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Sound Processor with Built-in 3-band Equalizer

BD37531FV

General Description

BD37531FV is a sound processor with built-in 3-band equalizer for car audio. A stereo input selector is available that functions to switch single end input and ground isolation input, input-gain control, main volume, loudness and 5ch fader volume. Moreover, “Advanced switch circuit”, which is an original ROHM technology, can reduce various switching noise (ex. No-signal, low frequency like 20Hz & large signal inputs). Also, “Advanced switch” makes microcomputer control easier and constructs a high quality car audio system.

Features

- Reduced switching noise of input gain control, mute, main volume, fader volume, bass, middle, treble, loudness by using advanced switch circuit
- Built-in differential input selector that can make various combination of single-ended / differential input.
- Built-in ground isolation amplifier inputs, which is ideal for external stereo input.
- Built-in input gain controller reduces volume switching noise of a portable audio input.
- Decreased number of external components due to built-in 3-band equalizer filter and loudness filter. It is possible to freely control the Q, Gv, fo of the 3-band equalizer, and Gv of the loudness through the I^{2}C BUS control
- A gain adjustment quantity of ±20dB with a 1 dB step gain adjustment is possible for the bass, middle and treble.
- Equipped with terminals for the subwoofer outputs. Also, the audio signal outputs of the front, rear and subwoofer can be chosen using the I^{2}C BUS control.
- Energy-saving design resulting in low current consumption is achieved utilizing the BiCMOS process. It has the advantage in quality over scaling down the power heat control of the internal regulators.
- Input pins and output pins are organized and separately laid out to keep the signal flow in one direction which consequently, simplify pattern layout of the set board and decrease the board dimensions.
- It is possible to control I^{2}C BUS with 3.3V / 5V.

Key Specifications

- Power Supply Voltage Range: 7.0V to 9.5V
- Circuit Current (No signal) : 38mA(Typ)
- Total Harmonic Distortion 1: (FRONT,REAR) 0.001%(Typ)
- Total Harmonic Distortion 2: (SUBWOOFER) 0.002%(Typ)
- Maximum Input voltage: 2.3Vrms (Typ)
- Cross-talk Between Selectors: -100dB (Typ)
- Volume Control Range: +15dB to -79dB
- Output Noise Voltage 1: (FRONT,REAR) 3.8µVrms(Typ)
- Output Noise Voltage 2: (SUBWOOFER) 4.8µVrms(Typ)
- Residual Output Noise Voltage: 1.8µVrms(Typ)
- Operating Temperature Range: -40°C to +85°C

Package

W(Typ) x D(Typ) x H(Max)

SSOP-B28
10.0mm x 7.60mm x 1.35mm

Applications

It is optimal for car audio systems. It can also be used for audio equipment of mini Compo, micro Compo, TV, etc.

