Ordering number : ENN*7378

CMOS LSI

LC75347E

Six-Channel Single-Chip Electronic Volume Control System

Preliminary

Overview

The LC75347E is a 6-channel 97-step electronic volume control system IC that provides a 2-channel input selector, bass and treble tone controls, external output ports, and a zero-cross volume switching function.

Functions

- Volume: 0 to –95 dB (in 1 dB steps) and –∞, for a total of 97 positions.
  Each of the six input channels can be controlled independently.
- Bass and treble: Each band can be controlled over a ±12 dB range in 2 dB steps.
  The bass control provides peaking characteristics and the treble control provides shelving characteristics.
- Selector: 2-channel input selector
- Zero cross: Provides independent zero-cross detection for each of the 6 channels and a timer overflow detection circuit.
- External muting: Mute in/mute out function using zero-cross detection and dedicated pins.
- External output ports: Provides 4 n-channel transistor open-drain outputs.

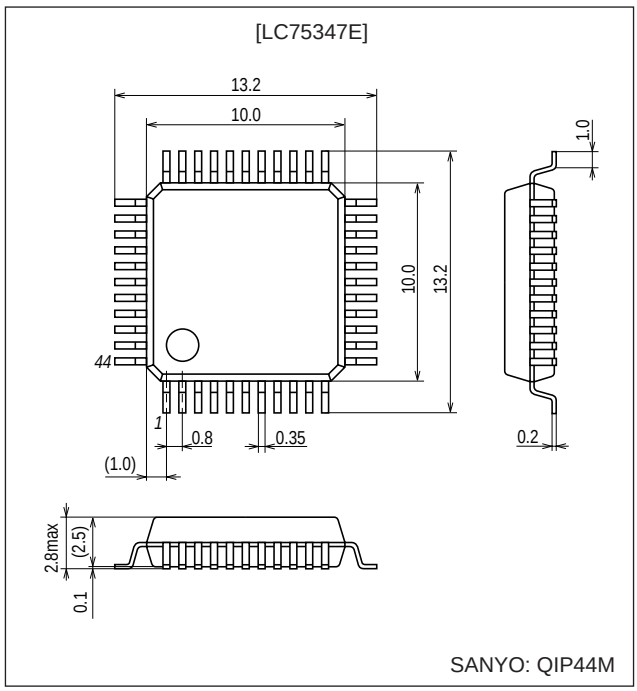
Features

- Built-in buffer amplifiers reduce the number of external components to a minimum.
- Fabricated in a silicon-gate CMOS process for minimal noise generation from internal switches.
- Built-in analog ground reference voltage generator circuit
- All settings are controlled by serial data transmitted over a CCB interface.

Package Dimensions

unit: mm

3148A-QIP44M



- **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.**

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Specifications

Absolute Maximum Ratings at Ta = 25°C, V_{SS} = 0 V

Parameter	Symbol	Pin	Conditions	Ratings	Unit
Maximum supply voltage	V_{DD} max	V_{DD}		11	V
Maximum input voltage	V_{IN}1 max	CE, DI, CL, MUTE OUTP1 to OUTP4		–0.3 to +11	V
	V_{IN}2 max	FL, FR, RL, RR, C, SBW, FLTON, FRTON, FLIN, FRIN		V_{SS} – 0.3 to V_{DD} + 0.3	
Output current	I_{OUT}	OUTP1 to OUTP4		0 to 1	mA
Allowable power dissipation	Pdmax		Ta ≤ 85°C *1. When mounted on a PCB	600	mW
Operating temperature	Topr			–40 to +85	°C
Storage temperature	Tstg			–50 to +125	°C

*1: PCB dimensions: 76.1 × 114.3 × 1.6 mm, PCB materials: glass epoxy

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

Parameter	Symbol	Pin	Conditions	Ratings			Unit
				min	typ	max	
Supply voltage	V_{DD}	V_{DD}		4.5		10.5	V
High-level input voltage	V_{IH}	CL, DI, CE, MUTE OUTP1 to OUTP4		2.5		10.5	V
Low-level input voltage	V_{IL}	CL, DI, CE, MUTE	7.5 ≤ V_{DD} ≤ 10.5	V_{SS}		0.8	V
			4.5 ≤ V_{DD} < 7.5	V_{SS}		0.3	
Input amplitude	V_{IN}	FL, FR, RL, RR, C, SBW, FLTON, FRTON, FLIN, FRIN		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	Conditions	Ratings			Unit
				min	typ	max	
[Volume and Selector Blocks]							
Input resistance	Rin	FL, FR, RL, RR, C, SBW, FLTON, FRTON, FLIN, FRIN			50		kΩ
[Treble Band Equalizer Control Block]							
Control range	Geq		max. boost/cut	±10	±12	±14	dB
Step resolution	Estep			1	2	3	dB
Internal feedback resistance	Rfeed				51.7		kΩ
[Bass Band Equalizer Control Block]							
Control range	Geq		max. boost/cut	±10	±12	±14	dB
Step resolution	Estep			1	2	3	dB
Internal feedback resistance	Rfeed				38.9		kΩ
[Output Port Block]							
Low-level output voltage	V0	OUTP1 to OUTP4	Rh = 10 kΩ, Vd = 5 V			0.5	V

