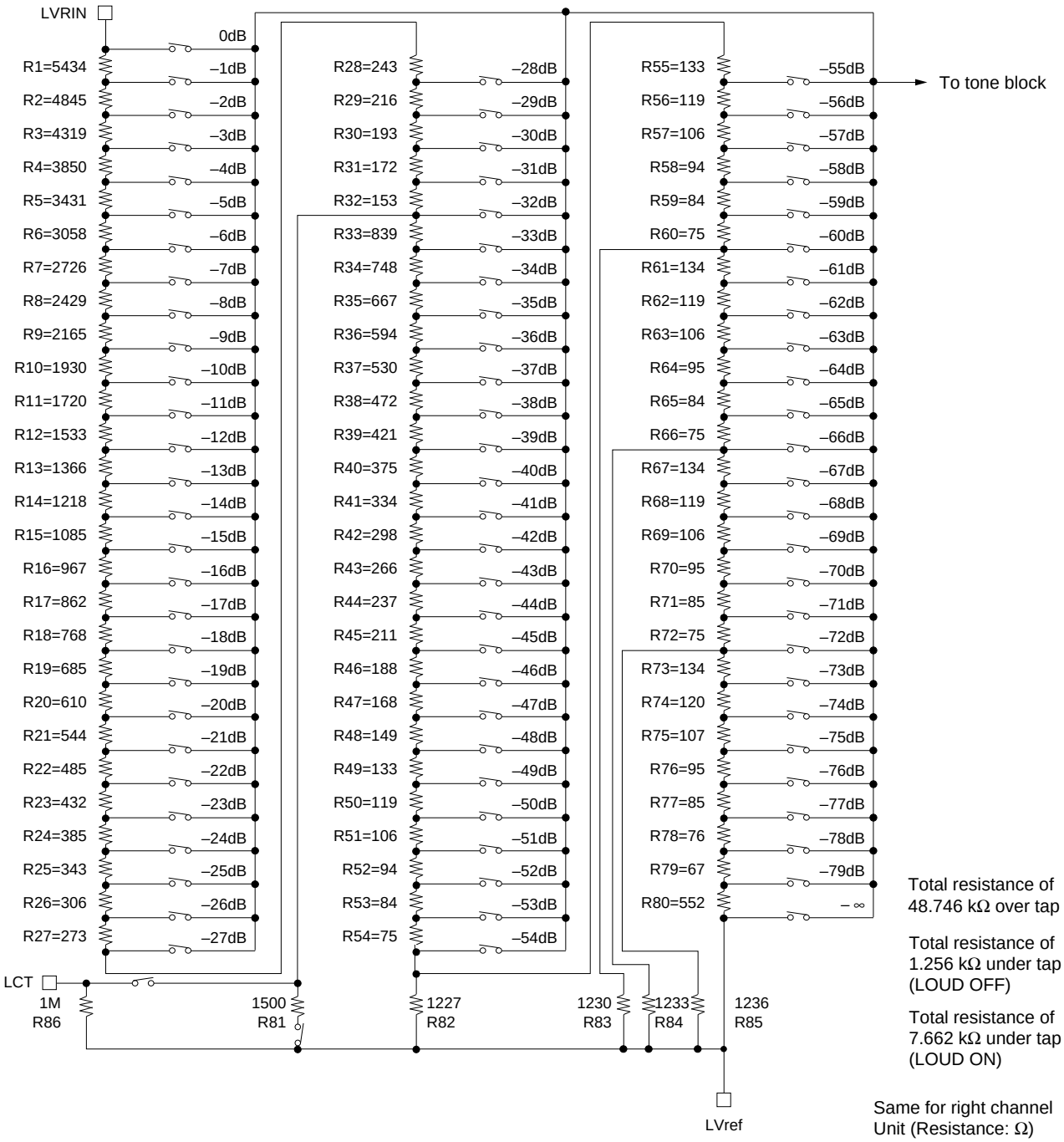
Internal Equivalent Circuit Block Diagram