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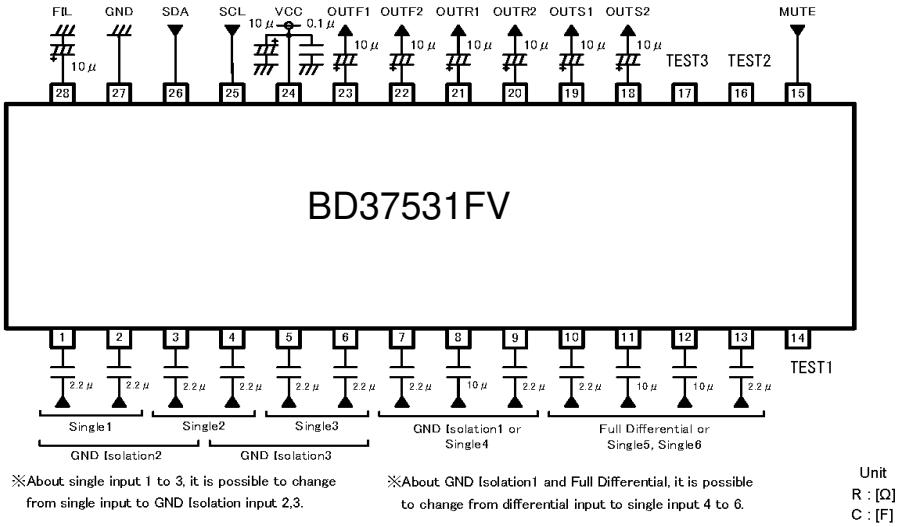
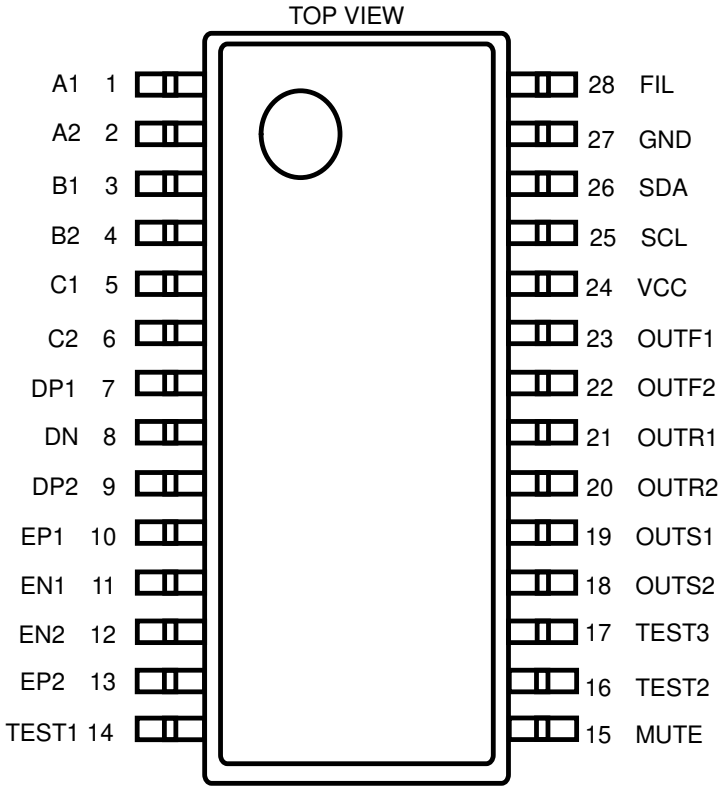
Typical Application Circuit



Pin Configuration



Pin Descriptions

Pin No.	Pin Name	Description	Pin No.	Pin Name	Description
1	A1	A input terminal of 1ch	15	MUTE	External compulsory mute terminal
2	A2	A input terminal of 2ch	16	TEST2	Test Pin
3	B1	B input terminal of 1ch	17	TEST3	Test Pin
4	B2	B input terminal of 2ch	18	OUTS2	Subwoofer output terminal of 2ch
5	C1	C input terminal of 1ch	19	OUTS1	Subwoofer output terminal of 1ch
6	C2	C input terminal of 2ch	20	OUTR2	Rear output terminal of 2ch
7	DP1	D positive input terminal of 1ch	21	OUTR1	Rear output terminal of 1ch
8	DN	D negative input terminal	22	OUTF2	Front output terminal of 2ch
9	DP2	D positive input terminal of 2ch	23	OUTF1	Front output terminal of 1ch
10	EP1	E positive input terminal of 1ch	24	VCC	Power supply terminal
11	EN1	E negative input terminal of 1ch	25	SCL	I^2C Communication clock terminal
12	EN2	E negative input terminal of 2ch	26	SDA	I^2C Communication data terminal
13	EP2	E positive input terminal of 2ch	27	GND	GND terminal
14	TEST1	Test Pin	28	FIL	VCC/2 terminal

