Sound Processors for BOOM BOX / Mini-component Stereo

Sound Processors with Built-in 2-band Equalizers

BD3870FS,BD3871FS,BD3872FS,BD3873FS   No.10086EAT02

● Description

The Sound Processor with built-in 2 Band Equalizer, incorporates functions required for BOOM BOX and mini-component systems, such as input selector, input gain amp, volume, surround, tone (bass, treble), and loud speaker equalizer (BD3872FS only). These functions can be controlled through the two-wire serial control.

● Features

1) Using external components, center frequencies and Q factors of the bass characteristics are flexible.
2) Providing a mute switch onto one of the input pins allows cross-talk suppression.
3) A surround function can be constructed without external components.
4) Energy-saving design resulting in low current consumption, by utilizing the BiCMOS process

● Applications

BOOM BOX, mini-audio systems, and micro-audio systems.

● Line up matrix

Parameter	BD3870FS	BD3871FS	BD3873FS	BD3872FS
Input Gain	0, 6, 12, 18dB	24, 26, 28dB	18, 21, 24, 27dB	0, 5, 10, 19, 21, 23, 26, 28dB
Loud Speaker Equalizer (SEQ)	No	No	No	Yes
Input Selector	Three inputs	Three inputs	Three inputs	Five inputs
Volume	0 to -87dB/ 1dB step, -∞dB	0 to -87dB/ 1dB step, -∞dB	0 to –87dB/ 1dB step, -∞dB	0 to -87dB/ 1dB step, -∞dB
Equalizer	2 band (Bass, Treble)	2 band (Bass, Treble)	2 band (Bass, Treble)	2 band (Bass, Treble)
Surround	Yes	Yes	Yes	Yes
Serial Control	Two-wire serial	Two-wire serial	Two-wire serial	Two-wire serial
Package	SSOP-A24	SSOP-A24	SSOP-A24	SSOP-A32

● Absolute maximum ratings (Ta=25℃)

Prameter	Symbol	Ratings				Unit
		BD3870FS	BD3871FS	BD3873FS	BD3872FS	
Power Supply Voltage	Vcc	10	10	10	10	V
Power Dissipation	Pd	800 *1	800 *1	800 *1	950 *2	mW
Operating Temperature Range	Topr	-25 to +75	-25 to +75	-25 to +75	-25 to +75	℃
Storage Temperature Range	Tstg	-55 to +125	-55 to +125	-55 to +125	-55 to +125	℃

*1 Reduced by 8.0 mW/℃ at 25℃ or higher, when installed on the standard board (Size: 70×70×1.6mm).
*2 Reduced by 9.5 mW/℃ at 25℃ or higher, when installed on the standard board (Size: 70×70×1.6mm).

● Operating voltage range

Prameter	Symbol	Ratings				Unit
		BD3870FS	BD3871FS	BD3873FS	BD3872FS	
Operating Voltage Range	Vcc	4.5 to 9.5	4.5 to 9.5	4.5 to 9.5	4.5 to 9.5	V

*It must function normally at Ta=25℃.

●Electrical characteristics
(Ta=25 ℃ , VCC=8V, f=1kHz, Vi=200mVrms, RL=10kΩ, Rg=600Ω, Input Gain=0dB (BD3870FS, BD3872FS only), Input Gain=24dB (BD3871FS only), Input Gain=18dB (BD3873FS only),Volume=0dB, Bass=0dB, Treble=0dB, Surround=OFF, Loud Speaker Equalizer=OFF (BD3872FS only), unless otherwise noted)

Block	Parameter	Symbol	Limits			Unit	Condition
			Min.	Typ.	Max.		
Total	Circuit Current	IQ	-	8	21	mA	At no signal
	Total Output Voltage Gain	Gv	-2	0	2	dB	BD3870FS, BD3872FS Gv=20log(VOUT/VIN)
			22	24	26		BD3871FS Gv=20log(VOUT/VIN)
			16	18	20		BD3873FS Gv=20log(VOUT/VIN)
	Total Harmonic Distortion ratio	THD	-	0.01	0.1	%	BW=400 to 30kHz
	Maximum Output Voltage	Vom	1.6	2.1	-	Vrms	THD=1% BW=400 to 30kHz
	Total Output Noise Voltage	Vno	-	4.5	15	µVrms	BD3870FS, BD3872FS Rg=0Ω, BW=IHF-A
			-	40	80		BD3871FS, BD3873FS Rg=0Ω, BW=IHF-A
	Total Residual Noise Voltage	Vmno	-	4.5	15	µVrms	Rg=0Ω, BW=IHF-A Volume=-∞dB
	Cross-talk between Channels	CTC	-	-80	-70	dB	Rg=0Ω, BW=IHF-A VOUT=1Vrms
	Cross-talk between Selectors	CTS	-	-80	-70	dB	Rg=0Ω, BW=IHF-A
	Input Impedance	Rin	35	50	65	kΩ	BD3870FS, BD3871FS, BD3873FS
			70	100	130		BD3872FS
	Output Impedance	Rout	-	-	50	Ω	
Volume	Volume Control Range	VRI	-90	-87	-84	dB	VR=20log(VOUT/VIN)
	Maximum Volume Attenuation	Vmin	-	-	-90	dB	BW=IHF-A
	Volume Input Impedance	Rvin	39	56	73	kΩ	
Bass	Bass Boost Gain	GBB	12	14	16	dB	GB=20log(VOUT/VIN)
	Bass Cut Gain	GBC	-16	-14	-12	dB	GB=20log(VOUT/VIN)
	Bass Step Resolution	BR	-	2	-	dB	
Treble	Treble Boost Gain	GTB	10	12	14	dB	BD3870FS, BD3871FS, BD3873FS
			12	14	16		BD3872FS
	Treble Cut Gain	GTC	-14	-12	-10	dB	BD3870FS, BD3871FS, BD3873FS
			-16	-14	-12		BD3872FS
	Treble Step Resolution	TR	-	2	-	dB	
Surround	Surround In-phase Gain	Vsur1	-2	0	2	dB	2ch in-phase inputs
	Surround Single-phase Gain	Vsur2	4.3	6.3	8.3	dB	1ch input, 1ch grounded
	Surround Opposite-phase Gain	Vsur3	8	10	12	dB	2ch opposite-phase inputs
SEQ	Loud Speaker Equalizer Gain (BD3872FS only)	Seq	3	5	7	dB	f=10kHz

* For measurement, VP-9690A (Average value wave detection, Effective value display) IHF-A filter by Matsushita Communication Industrial is used.
* Phase relation between Input/Output signal terminals is the same.
* Note: This IC is not designed to be radiation-resistant.