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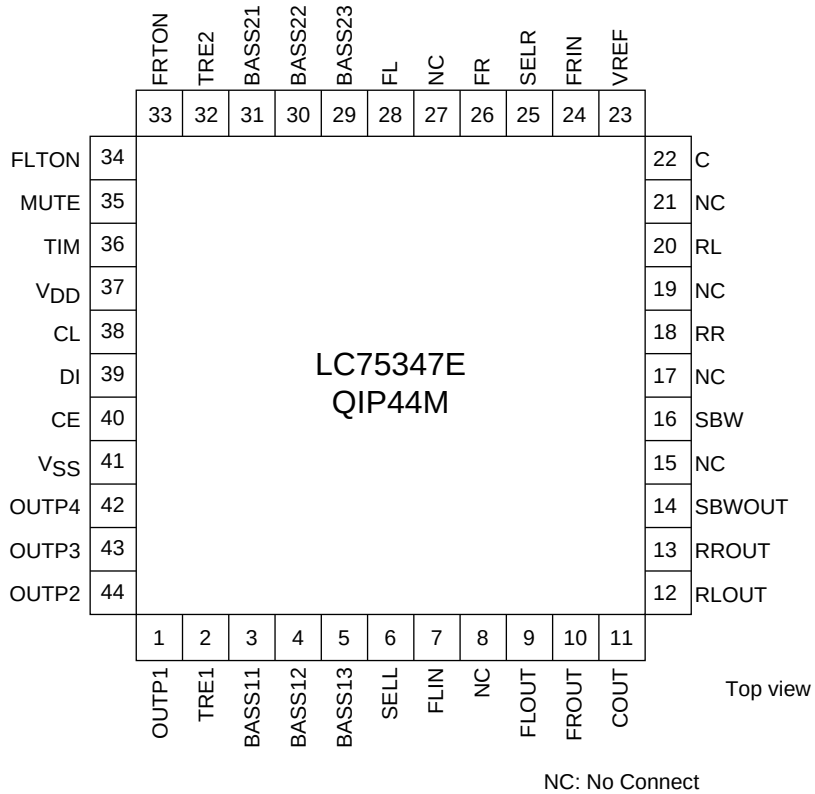
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
[Overall Characteristics]						
Total harmonic distortion (RL, RR, C and SBW inputs, direct output)	THD1	V_{IN} = 1 Vrms, f = 1 kHz, 80 kHz LPF Flat overall		0.001	0.01	%
Total harmonic distortion (FL and FR inputs, direct output)	THD2	V_{IN} = 1 Vrms, f = 1 kHz, 80 kHz LPF Flat overall FL and FR selected, direct output		0.002	0.01	
Total harmonic distortion (FLTON and FRTON inputs, FLOUT and FROUT outputs)	THD3	V_{IN} = 1 Vrms, f = 1 kHz, 80 kHz LPF Flat overall FLTON and FRTON selected, output after passing though tone controls.		0.003	0.01	
Output noise voltage (RL, RR, C and SBW inputs, direct output)	VN1	80 kHz LPF, Rg = 1 kΩ All controls flat overall		6		μV
		A-WIGHT, Rg = 1 kΩ All controls flat overall		2.5		
Output noise voltage (FL and FR inputs, direct output)	VN2	80 kHz LPF, Rg = 1 kΩ All controls flat overall		7		
		A-WIGHT, Rg = 1 kΩ All controls flat overall		3		
Output noise voltage (FLTON and FRTON inputs, FLOUT and FROUT outputs)	VN3	80 kHz LPF, Rg = 1 kΩ All controls flat overall		9		
		A-WIGHT, Rg = 1 kΩ All controls flat overall		4		
Characteristics at maximum attenuation	Vomin	V_{IN} = 1 Vrms, f = 1 kHz, 80 kHz LPF All controls flat overall		–95		dB
Crosstalk	CT	V_{IN} = 1 Vrms, f = 1 kHz, Rg = 1 kΩ All controls flat overall	80			dB
Current drain	I_{DD}	$V_{DD} - V_{SS}$ = +9 V		38		mA
High-level input current	I_{IH}	CL, DI, CE, MUTE: V_{IN} = 10.5 V,V_{DD} = 10.5 V			10	μA
Low-level input current	I_{IL}	CL, DI, CE, MUTE: V_{IN} = 0 V,V_{DD} = 10.5 V	–10			μA