Selector Block Equivalent Circuit Block Diagram

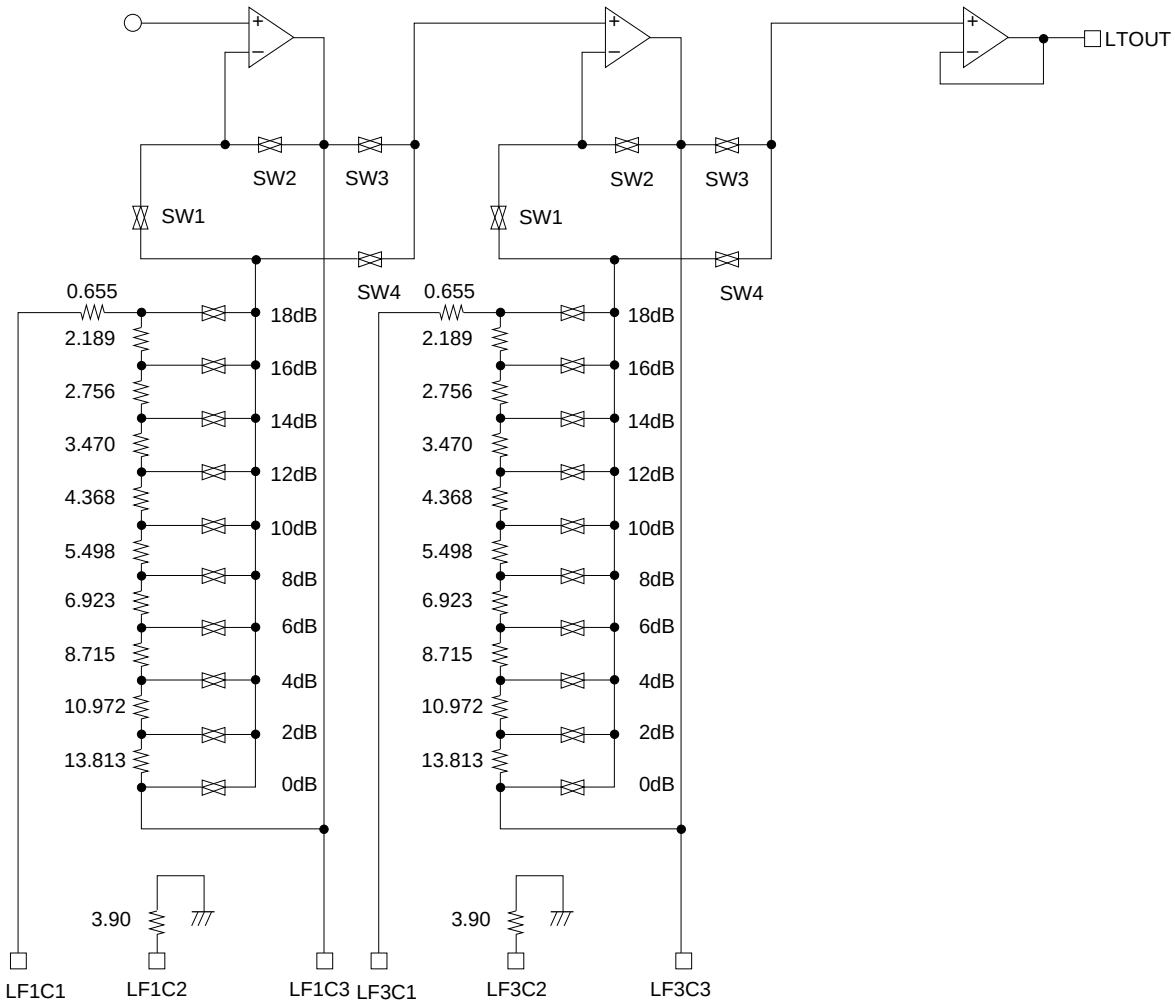


Total resistance: 50 kΩ
Same for right channel
Unit (Resistance: Ω)

Volume Block Equivalent Circuit Block Diagram



Tone Control Block Equivalent Circuit Diagram



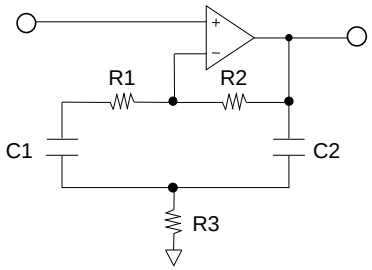
Unit: kΩ
Total resistance: 59.359 kΩ
Same for right channel

During boost, SW 1 and SW 3 are ON, during cut SW 2 and SW 4 are ON, and when 0 dB, 0 dB SW and SW 2 and SW 3 are ON.