●Timing chart

1) Signal Timing Conditions
   ・Data is read on the rising edge of the clock.
   ・Latch is read out on the falling edge of the clock.
   ・Latch signal must end with the LOW state.
   ・To avoid malfunctions, clock and data signals must terminate with the LOW state.
     1byte=10bit

Fig.1
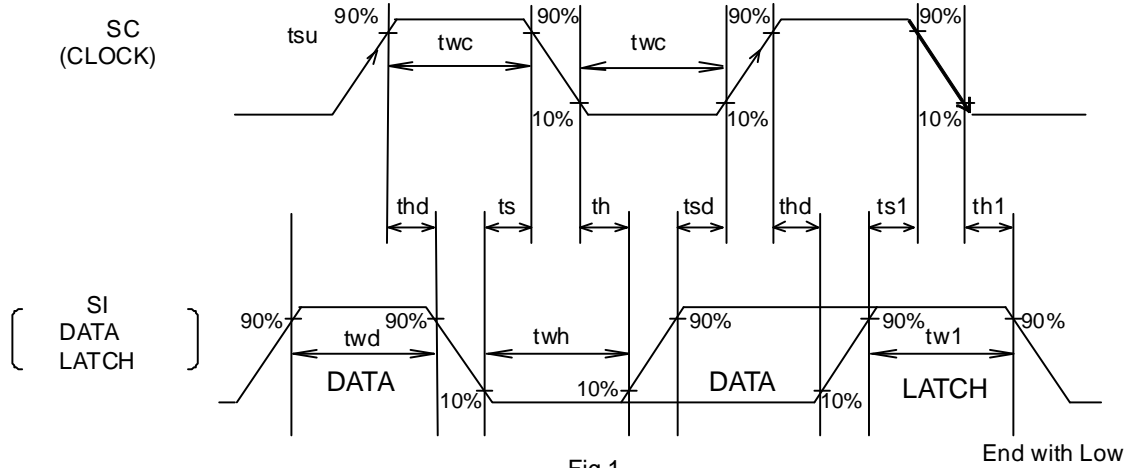
Parameter	Symbol	Limits			Unit
		Min.	Typ.	Max.	
Minimum Clock Width	Twc	2.0	-	-	µs
Minimum Data Width	twd	2.0	-	-	µs
Minimum Latch Width	Tw1	2.0	-	-	µs
Data Set-up Time (DATA→CLK)	Tsd	1.0	-	-	µs
Data Hold Time (CLK→DATA)	Thd	1.0	-	-	µs
Latch Set-up Time (CLK→LATCH)	Ts1	1.0	-	-	µs
Latch Hold Time (DATA→LATCH)	Th1	1.0	-	-	µs
Latch Low Set-up Time	Ts	1.0	-	-	µs
Latch Low Hold Width	Twh	2.0	-	-	µs

2) Voltage Conditions for Control Signals

Parameter	Limits			Unit	Condition
	Min.	Typ.	Max. (≦Vcc)		
"H" Input Voltage	2.2	-	5.5	V	Vcc=4.5 to 9.5V
"L" Input Voltage	0	-	1.0	V	Vcc=4.5 to 9.5V

3) Control Data Format List
   Basic Configuration of Control Data Format
       ← Data input direction

MSB									LSB
D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data								Select Address	

Control Data Format (BD3870FS, BD3871FS, BD3873FS)
   ← Data input direction

	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
(1)	Input Selector		Input Gain		Surround	*	*	*	0	0
(2)	Volume A					Volume B		*	0	1
(3)	Bass Gain				Treble Gain				1	0
(4)	*	*	*	*	*	*	*	*	1	1

Control Data Format (BD3872FS)
   ← Data input direction

	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
(1)	Input Gain			Input Selector			*	*	0	0
(2)	Volume A					Volume B		*	0	1
(3)	Bass Gain				Treble Gain				1	0
(4)	*	*	*	*	*	*	Surround	SEQ	1	1

・"*" indicates 0 or 1.
・By changing the setting of Select Address, three or four different control formats (BD3871FS, BD3872FS, BD3873FS, plus BD3872FS) are selectable.
・In every power-on sequence, all of the address data must be initialized.
   Example:
       ←Input direction

MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB
Data(1)	L	Data(2)	L	Data(3)	L	Data(4)	L

"L" indicates a latch.

・After power-on, for the second and subsequent times, only the necessary data can be selected for setting.

   Example: When changing the volume,
       ←Input direction

MSB	LSB
Data(2)	L

"L" indicates a latch.