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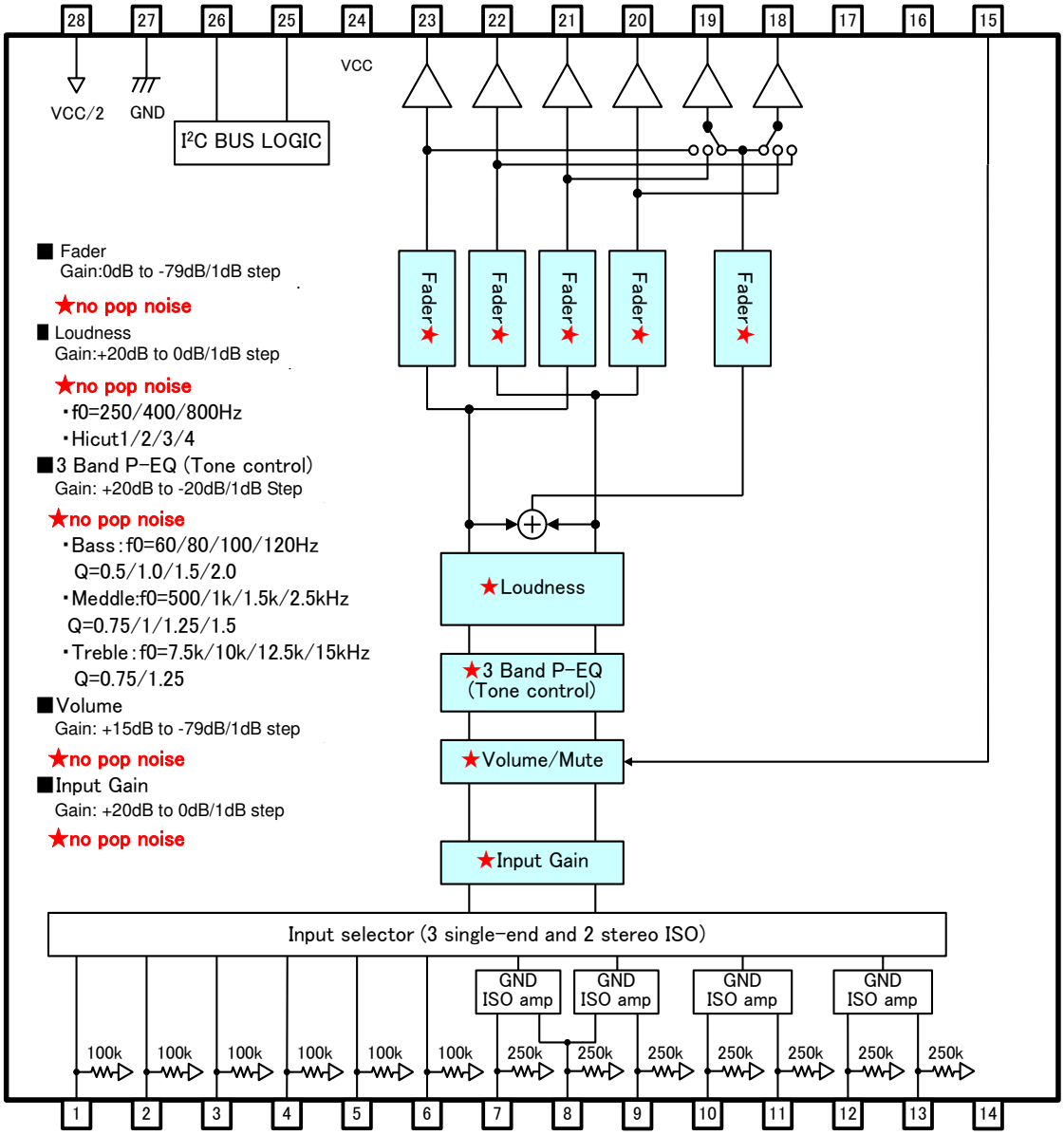
Block Diagram



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Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	10.0	V
Input Voltage	V_{IN}	V_{CC}+0.3 to GND-0.3	V
Power Dissipation	Pd	1.06 (Note 1)	W
Storage Temperature	Tstg	-55 to +150	°C

(Note 1) When mounted on ROHM standard board (70 x 70 x 1.6(mm^3), derate by 8.5mW/°C for Ta above 25°C.
Thermal resistance θja = 117.6(°C/W)
Material : A FR4 grass epoxy board(3% or less of copper foil area)

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Recommended Operating Conditions

Parameter	Symbol	Limit	Unit
Power Supply Voltage	V_{CC}	7.0 to 9.5	V
Temperature	Topr	-40 to +85	°C

Electrical Characteristics

(Unless otherwise noted, Ta=25°C, V_{CC}=8.5V, f=1kHz, V_{IN}=1Vrms, Rg=600Ω, R_L=10kΩ, A1 input, Input gain 0dB, Mute OFF, Volume 0dB, Tone control 0dB, Loudness 0dB, Fader 0dB)