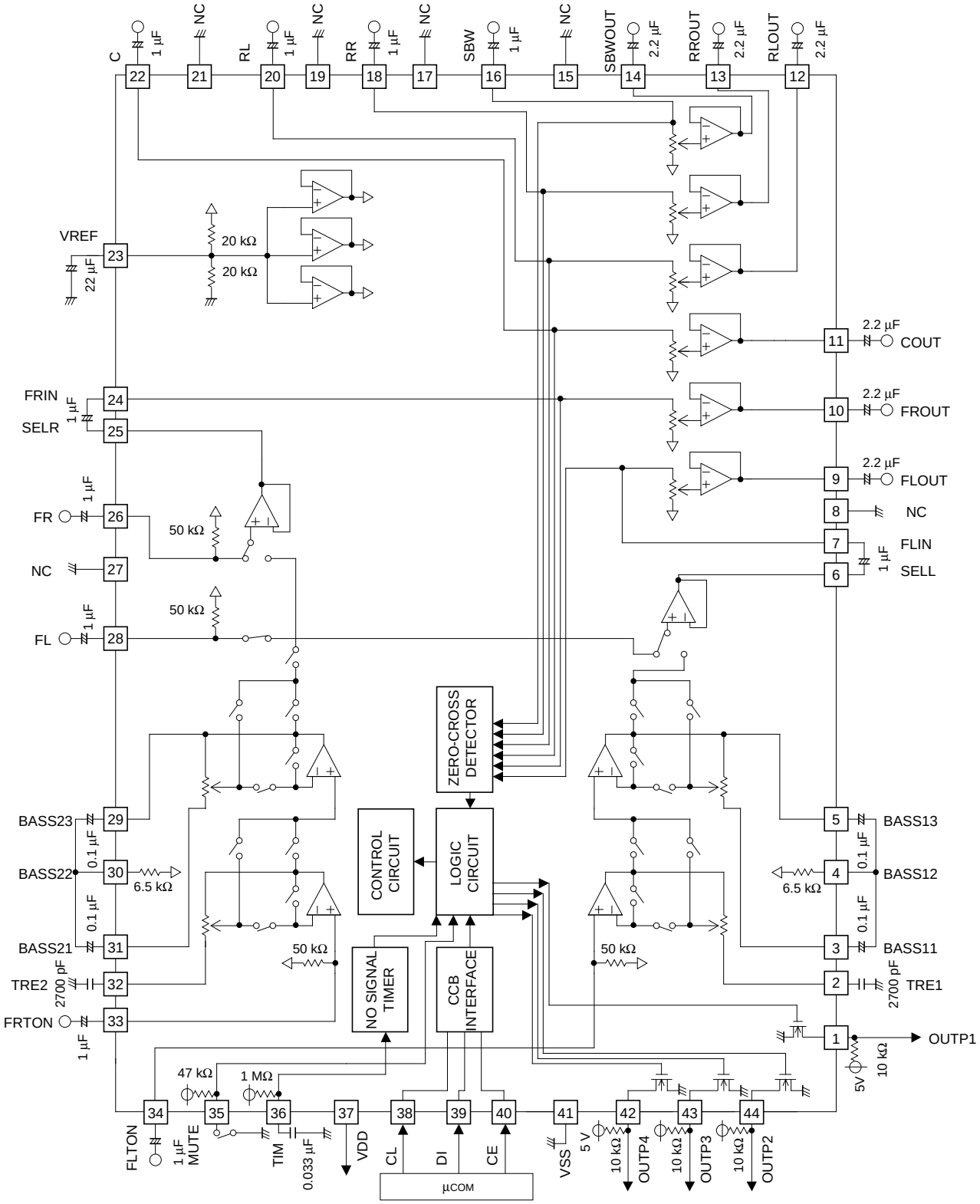
Pin Assignment



Top view

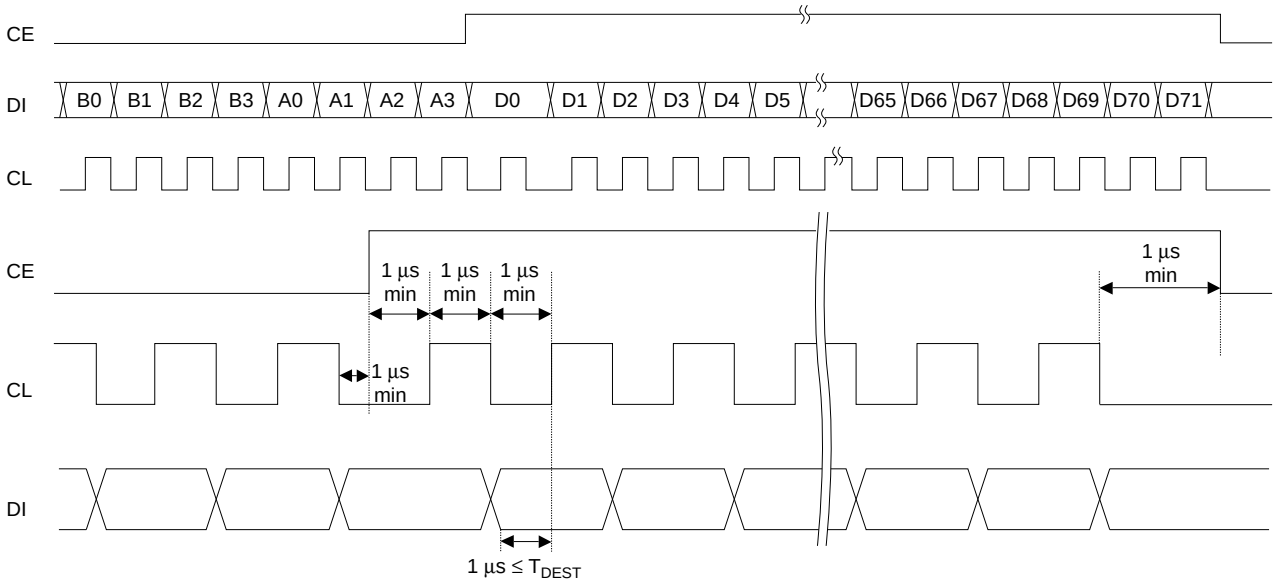
NC: No Connect

Equivalent Circuit/Application Circuit Example



Control System Timing and Data Format

The stipulated serial data must be applied to the CL, DI, and CE pins to control the LC75347E. The data consists of 80 bits, of which 8 bits are address and 72 bits are data.



- Address Code (B0 to A3)
  This IC has an 8-bit address code and can be used with the same specifications as other Sanyo CCB serial bus ICs.

Address code (LSB) (82HEX)

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

• Control Code Allocations

Volume Control

D0	D1	D2	D3	D4	D5	D6	D7	SBW setting
D8	D9	D10	D11	D12	D13	D14	D15	RR setting
D16	D17	D18	D19	D20	D21	D22	D23	RL setting
D24	D25	D26	D27	D28	D29	D30	D31	C setting
D32	D33	D34	D35	D36	D37	D38	D39	FRIN setting
D40	D41	D42	D43	D44	D45	D46	D47	FLIN setting
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
1	1	0	0	0	1	0	0	–35 dB
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

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D0	D1	D2	D3	D4	D5	D6	D7	SBW setting
D8	D9	D10	D11	D12	D13	D14	D15	RR setting
D16	D17	D18	D19	D20	D21	D22	D23	RL setting
D24	D25	D26	D27	D28	D29	D30	D31	C setting
D32	D33	D34	D35	D36	D37	D38	D39	FRIN setting
D40	D41	D42	D43	D44	D45	D46	D47	FLIN setting
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
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	–80 dB
1	0	0	0	1	0	1	0	–81 dB
0	1	0	0	1	0	1	0	–82 dB
1	1	0	0	1	0	1	0	–83 dB
0	0	1	0	1	0	1	0	–84 dB
1	0	1	0	1	0	1	0	–85 dB
0	1	1	0	1	0	1	0	–86 dB
1	1	1	0	1	0	1	0	–87 dB
0	0	0	1	1	0	1	0	–88 dB
1	0	0	1	1	0	1	0	–89 dB
0	1	0	1	1	0	1	0	–90 dB
1	1	0	1	1	0	1	0	–91 dB
0	0	1	1	1	0	1	0	–92 dB
1	0	1	1	1	0	1	0	–93 dB
0	1	1	1	1	0	1	0	–94 dB
1	1	1	1	1	0	1	0	–95 dB
1	1	1	1	1	1	1	0	–∞

Zero cross control

D48	SBW setting	Operation
D49	RR setting	
D50	RL setting	
D51	C setting	
D52	FRIN setting	
D53	FLIN setting	
0	Zero cross operation	
1	Zero cross operation is disabled (This setting takes effect on the fall of CE.)	