●**Block diagram, application circuit, pin assignment** (BD3870FS, BD3871FS, BD3873FS)
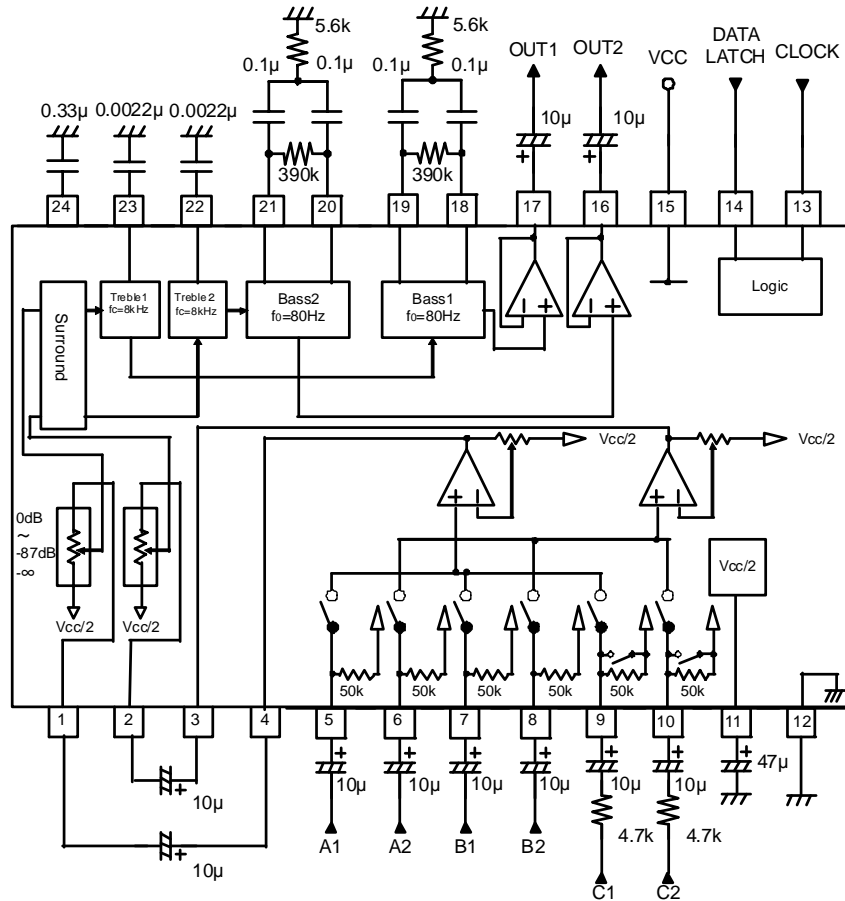
Unit: Resistance =Ω, Capacitor = F

Fig.2

●**Pin description** (BD3870FS, BD3871FS, BD3873FS)

Pin No.	Pin Name	Description	Pin No.	Pin Name	Description
1	VIN1	1ch volume input pin	13	SC	Serial clock input pin
2	VIN2	2ch volume input pin	14	SI	Serial data input pin
3	SEL2	2ch input selector output pin	15	VCC	Power supply pin
4	SEL1	1ch input selector output pin	16	OUT2	2ch output pin
5	A1	1ch input pin A	17	OUT1	1ch output pin
6	A2	2ch input pin A	18	BOUT1	1ch bass filter setting pin
7	B1	1ch input pin B	19	BNF1	1ch bass filter setting pin
8	B2	2ch input pin B	20	BOUT2	2ch bass filter setting pin
9	C1	1ch input pin C	21	BNF2	2ch bass filter setting pin
10	C2	2ch input pin C	22	TNF2	2ch treble filter setting pin
11	FILTER	1/2 VCC pin	23	TNF1	1ch treble filter setting pin
12	GND	Ground pin	24	CAP	Time constant setting pin for absorbing surround switching shock sound

●Block diagram, application circuit, pin assignment (BD3872FS)