BLOCK	Parameter	Symbol	Limit			Unit	Conditions
			Min	Typ	Max		
GENERAL	Circuit Current	I_Q	-	38	48	mA	No signal
	Voltage Gain	G_V	-1.5	0	+1.5	dB	G_V=20log(V_{OUT}/V_{IN})
	Channel Balance	CB	-1.5	0	+1.5	dB	CB = G_{V1}-G_{V2}
	Total Harmonic Distortion 1 (FRONT,REAR)	THD+N1	-	0.001	0.05	%	V_{OUT}=1Vrms BW=400Hz-30KHz
	Total Harmonic Distortion 2 (SUBWOOFER)	THD+N2	-	0.002	0.05	%	V_{OUT}=1Vrms BW=400HZ-30KHZ
	Output Noise Voltage 1 (FRONT,REAR) *	V_{NO1}	-	3.8	15	μVrms	Rg = 0Ω BW = IHF-A
	Output Noise Voltage 2 (SUBWOOFER) *	V_{NO2}	-	4.8	15	μVrms	Rg = 0Ω BW = IHF-A
	Residual Output Noise Voltage *	V_{NOR}	-	1.8	10	μVrms	Fader = -∞dB Rg = 0Ω BW = IHF-A
	Crosstalk Between Channels *	CTC	-	-100	-90	dB	Rg = 0Ω CTC=20log(V_{OUT}/V_{IN}) BW = IHF-A
	Ripple Rejection	RR	-	-70	-40	dB	f=1kHz V_{RR}=100mVrms RR=20log(V_{CC} IN/V_{OUT})
INPUT SELECTOR	Input Impedance(A, B, C)	R_{IN_S}	70	100	130	kΩ	
	Input Impedance (D, E)	R_{IN_D}	175	250	325	kΩ	
	Maximum Input Voltage	V_{IM}	2.1	2.3	-	Vrms	V_{IM} at THD+N(V_{OUT})=1% BW=400Hz-30KHz
	Crosstalk Between Selectors *	CTS	-	-100	-90	dB	Rg = 0Ω CTS=20log(V_{OUT}/V_{IN}) BW = IHF-A
	Common Mode Rejection Ratio * (D, E)	CMRR	50	65	-	dB	XP1 and XN input XP2 and XN input CMRR=20log(V_{IN}/V_{OUT}) BW = IHF-A,[*X・・・D,E]

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Electrical Characteristics – continued

BLOCK	Parameter	Symbol	Limit			Unit	Conditions
			Min	Typ	Max		
INPUT GAIN	Minimum Input Gain	G_{IN_MIN}	-2	0	+2	dB	Input gain 0dB V_{IN}=100mVrms G_{IN}=20log(V_{OUT}/V_{IN})
	Maximum Input Gain	G_{IN_MAX}	+18	+20	+22	dB	Input gain +20dB V_{IN}=100mVrms G_{IN}=20log(V_{OUT}/V_{IN})
	Gain Set Error	G_{IN_ERR}	-2	0	+2	dB	GAIN=+20dB to +1dB
MUTE	Mute Attenuation *	G_{MUTE}	-	-105	-85	dB	Mute ON G_{MUTE}=20log(V_{OUT}/V_{IN}) BW = IHF-A