Tone Switch Selection

D54	D55	Setting
0	0	The analog switches are set so that FL and FR bypass the tone circuit.
1	0	The analog switches are set so that FL is connected to, and FR bypass the tone circuit.
0	1	The analog switches are set so that FR is connected to, and FL bypass the tone circuit.
1	1	The analog switches are set so that FL and FR are connected to the tone circuit.

Bass

D56	D57	D58	D59	FLTON setting FRTON setting
0	1	1	0	+12 dB
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
0	1	1	1	–12 dB

Treble

D60	D61	D62	D63	FLTON setting FRTON setting
0	1	1	0	+12 dB
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
0	1	1	1	–12 dB

Tone Mode

D64	D65	Setting
0	0	FLTON and FRTON not changed
1	0	Only FLTON changed
0	1	Only FRTON changed
1	1	Both FLTON and FRTON changed

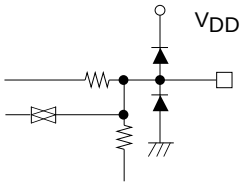
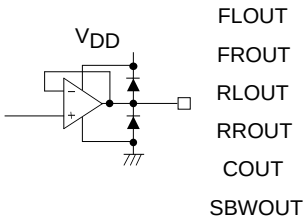
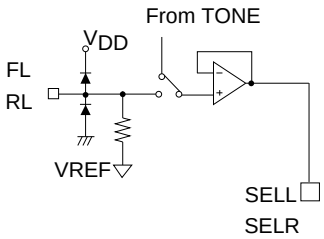
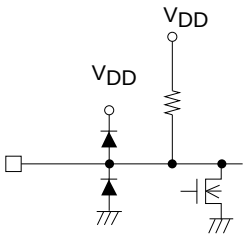
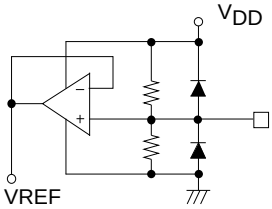
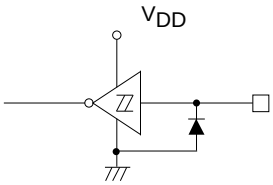
Output Ports

	Setting
D66	OUTP1 (VSS: 1, OPEN: 0)
D67	OUTP2 (VSS: 1, OPEN: 0)
D68	OUTP3 (VSS: 1, OPEN: 0)
D69	OUTP4 (VSS: 1, OPEN: 0)

Test Mode

D70	D71	Setting
0	0	These bits are used for IC testing. They must be set to 0 during normal operation.

Pin Functions

Pin No.	Pin	Function	Notes
7 24 20 18 22 16	FLIN FRIN RL RR C SBW	• Volume control inputs	
9 10 11 12 13 14	FLOUT FROUT COUT RLOUT RROUT SBWOUT	• Volume control outputs	
28 26	FL FR	• Selector volume inputs	
6 25	SELL SELR	• Selector volume outputs	
36	TIM	• Zero cross circuit timer If a zero cross is not detected during the period from the completion of the data transfer to the point the timer overflows, the control data is enabled forcibly.	
23	VREF	• $0.5 \times V_{DD}$ voltage generator used for analog ground A capacitor of several ten µF must be connected between VREF and V_{SS} to minimize power supply ripple.	
41	V_{SS}	• Ground	
37	V_{DD}	• Power supply	
40	CE	• Chip enable Data is written to the internal latch when this pin goes from high to low. The analog switches operate at that time. Data transfer is enabled when CE is high.	
39 38	DI CL	• Serial data and clock inputs for the control data.	