Unit: Resistance =Ω, Capacitor = F
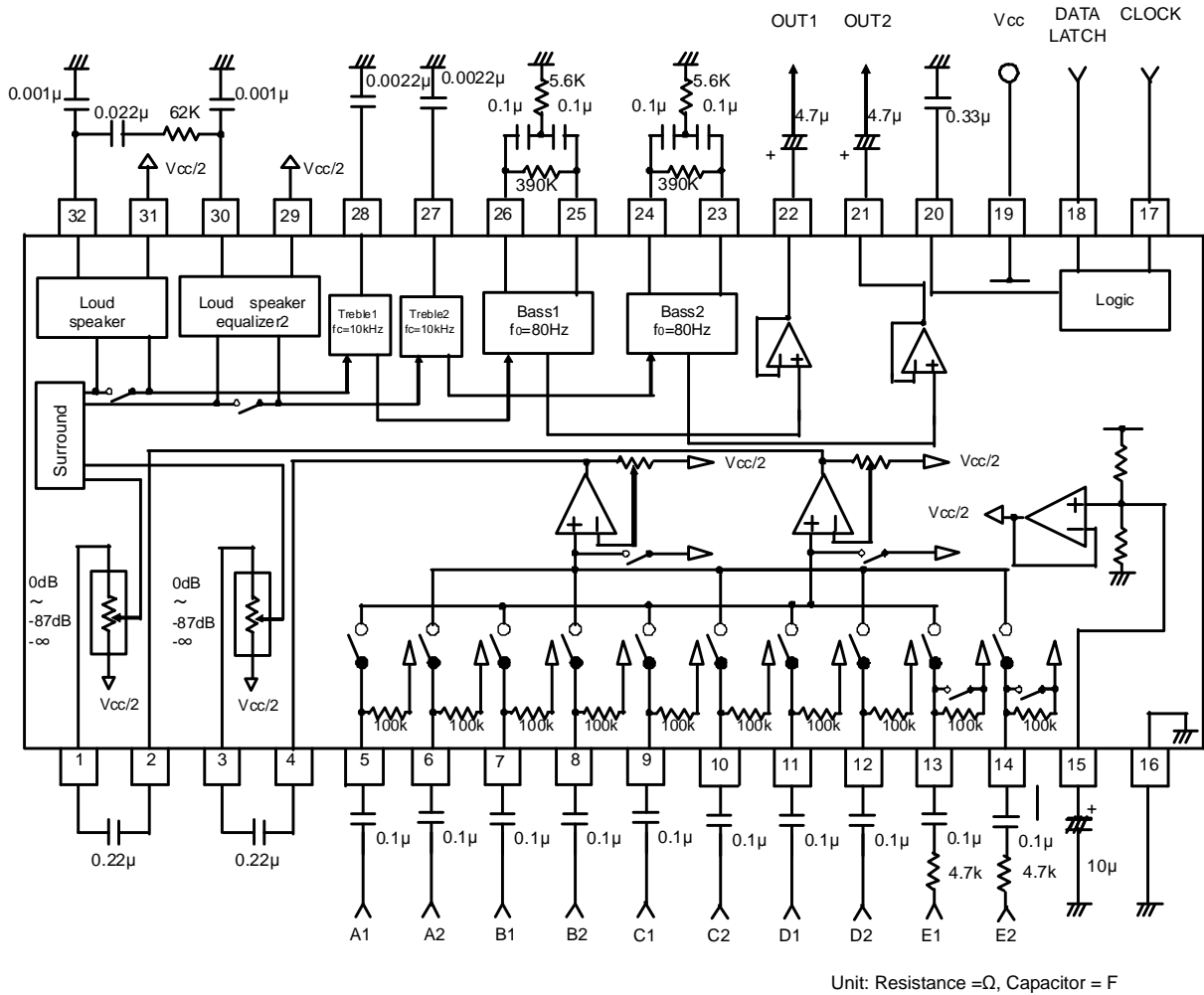
Fig.3 Application to Cinema Surround
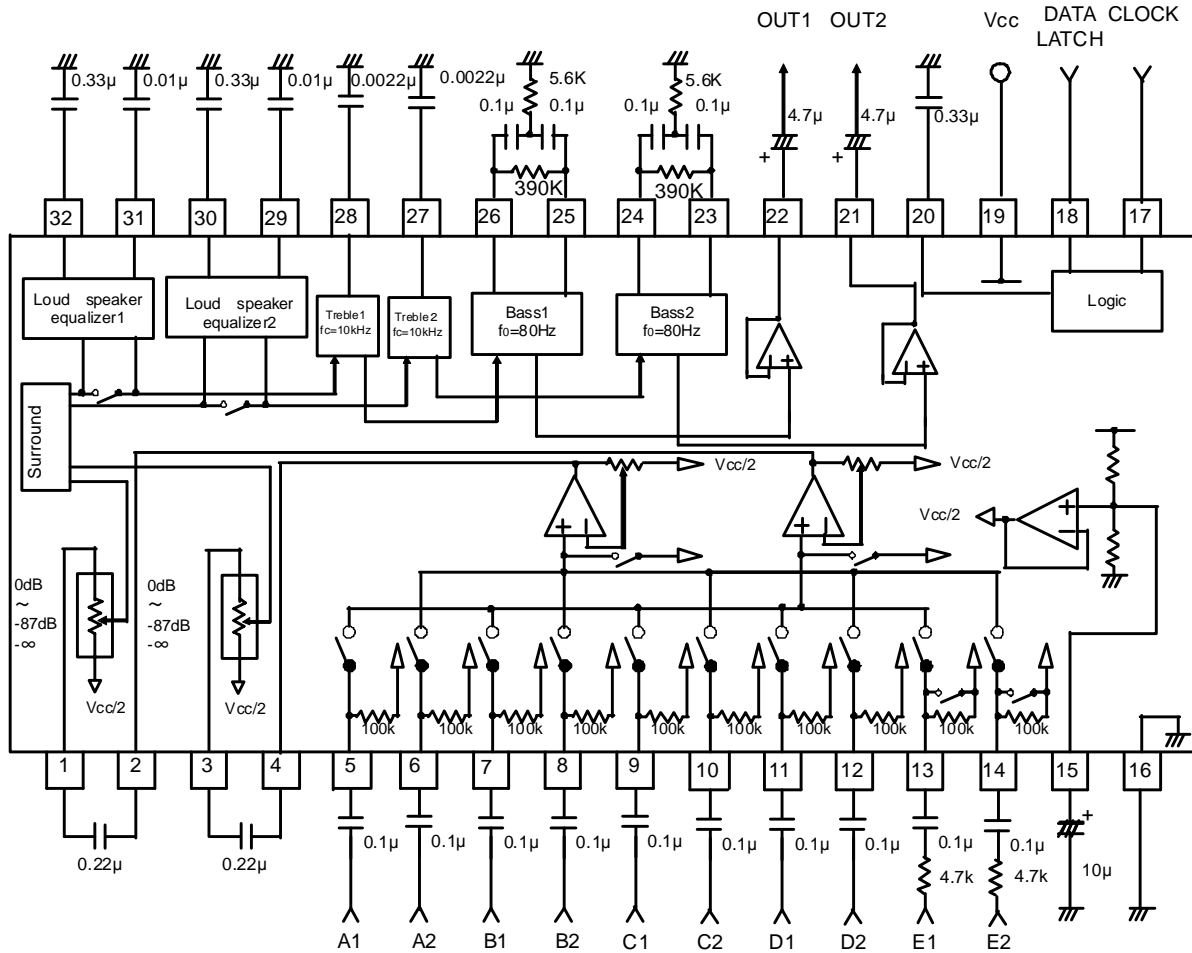
Unit: Resistance =Ω, Capacitor = F

Fig.4 Application to Loud Speaker Equalizer

●Pin description (BD3872FS)

Pin No.	Pin Name	Description	Pin No.	Pin Name	Description
1	VIN1	1ch volume input pin	17	SC	Serial clock input pin
2	SEL1	1ch input selector output pin	18	SI	Serial data input pin
3	VIN2	2ch volume input pin	19	VCC	Power supply pin
4	SEL2	2ch input selector output pin	20	CAP	Time constant setting pin for absorbing switching shock sound
5	A1	1ch input pin A	21	OUT2	2ch output pin
6	A2	2ch input pin A	22	OUT1	1ch output pin
7	B1	1ch input pin B	23	BOUT2	2ch bass filter setting pin
8	B2	2ch input pin B	24	BNF2	2ch bass filter setting pin
9	C1	1ch input pin C	25	BOUT1	1ch bass filter setting pin
10	C2	2ch input pin C	26	BNF1	1ch bass filter setting pin
11	D1	1ch input pin D	27	TNF2	2ch treble filter setting pin
12	D2	2ch input pin D	28	TNF1	1ch treble filter setting pin
13	E1	1ch input pin E	29	SOUT2	2ch cinema surround or SEQ setting pin
14	E2	2ch input pin E	30	SQI2	2ch cinema surround or SEQ setting pin
15	FILTER	1/2 VCC pin	31	SOUT1	1ch cinema surround or SEQ setting pin
16	GND	Ground pin	32	SQI1	1ch cinema surround or SEQ setting pin