VOLUME	Maximum Gain	G_{V_MAX}	13	15	17	dB	Volume = 15dB V_{IN}=100mVrms Gv=20log(V_{OUT}/V_{IN})
	Maximum Attenuation *	G_{V_MIN}	-	-100	-85	dB	Volume = -∞dB Gv=20log(V_{OUT}/V_{IN}) BW = IHF-A
	Attenuation Set Error 1	G_{V_ERR1}	-2	0	+2	dB	GAIN & ATT=+15dB to -15dB
	Attenuation Set Error 2	G_{V_ERR2}	-3	0	+3	dB	ATT=-16dB to -47dB
	Attenuation Set Error 3	G_{V_ERR3}	-4	0	+4	dB	ATT=-48dB to -79dB
BASS	Maximum Boost Gain	G_{B_BST}	18	20	22	dB	Gain=+20dB f=100Hz V_{IN}=100mVrms GB=20log (V_{OUT}/V_{IN})
	Maximum Cut Gain	G_{B_CUT}	-22	-20	-18	dB	Gain=-20dB f=100Hz V_{IN}=2Vrms GB=20log (V_{OUT}/V_{IN})
	Gain Set Error	G_{B_ERR}	-2	0	+2	dB	Gain=+20dB to -20dB f=100Hz
MIDDLE	Maximum Boost Gain	G_{M_BST}	18	20	22	dB	Gain=+20dB f=1kHz V_{IN}=100mVrms G_M=20log (V_{OUT}/V_{IN})
	Maximum Cut Gain	G_{M_CUT}	-22	-20	-18	dB	Gain=-20dB f=1kHz V_{IN}=2Vrms G_M=20log (V_{OUT}/V_{IN})
	Gain Set Error	G_{M_ERR}	-2	0	+2	dB	Gain=+20dB to -20dB f=1kHz
TREBLE	Maximum Boost Gain	G_{T_BST}	18	20	22	dB	Gain=+20dB f=10kHz V_{IN}=100mVrms GT=20log (V_{OUT}/V_{IN})
	Maximum Cut Gain	G_{T_CUT}	-22	-20	-18	dB	Gain=-20dB f=10kHz V_{IN}=2Vrms GT=20log (V_{OUT}/V_{IN})
	Gain Set Error	G_{T_ERR}	-2	0	+2	dB	Gain=+20dB to -20dB f=10kHz
FADER / SUBWOOFER	Maximum Attenuation *	G_{F_MIN}	-	-100	-90	dB	Fader = -∞dB GF=20log(V_{OUT}/V_{IN}) BW = IHF-A
	Attenuation Set Error 1	G_{F_ERR1}	-2	0	+2	dB	ATT=-1dB to -15dB
	Attenuation Set Error 2	G_{F_ERR2}	-3	0	+3	dB	ATT=-16dB to -47dB
	Attenuation Set Error 3	G_{F_ERR3}	-4	0	+4	dB	ATT=-48dB to -79dB
	Output Impedance	R_{OUT}	-	-	50	Ω	V_{IN}=100mVrms
	Maximum Output Voltage	V_{OM}	2	2.2	-	Vrms	THD+N=1% BW=400Hz-30KHz
LOUDNESS	Maximum Gain	G_{L_MAX}	17	20	23	dB	Gain 20dB V_{IN}=100mVrms GL=20log(V_{OUT}/V_{IN})
	Gain Set Error	G_{L_ERR}	-2	0	+2	dB	GAIN=+20dB to +1dB