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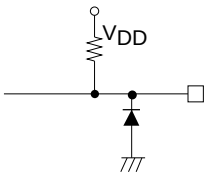
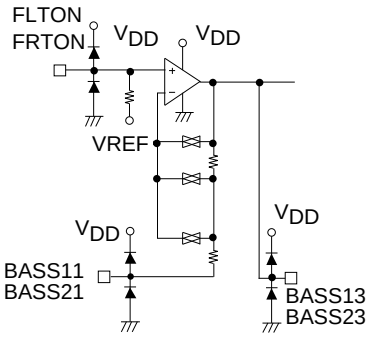
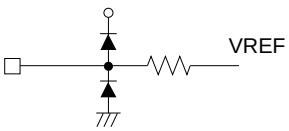
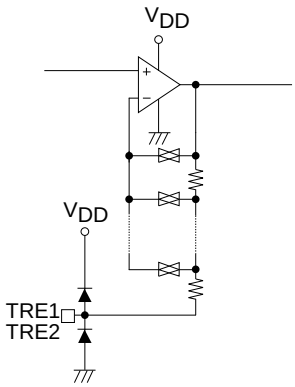
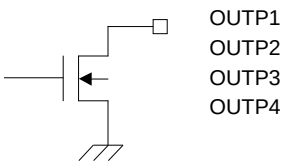
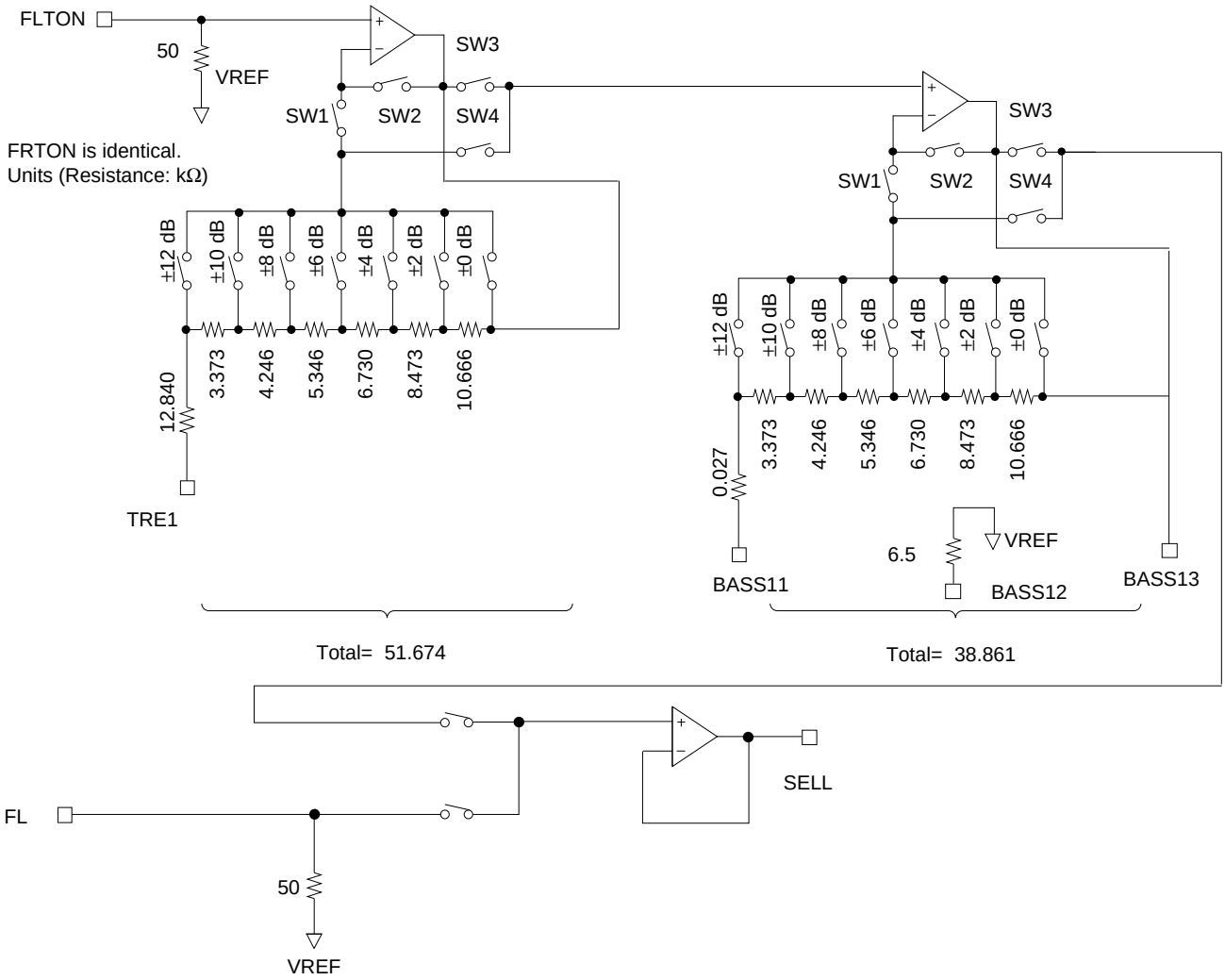
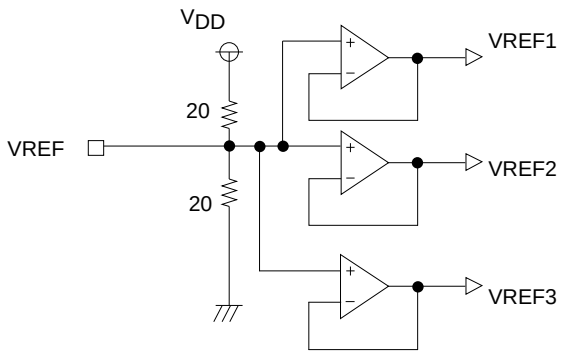
Pin No.	Pin	Function	Notes
35	MUTE	• External control mute pin Applying the V_{SS} level to this pin forcibly sets the volume level for all channels to –∞.	
34 33	FLTON FRTON	• Tone control block inputs After passing through the tone control circuit, the audio signals are output to the selector amplifier.	
3 5 31 29	BASS11 BASS13 BASS21 BASS23	• Connections for the capacitors that form the bass filters	
4 30	BASS12 BASS22	• Connections for the resistors that form the bass filters	
2 32	TRE1 TRE2	• Connections for the capacitors that form the treble filters	
1 44 43 42	OUTP1 OUTP2 OUTP3 OUTP4	• N-channel transistor open-drain outputs When off, these outputs are in the high-impedance state.	
8 15 17 19 21 27	NC	• Unused pins These pins must either be left open or connected to V_{SS}.	