●Description of operations

1) Bass filter

Using external components, center frequencies and Q factors of the bass characteristics are flexible
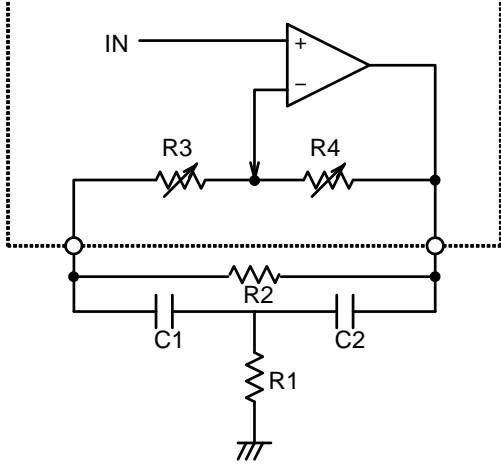
$$f_0 = \cfrac{1}{2\pi\sqrt{\cfrac{R1R2(R3+R4)C1C2}{R2+R3+R4}}} \quad (Hz)$$

Fig.5

$$Q = \cfrac{\sqrt{\cfrac{R1R2R4C1C2}{R2+R3+R4}}}{R1(C1+C2)}$$

$$G(boost) = 20\log\cfrac{\cfrac{R2(R3+R4)}{R1(R2+R3+R4)}+\cfrac{C2}{C1}+1}{\cfrac{R2R3}{R1(R2+R3+R4)}+\cfrac{C2}{C1}+1} \quad (dB)$$

$$Gcut = 20\log\cfrac{\cfrac{R2R3}{R1(R2+R3+R4)}+\cfrac{C2}{C1}+1}{\cfrac{R2(R3+R4)}{R1(R2+R3+R4)}+\cfrac{C2}{C1}+1} \quad (dB)$$

Standard values of R3, R4 (reference)
(R1=5.6kΩ, R2=390kΩ, C1=C2=0.1μF)

Bass Boost Cut Amount	Resistance (kΩ) * Typ.	
	R3	R4
0dB	77.64	0
2dB	58.90	18.73
4dB	44.02	33.60
6dB	32.20	45.42
8dB	22.82	54.80
10dB	15.36	62.26
12dB	9.44	68.18
14dB	4.78	72.84

* The actual boost cut amount may deviate from the standard values in some degree.
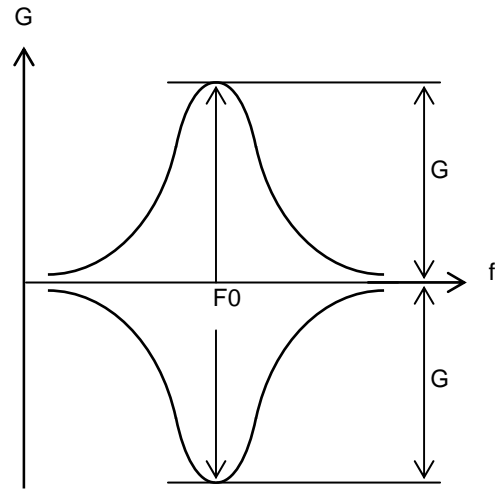
Fig.6

2) Treble filter
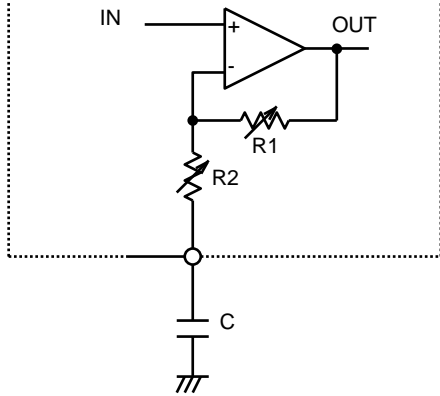
Fig.7

$$fc = \frac{1}{2\pi R2C} \text{ (Hz)}$$

$$G \text{ (boost)} = 20\log \frac{R1+R2+Zc}{R2+Zc} \text{ (dB)}$$

$$G \text{ (cut)} = 20\log \frac{R2+Zc}{R1+R2+Zc} \text{ (dB)}$$

$$Zc = \frac{1}{j\omega c} \text{ (}\Omega\text{)}$$

Standard values of R1, R2 (reference)

Treble Boost Cut Amount	Resistance (kΩ) * Typ.	
	R1	R2
0dB	0	36.28
2dB	7.46	28.82
4dB	13.39	22.89
6dB	18.10	18.18
8dB	21.84	14.44
10dB	24.81	11.47
12dB	27.20	9.08
14dB (BD3872FS only)	29.04	7.24

 * The actual boost cut amount may deviate from the standard values in some degree.
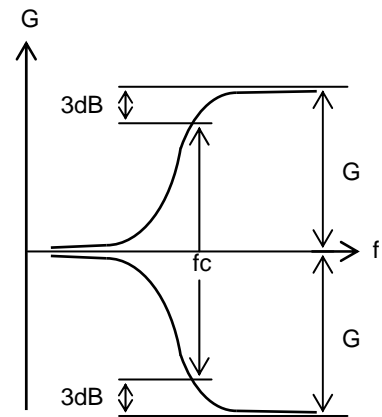
Fig.8

3) Matrix surround
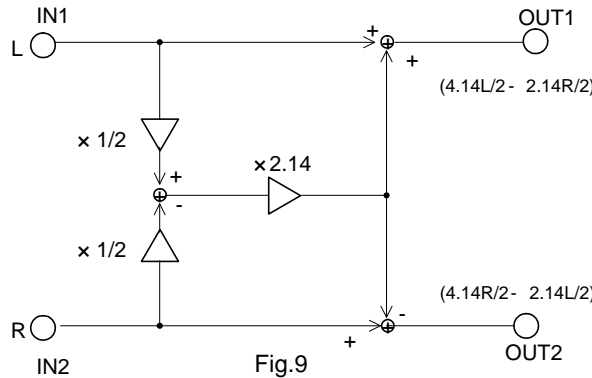
Fig.9

Matrix surround is constructed as shown above.   Gains are defined as follows:
In-phase Gain: Gains obtained on OUT1 and OUT2 against IN1 when inputting a signal of the equivalent level and in-phase (L=R) to IN1 and IN2.

$$\frac{OUT1}{IN1} = \frac{OUT2}{IN2} = \left(\frac{4.14}{2} L - \frac{2.14}{2} L \right) \Big/ L = 1 \qquad 20\log1 = 0 \quad \text{(dB)}$$