F1/F3 Band Circuit

The equivalent circuit and the formula for calculating the external RC with a mean frequency of 1 kHz are shown below.

• F1/F3 band equivalent circuit block diagram



• Calculation example

Specification Mean frequency: f0 = 1 kHz

Gain during maximum boost: $G_{+18\ dB}$ = 18 dB

Let us use R1 = 0.665 kΩ, R2 = 58.704 kΩ, and C1 = C2 = C.

$$G_{+18\ dB} = 20 \times LOG_{10}\left(1 + \frac{R2}{2R3+R1}\right)$$

1. Calculate R3 with $G_{+18\ dB}$ = 18 dB:

$$R3 = \left(\frac{R2}{10^{G/20} - 1} - R1\right) \div 2 = 3900\ \Omega$$

2. Calculate C with the center frequency f0 = 1 kHz

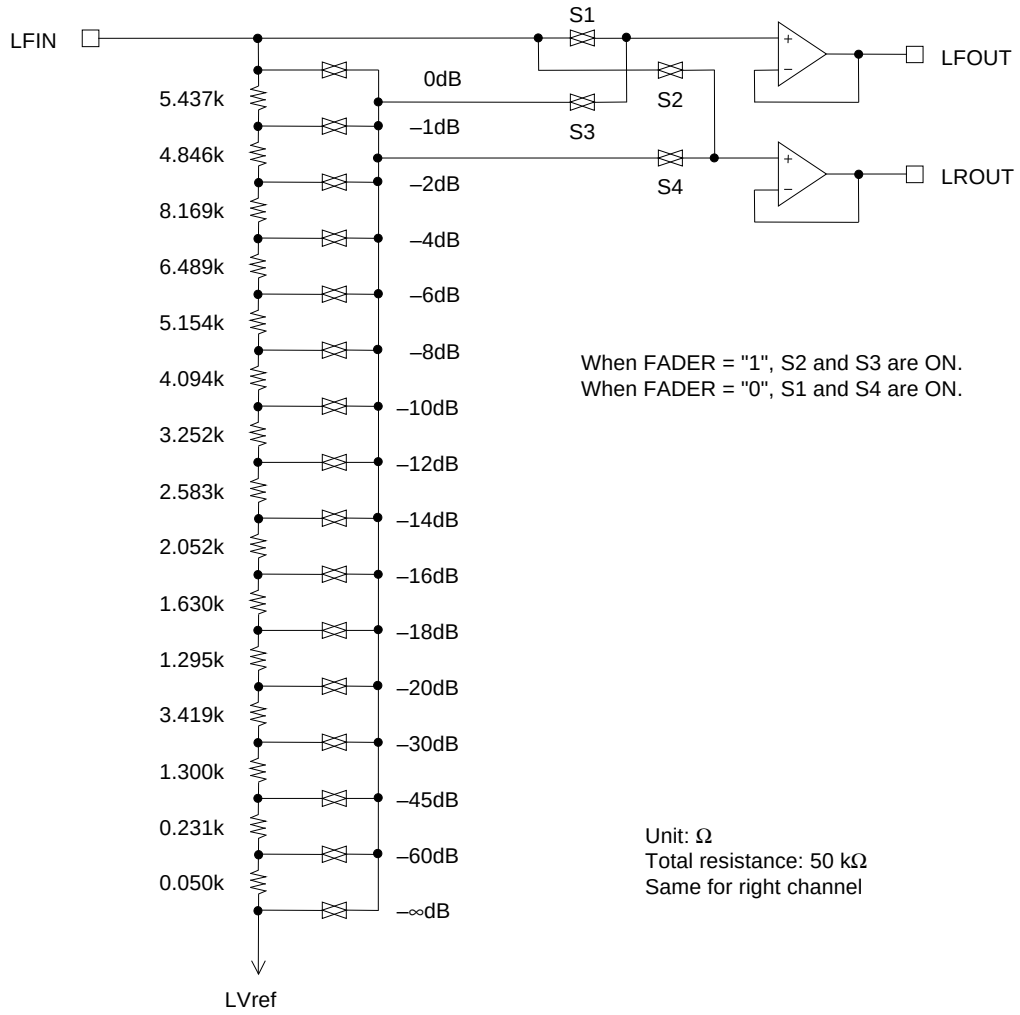
$$f0 = \frac{1}{2\pi\sqrt{(R1+R2)R3C1C2}}$$