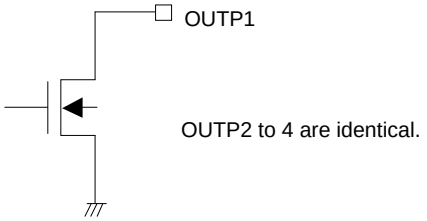
Internal Equivalent Circuits

- Selector, Bass/Treble, VREF Amplifier, Output Ports

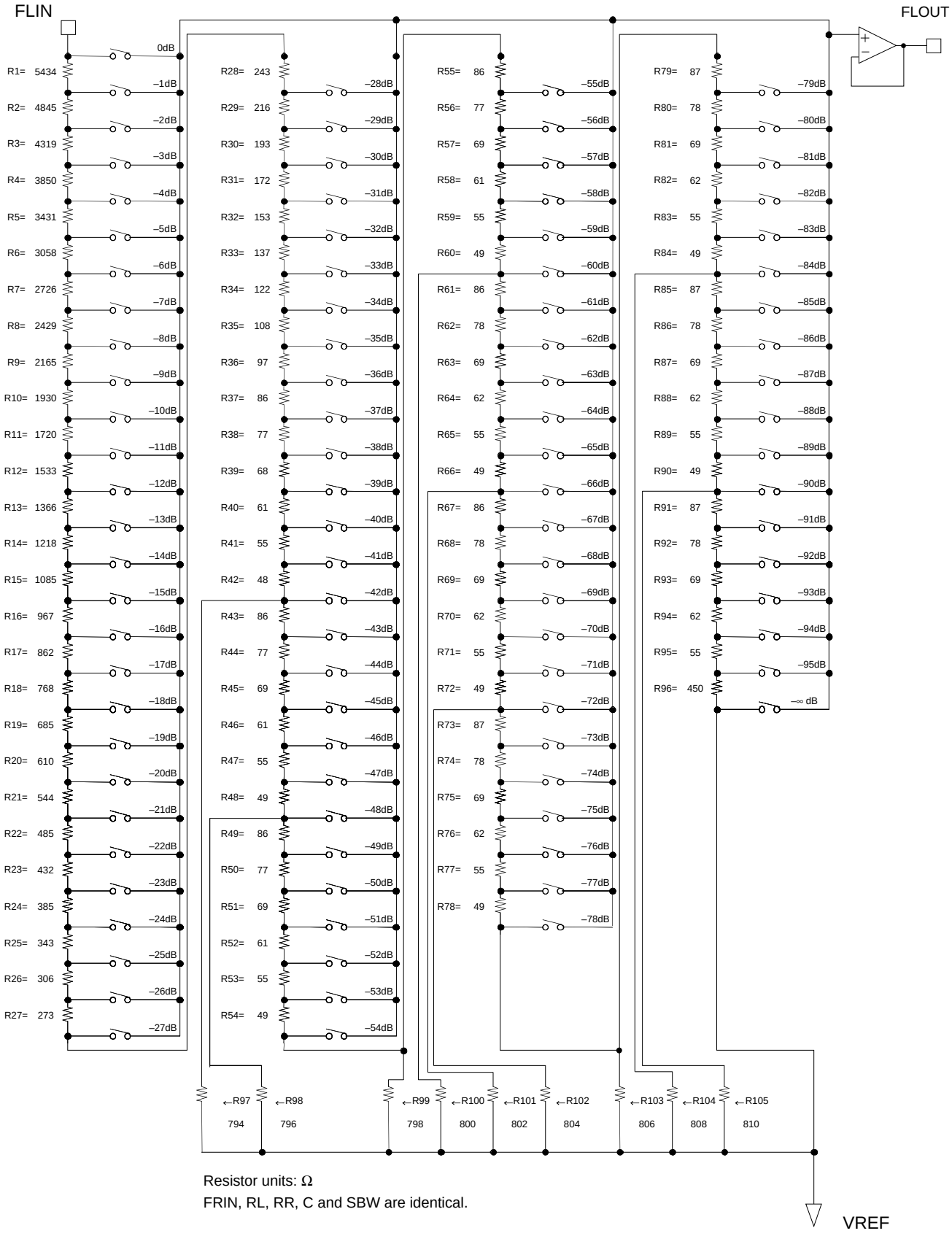


For boost, set switches 1 and 3 to the on position, for cut, set switches 2 and 4 to the on position, and for 0 dB, set switches 2, 3 and 0 dB switch to the on position.





• Volume Block
Total resistance: 50 kΩ (Parallel resistors)

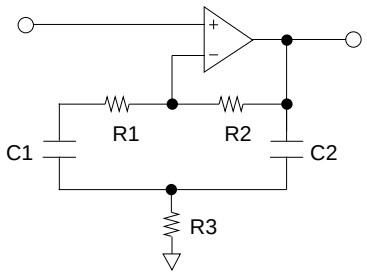


Resistor units: Ω
FRIN, RL, RR, C and SBW are identical.

Calculating the Equalizer External Component Values

1. Bass Band Circuit
   Here we show the equivalent circuit and the formulas for calculating the capacitor and resistor values for a center frequency of 100 Hz.

- Bass band equivalent circuit



- Sample calculation

  Specifications: Center frequency, f_0 = 100 Hz
  Gain at maximum boost: G = 12 dB
  Assume R1 = 27 Ω, R2 = 38,834 Ω, and C1 = C2 = C.

  (1) Determine R3 from the fact that G = 12 dB.

$$G_{+12dB} = 20 \times LOG_{10}\left(1 + \frac{R2}{2R3 + R1}\right)$$

$$R3 = \frac{\left|\frac{R2}{(10^{G/20} - 1)} - R1\right|}{2} = \frac{\frac{38834}{(3.981 - 1)} - 27}{2} \neq 6500\ \Omega$$

  (2) Determine C from the fact that the center frequency, f_0, is 100 Hz.

$$f_0 = \frac{1}{2\pi\sqrt{(R1 + R2)\, R3C1C2}}$$

$$C = \frac{1}{2\pi f_0\sqrt{(R1 + R2)\, R3}} = \frac{1}{2\pi \times 100\sqrt{(38834 + 27) \times 6500}} \neq 0.1\ \mu F$$

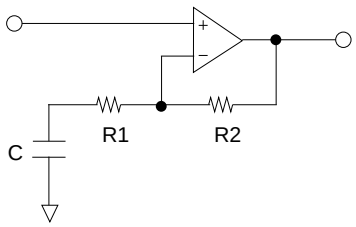
  (3) Determine Q.

$$Q = \frac{(R1 + R2)\, R3}{2R3 + R1} \cdot \frac{1}{\sqrt{(R1 + R2)\, R3}} \neq 1.22$$

2. Treble Band Circuit

The treble band circuit can provide shelving characteristics. Here we present the equivalent circuit when the circuit is providing boost and the circuit calculation formulas.