Single-phase Gain: Gains obtained on OUT1 and OUT2 against IN1 when inputting a signal to IN1 and AC-grounding IN2 (R=0).

$$\frac{OUT1}{IN1} = \frac{4.14}{2} L \Big/ L = 2,07 \qquad 20\log2.07 = 6.3 \quad \text{(dB)}$$

$$\frac{OUT2}{IN1} = -\frac{2.14}{2} L \Big/ L = -1.07 \qquad 20\log|-1.07| = 0.59 \quad \text{(dB)}$$

Opposite-phase Gain: Gains obtained on OUT1 and OUT2 against IN1 when inputting signals of the equivalent level and opposite-phase (L-R) to IN1 and IN2.

$$\frac{OUT1}{IN1} = \frac{OUT2}{IN2} = \left(\frac{4.14}{2} L + \frac{2.14}{2} L \right) \Big/ L = 3.14 \qquad 20\log3.14 = 10 \quad \text{(dB)}$$

1) Sound generation using Loud Speaker Equalizer (BD3872FS)
Using external components, one of the following two functions can be established; one having an effect to localize the vocal forward and enhance it (Loud Speaker Equalizer) and the other having an effect to clarify the vocal quality and improve the Articulation Index (Cinema Surround). Those characteristic values can be adjusted by choosing the external components with desirable constants. Details of above two functions are described below:

◎Cinema Surround
Constructing the external components as shown below allows the vocals to be moved forward and enhanced. Surround effect with enhanced vocal is achieved by turning on the built-in surround simultaneously.
Merging this effect, while playing movies on a DVD player, will make vocal listening clearer and surround effect more impactful.
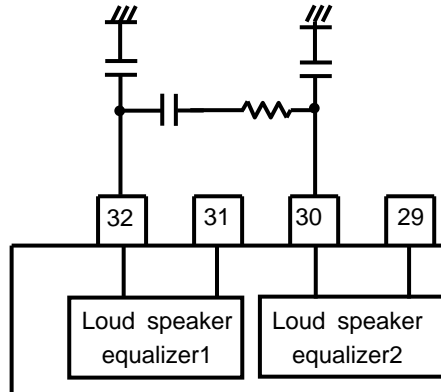
Fig.10

◎Loud Speaker Equalizer (SEQ)
BOOM BOX and Micro-sound systems are often restricted to using small-diameter speakers because of location space. These speakers, where the vocal range are attenuated, may give an impression of having a muffled vocal sound with respect to its audibility. Using the Loud Speaker Equalizer, the vocal quality which degrades in small-diameter speakers, can be improved and the Articulation Index is also increased.
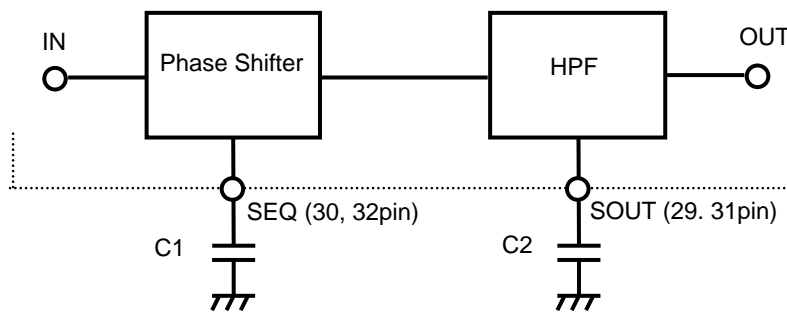
Fig.11

・C1 can be selected to determine the frequency where the phase should be inverted.

C1	Frequency where the phase is inverted
Larger value	Set to the lower frequency side
Smaller value	Set to the higher frequency side

・C2 can be selected to determine the HPF cut-off frequency fc. The SEQ gain remains constant.

$$fc = \frac{1}{2\pi RC} \quad (Hz)$$

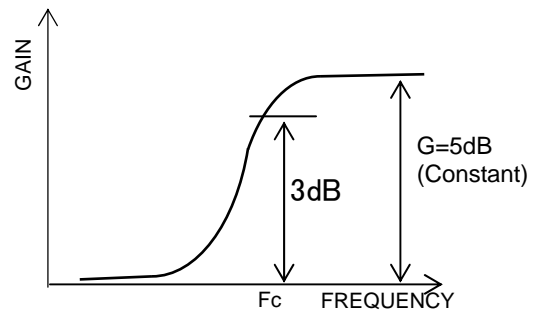(Where R is a built-in resistance of 10kΩ)
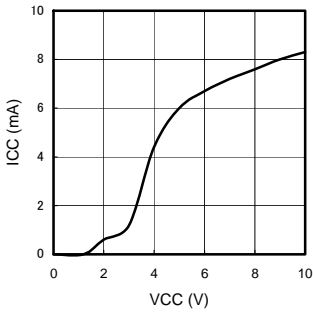

Fig.12

●Reference data

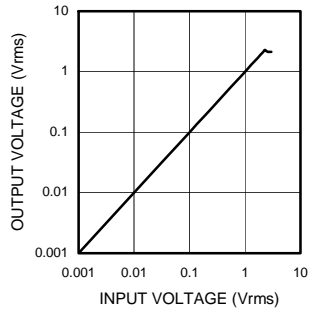Fig.13 Circuit Current - Power Supply
Voltage

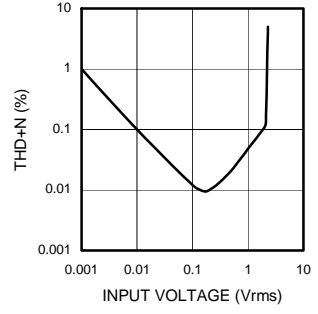
Fig.14 Output Voltage - Input Voltage
(BD3870FS)

Fig.15 Total Harmonic Distortion
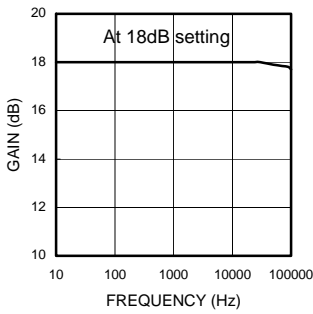ratio - Input Voltage (BD3870FS)