VP-9690A(Average value detection, effective value display) filter by Matsushita Communication is used for * measurement.
Phase between input / output is same.

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Typical Performance Curves

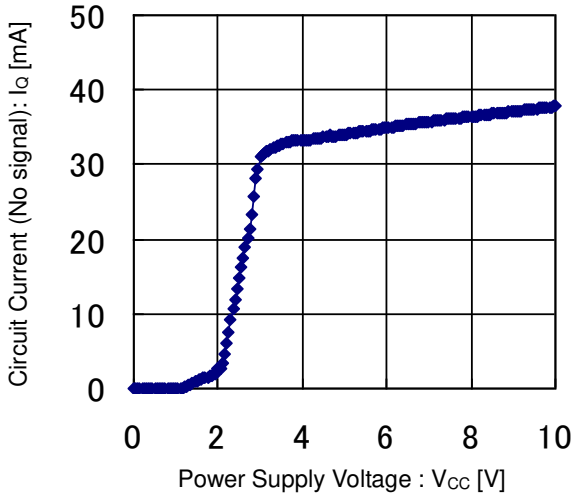

Figure 1. Circuit Current (No signal) vs Power Supply Voltage

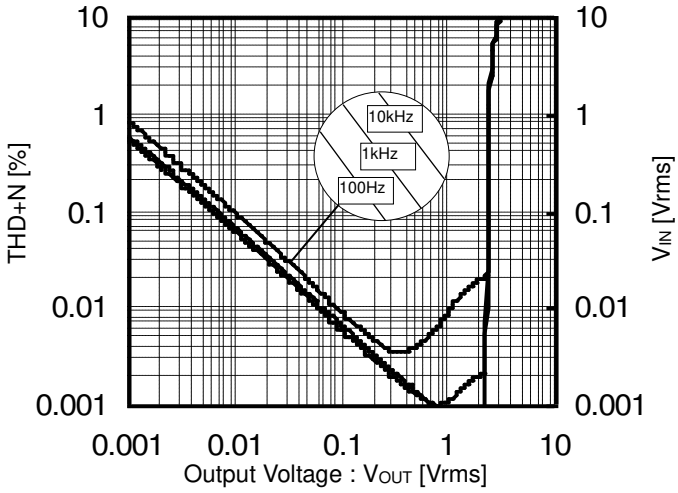

Figure 2. THD+N vs Output Voltage

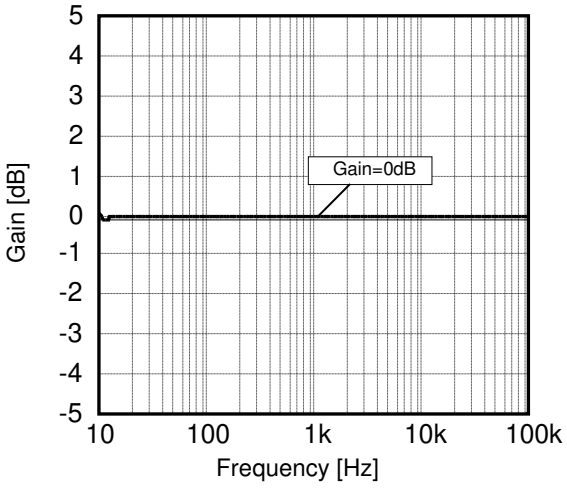

Figure 3. Gain vs Frequency

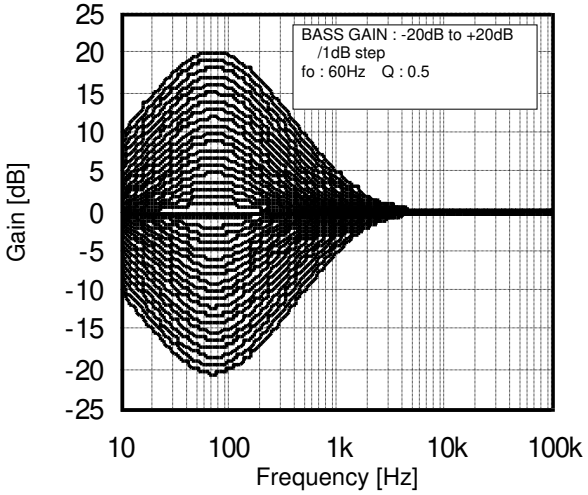

Figure 4. Bass Gain vs Frequency

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Typical Performance Curves – continued