• Treble band equivalent circuit



• Sample calculation

Specifications: Set frequency, f = 26,000 Hz
Gain at maximum boost: $G_{+12\ dB}$ = 12 dB
Assume R1 = 12,840 Ω and R2 = 38,834 Ω.
Substituting the above values into the following formulas allows us to solve for C.

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

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

$$= \frac{1}{2\pi 26000 \sqrt{\left(\frac{38834}{3.98 - 1}\right)^2 - 12840^2}} \neq 2700\ (pF)$$

Usage Notes

1. Data Transmission after Power is First Applied
   The states of the internal analog switches are undefined when power is first applied. Applications should set up the initial data immediately after power is applied (after V_{DD} rises above 4.5 V). Applications should also mute the outputs until the data has been set up and the outputs are stable.
   To establish the states of the internal latches, set the bits D64 and D65 to 1 in the first data transferred after power is first applied.

2. Zero Cross Switching Control
   Zero cross switching is used by setting up data in which the zero cross control bits specify zero cross detection mode (by setting bits D48 to D53 to 0) and transfer that data. Since these control bits are latched first, immediately after the data is transferred, that is, on the fall of the CE signal, zero cross control can be performed with a single data transfer operation when updating the volume control settings. If the zero cross control bits specify zero cross detection disabled mode (by setting bits D48 to D53 to 1), the volume is switched on the fall of the CE signal at the end of the data transfer.

3. Zero Cross Timer Setting
   When the input signal is less than the detection sensitivity of the zero cross comparator, or if only a low-frequency signal is being input, the state where the IC does not detect a zero cross will continue and the data will not be latched. The zero cross timer allows applications to set a time at which data will be latched forcibly if the state where no zero cross is detected continues.

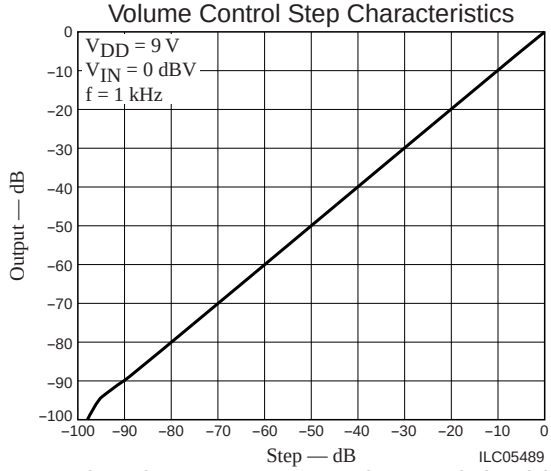
   For example, to set a time of 25 ms:
   $T = 0.69CR$
   Since the internal pull-up resistor is about 1 MΩ:

   $$C = \frac{25 \times 10^{-3}}{0.69 \times 1.0 \times 10^{6}} \fallingdotseq 0.036\ \mu F$$

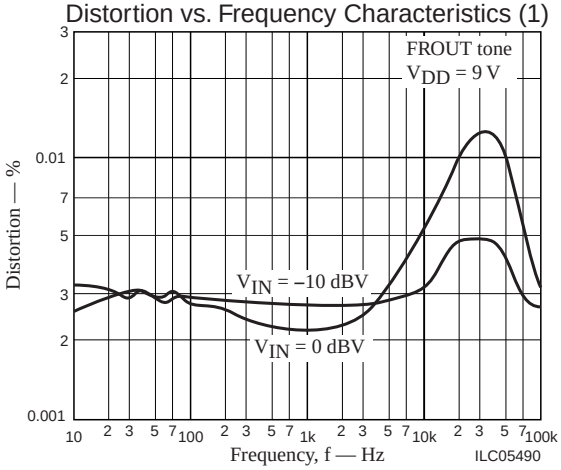
   Applications usually set a time in the range 10 to 50 ms.

4. Notes on Serial Data Transfer
   Cover the CL, DI, and CE pin signal lines with the ground pattern, or use shielded cables for these signals so that the high-frequency digital signals transmitted on these lines do not enter the analog signal system.

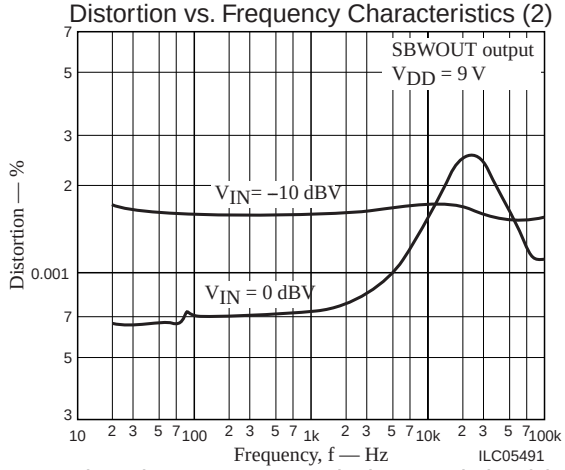
Volume Control Step Characteristics



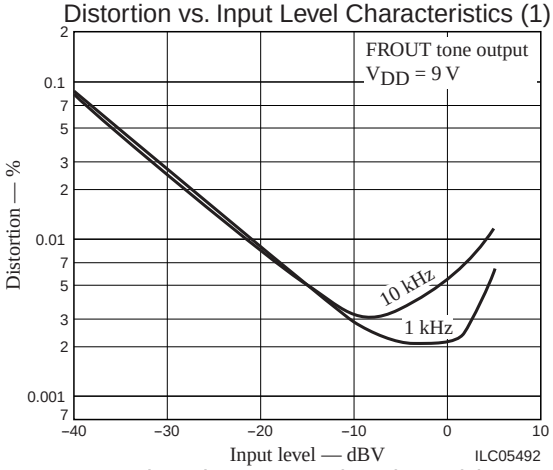
Distortion vs. Frequency Characteristics (1)