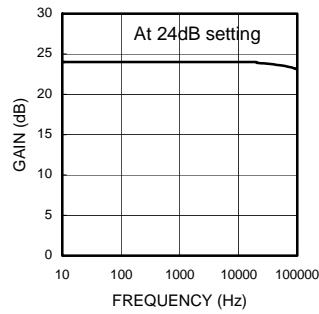

Fig.16 Current Gain - Frequency
(BD3870FS, BD3873FS)

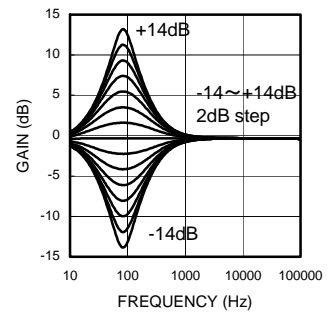Fig.17 Voltage Gain - Frequency
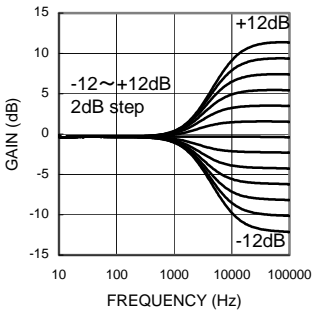(BD3871FS)

Fig.18 Bass Gain - Frequency

Fig.19 Treble Gain - Frequency
(BD3870FS,BD3871FS,BD3873FS)

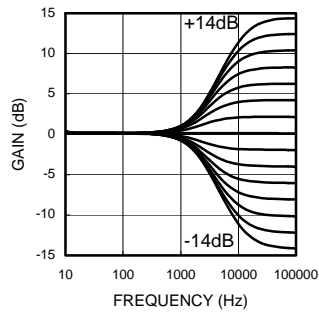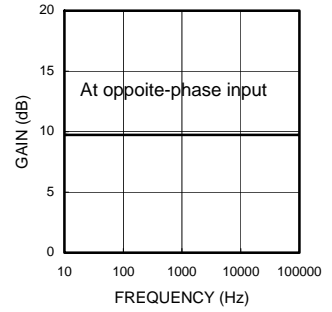Fig.20 Treble Gain - Frequency
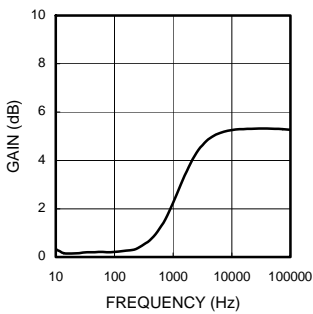(BD3872FS)

Fig.21 Surround Gain - Frequency

Fig. 22 Treble Gain - Frequency
(BD3872FS)

● Notes for use

1) Numbers and data in entries are representative design values and are not guaranteed values of the items.

2) Although ROHM is confident that the example application circuit reflects the best possible recommendations, be sure to verify circuit characteristics for your particular application. Modification of constants for other externally connected circuits may cause variations in both static and transient characteristics for external components as well as this Rohm IC. Allow for sufficient margins when determining circuit constants.

3) Absolute maximum ratings
Use of the IC in excess of absolute maximum ratings, such as the applied voltage or operating temperature range (Topr), may result in IC damage. Assumptions should not be made regarding the state of the IC (short mode or open mode) when such damage is suffered. A physical safety measure, such as a fuse, should be implemented when using the IC at times where the absolute maximum ratings may be exceeded.

4) GND potential
Ensure a minimum GND pin potential in all operating conditions. Make sure that no pins are at a voltage below the GND at any time, regardless of whether it is a transient signal or not.

5) Thermal design
Perform thermal design, in which there are adequate margins, by taking into account the permissible dissipation (Pd) in actual states of use.

6) Short circuit between terminals and erroneous mounting
Pay attention to the assembly direction of the ICs. Wrong mounting direction or shorts between terminals, GND, or other components on the circuits, can damage the IC.

7) Operation in strong electromagnetic field
Using the ICs in a strong electromagnetic field can cause operation malfunction.

8) Power-ON RESET
A built-in circuit for performing initialization inside the IC at power-ON is provided. In unstable systems it is recommended that the data shall be sent to all the addresses during power-ON, until this operation cycle is completed. Mute should be applied during this cycle.

Function	Initial Condition
Input Selector	Input A
Input Gain	0dB
Loud Speaker Equalizer (BD3872FS only)	OFF
Volume	-∞dB
Surround	OFF
Treble Gain	0dB
Bass Gain	0dB

9) 2-wire serial control
For the CL and DA terminals, the patterned and other wirings should be routed as not to cause interference with the analog-signal-related lines.

10) Switching between functions
Shock sound is absorbed when switching between the volume, bass, and treble functions.

11) Input coupling capacitor
As described in the figure below, low frequency characteristics are determined depending on the external capacitor value for input coupling, and the input impedance value inside the IC.
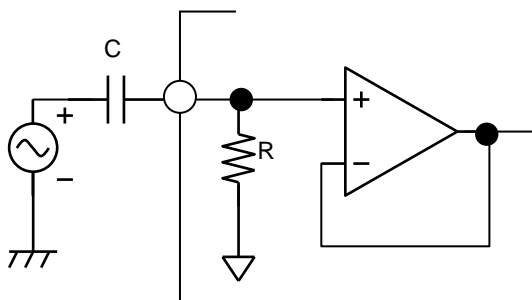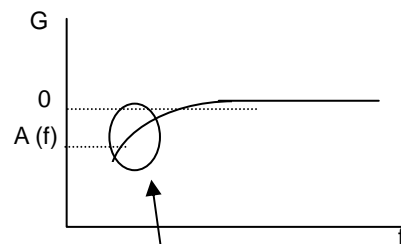

$$A(f) = \sqrt{\frac{(2\pi fCR)^2}{1+(2\pi fCR)^2}}$$

Fig.23   Fig.24

12) Switching noise

For Surround and Loud Speaker Equalizer (BD3872FS only), external capacitor C is attached to the CAP pin as a measures to control the switching noise. In the application circuit, a constant value as an example, is indicated by the CAP pin.