$$C = \frac{1}{2\pi f0\sqrt{(R1+R2)R3}} = \frac{1}{2\pi \times 1000\sqrt{39359 \times 3900}} = 0.010 \times 10^{-6} \cong 0.01\ \mu F$$

3. Calculate Q:

$$Q = \frac{1}{\sqrt{(R1+R2)R3}} \times \frac{R3(R1+R2)}{(2R3+R1)} \cong 1.789$$

Fader Volume Block Equivalent Circuit Block Diagram



When FADER = "1", S2 and S3 are ON.
When FADER = "0", S1 and S4 are ON.

Unit: Ω
Total resistance: 50 kΩ
Same for right channel

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

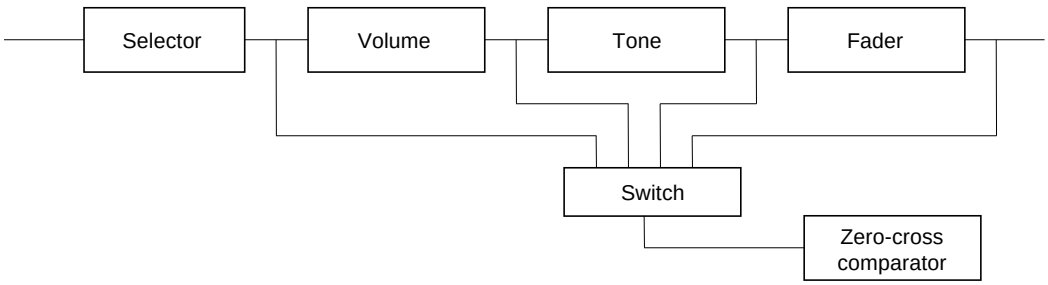
Usage Cautions

(1) Data transmission at power ON

- The status of internal analog switches is unstable at power ON. Therefore, perform muting or some other countermeasure until the data has been set.

(2) Description of zero-cross switching circuit operation

The LC75412E and 75412W have a function to switch zero-cross comparator signal detection locations, enabling the selection of the optimum detection location for blocks whose data is to be updated. Basically, the switching noise can be minimized by inputting the signal immediately following the block whose data is to be updated to the zero-cross comparator, so it is necessary to switch the detection location every time.



LC75412E, 75412W Zero-Cross Detection Circuit

(3) Zero-cross switching control method

The zero-cross switching control method consists of setting the zero-cross control bits to the zero-cross detection mode (D36, D37 = 0), and specifying the detection blocks (D38, D39) before transmitting the data. These control bits are latched immediately following data transfer, that is to say beforehand in sync with the falling edge of CE, so when updating data of volumes, etc., it is possible to perform mode setting and zero-cross switching with one data transfer. An example of control when updating the data of the volume block is shown below.

D36	D37	D38	D39
0	0	1	0

Zero-cross detection mode setting

Volume block setting

(4) Zero-cross timer setting

If the input signal becomes lower than the zero-cross comparator detection sensitivity, or if only low-frequency signals are input, zero-cross detection continues to be impossible, and data is not latched during this time.
The zero-cross timer can set a time for forcible latch during such a status when zero-cross detection is not possible.

For example, to set 25 ms,
using T = 0.69CR and C = 0.033 μF,
we obtain

$$R = \frac{25 \times 10^{-3}}{0.69 \times 0.033 \times 10^{-6}} \fallingdotseq 1.1\ \text{M}\Omega$$

Normally, a value between 10 ms and 50 ms is set.

(5) Cautions related to serial data transfer

1. To ensure that the high-frequency digital signals transferred 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.
2. The data format of the LC75412E and 75412W uses 8-bit addresses and 44-bit data. When sending data using multiples of 8 (when sending 48 bits), use the method described in Figure 1.