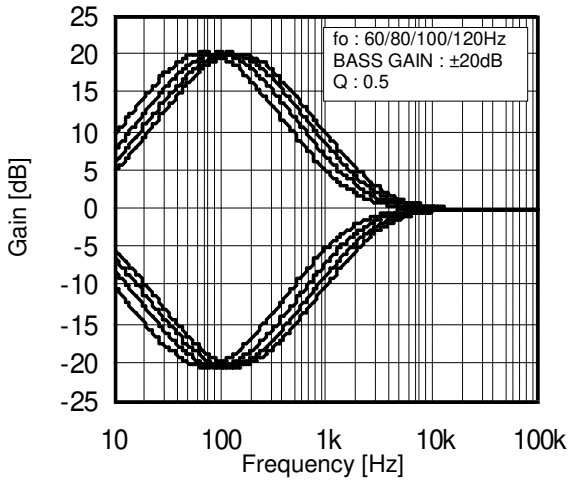

Figure 5. Bass fo vs Frequency

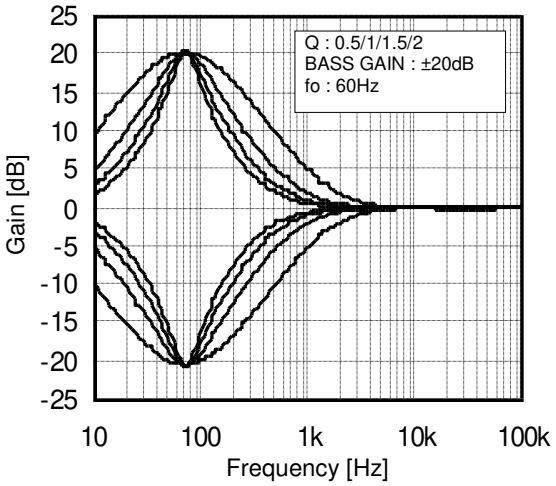

Figure 6. Bass Q vs Frequency

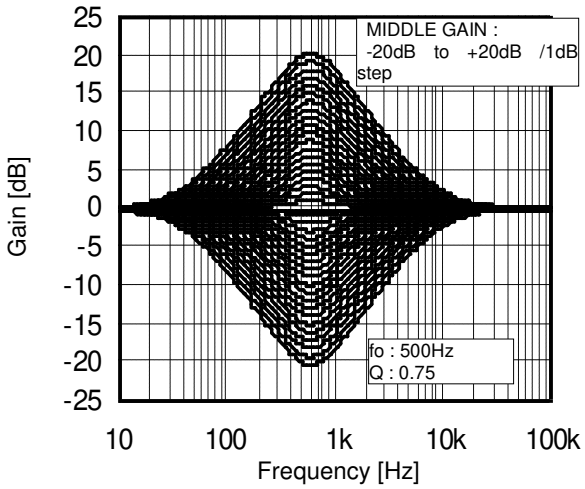

Figure 7. Middle Gain vs Frequency

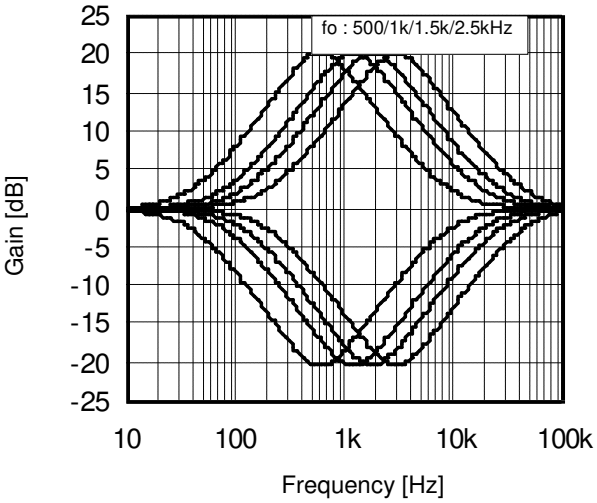

Figure 8. Middle fo vs Frequency

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Typical Performance Curves – continued