The time constant, which is used to charge/discharge the external capacitor C (varying between Vbe to 5Vbe (2.65V)) on the CAP pin, controls the soft switching operation. The switching time constant T is stated as $T=2.55 \times 10^5 \times C$.

Vbe has a temperature characteristic and may affect the time constant T.

13) Input Selector and Input Gain

When setting/changing Input Selector or Input Gain, the soft switching operation does not function and therefore noise is not controlled. For this reason, it is recommended to provide a mute circuit constructed of the external components for the set design.
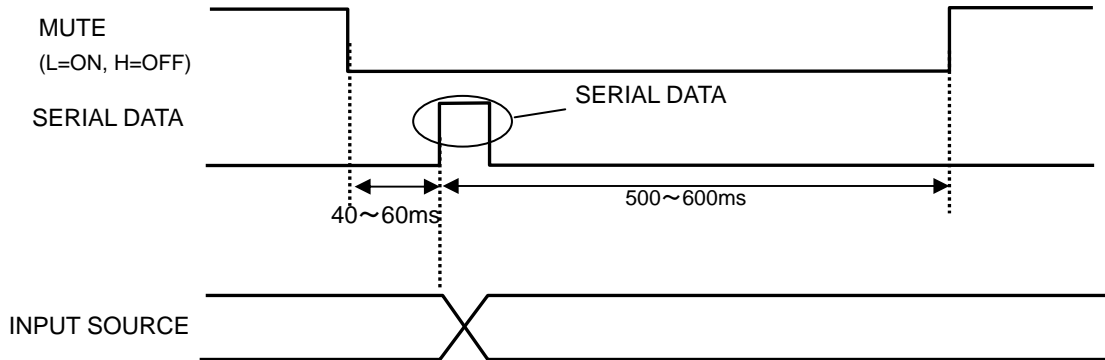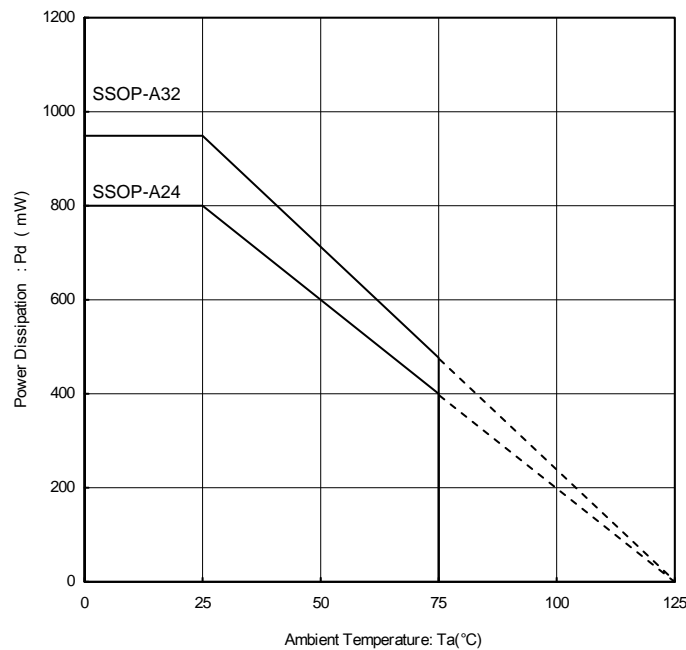
MUTE setting example

Fig.25

● Thermal Derating Curve

When installed ROHM standard board
(70×70×1.6mm Glass epoxy board)

Fig.26

●Ordering part number

| B | D | | 3 | 8 | 7 | 0 | | F | S | - | E | 2 |

Part No.

Part No.
3870,3871,3873
3872

Package
FS: SSOP-A24
     SSOP-A32

Packaging and forming specification
E2: Embossed tape and reel

SSOP-A24

10±0.2
(MAX 10.35 include BURR)

24   13

7.8±0.3
5.4±0.2

1   12

4°⁺⁶°₋₄°

0.5±0.2
1.2±0.15

0.17 ⁺⁰·¹₋₀.₀₅

1.8±0.1

0.1±0.1
0.8   0.1   0.38±0.1

(Unit : mm)

<Tape and Reel information>

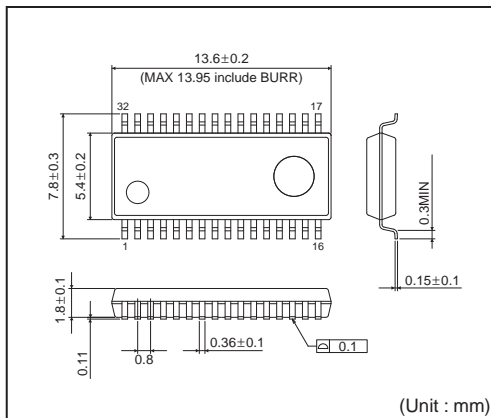| Tape	Embossed carrier tape
Quantity	2000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)

1pin

Direction of feed

Reel

＊Order quantity needs to be multiple of the minimum quantity.

SSOP-A32

13.6±0.2
(MAX 13.95 include BURR)

32   17

7.8±0.3
5.4±0.2

1   16

0.3MIN

0.15±0.1

1.8±0.1

0.11
0.8   0.36±0.1   0.1

(Unit : mm)

<Tape and Reel information>

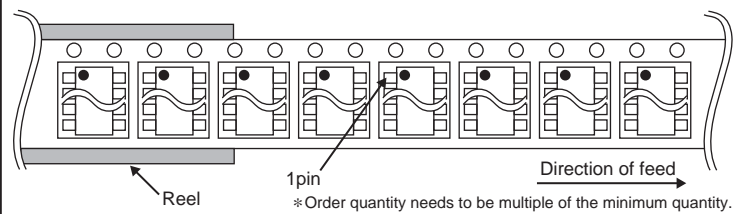| Tape	Embossed carrier tape
Quantity	2000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)

1pin

Direction of feed

Reel

＊Order quantity needs to be multiple of the minimum quantity.

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