Method for Receiving Data Using Multiple of 8 of LC75412E and 75412W

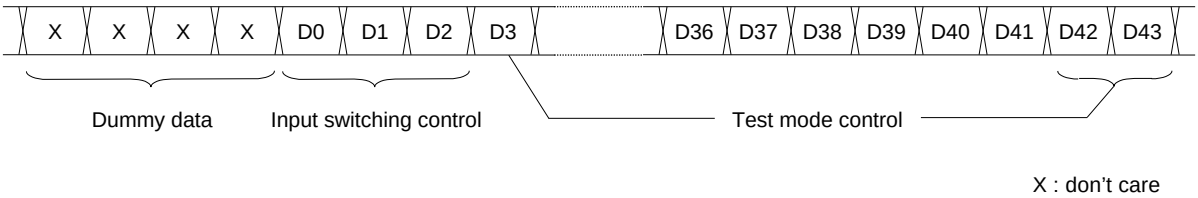
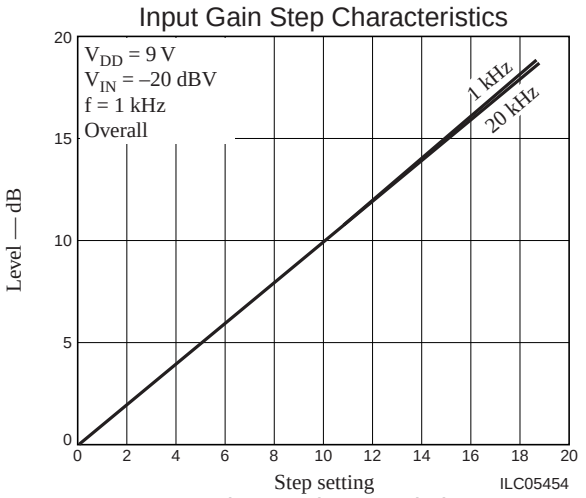
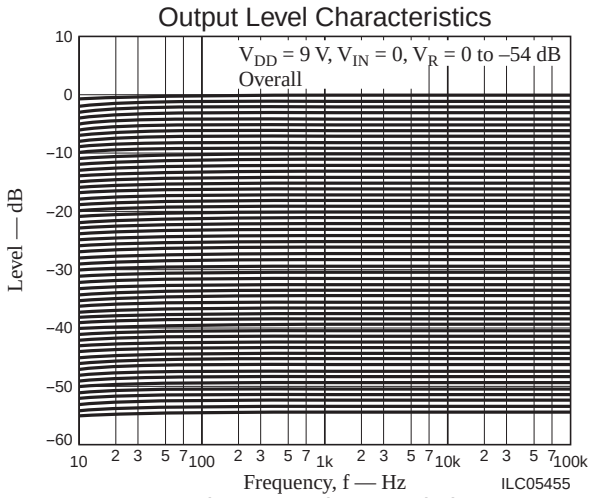