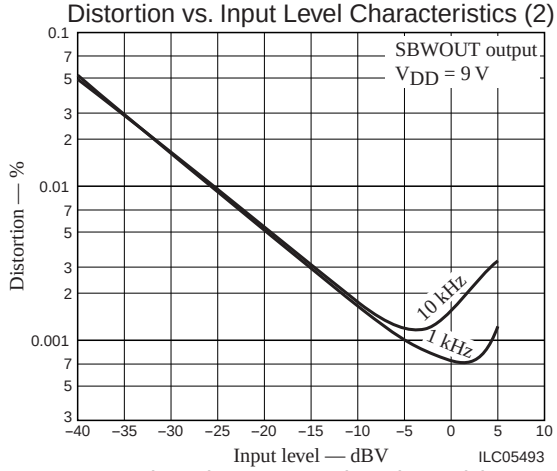
Distortion vs. Frequency Characteristics (2)



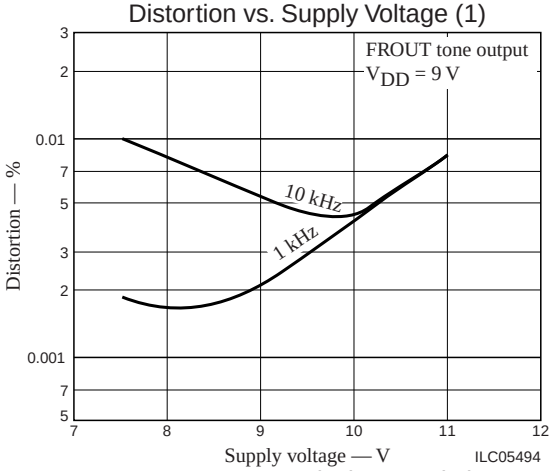
Distortion vs. Input Level Characteristics (1)



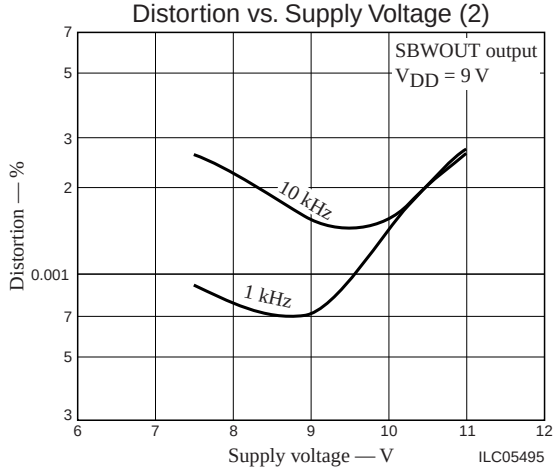
Distortion vs. Input Level Characteristics (2)



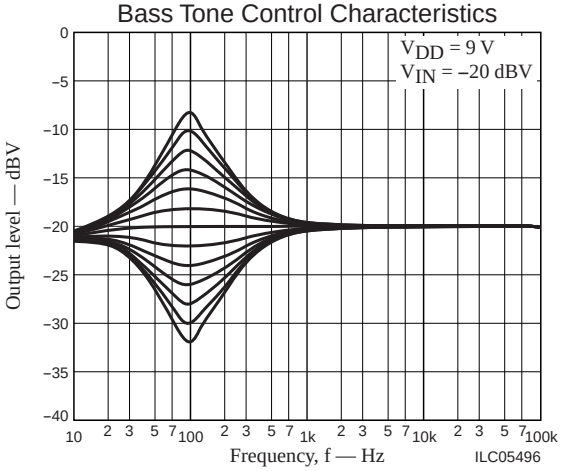
Distortion vs. Supply Voltage (1)



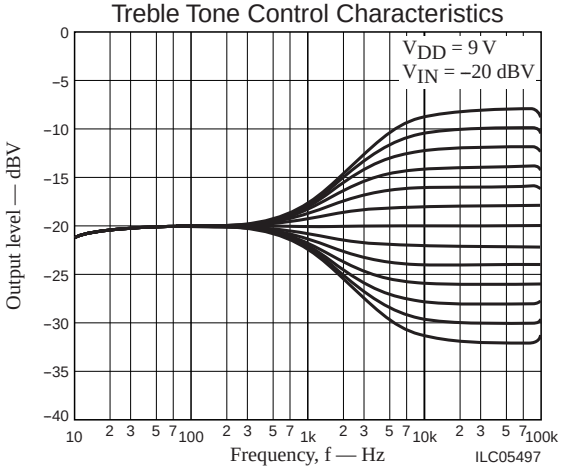
Distortion vs. Supply Voltage (2)



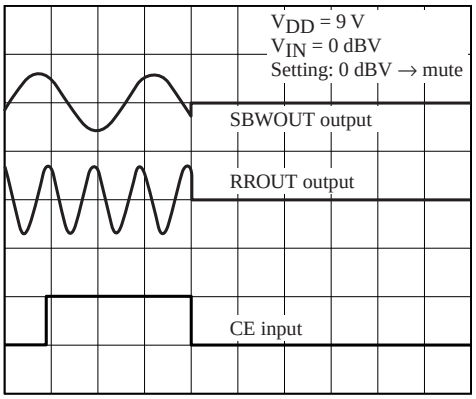
Bass Tone Control Characteristics



Treble Tone Control Characteristics



Zero Cross Circuit Off



Zero Cross Circuit On