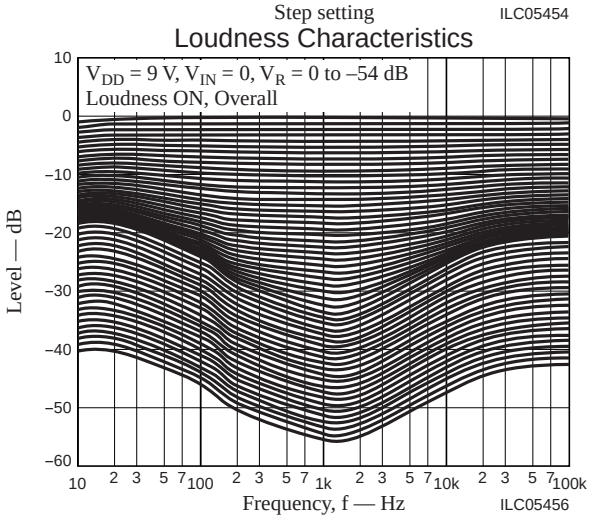
Figure 1

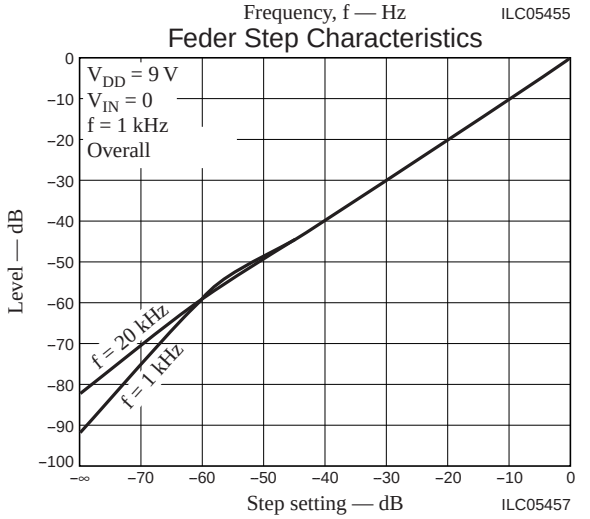
(6) Note on usage of external muting

When using external mute function, take adequate countermeasures against noise to prevent malfunction.

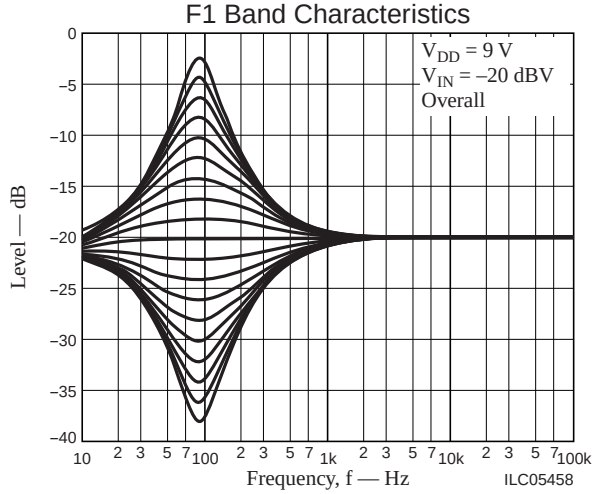




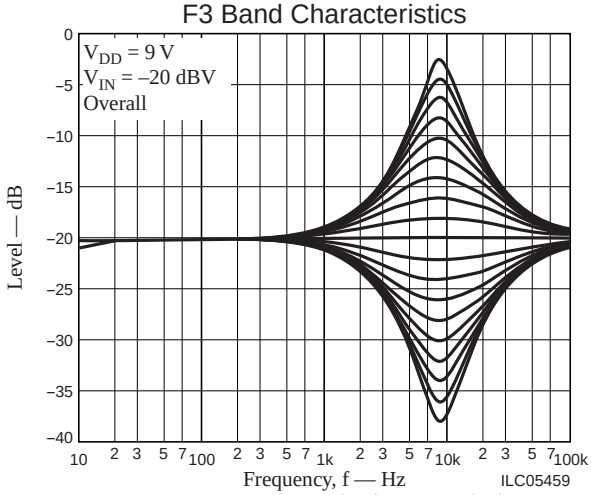




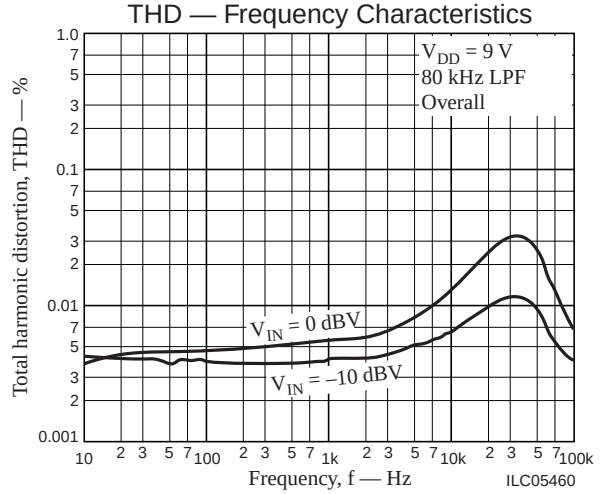
F1 Band Characteristics



F3 Band Characteristics



THD — Frequency Characteristics



THD — Input Level Characteristics