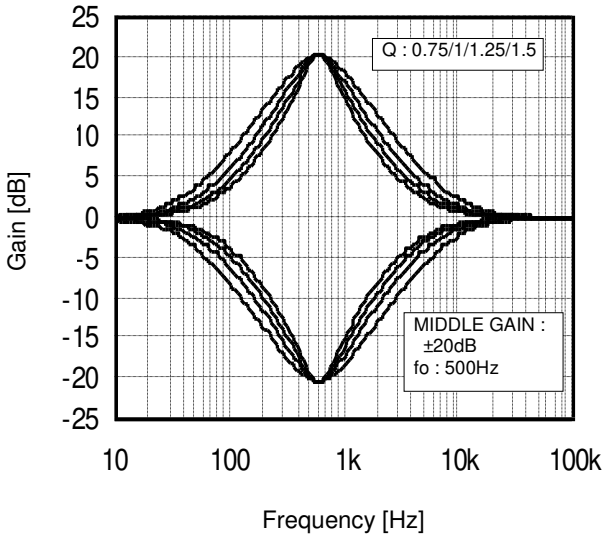

Figure 9. Middle Q vs Frequency

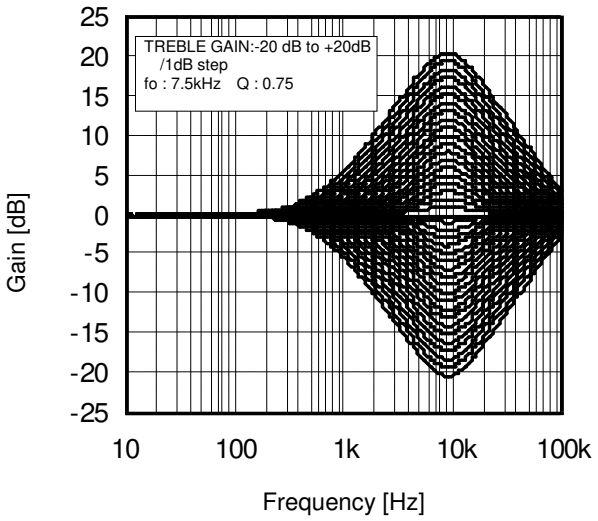

Figure 10. Treble Gain vs Frequency

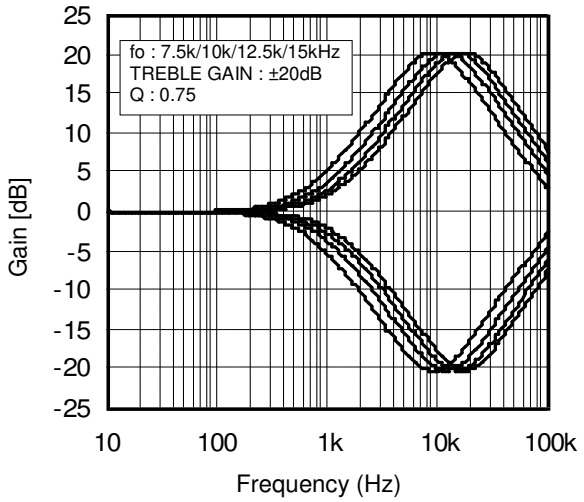

Figure 11. Treble fo vs Frequency

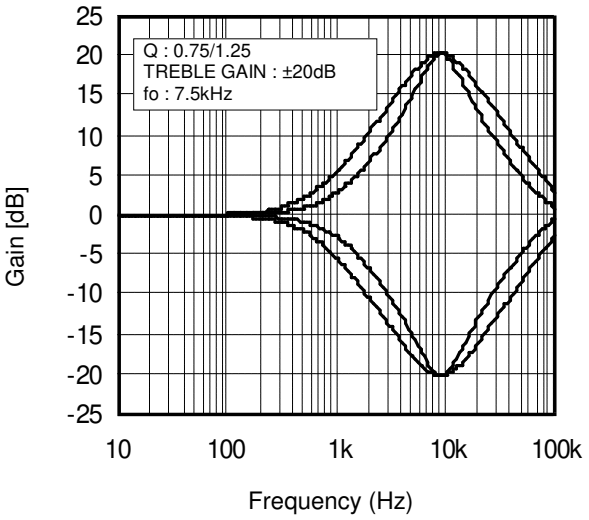

Figure 12. Treble Q vs Frequency

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Typical Performance Curves – continued

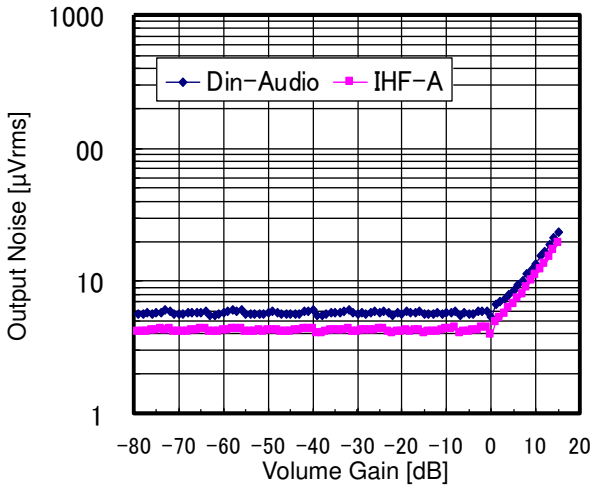

Figure 13. Output Noise vs Volume Gain

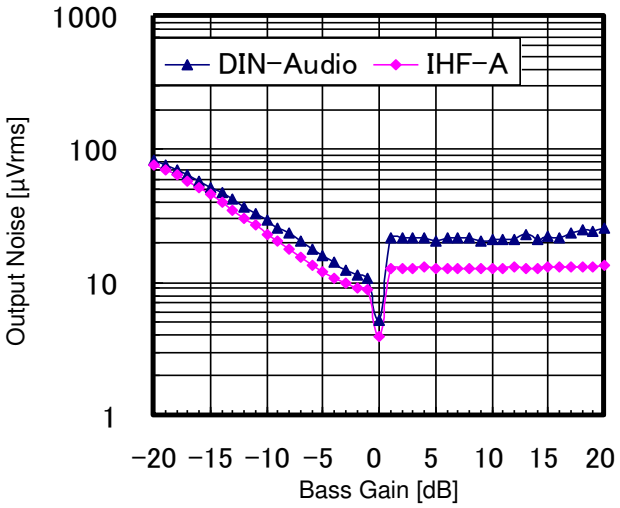

Figure 14. Output Noise vs Bass Gain

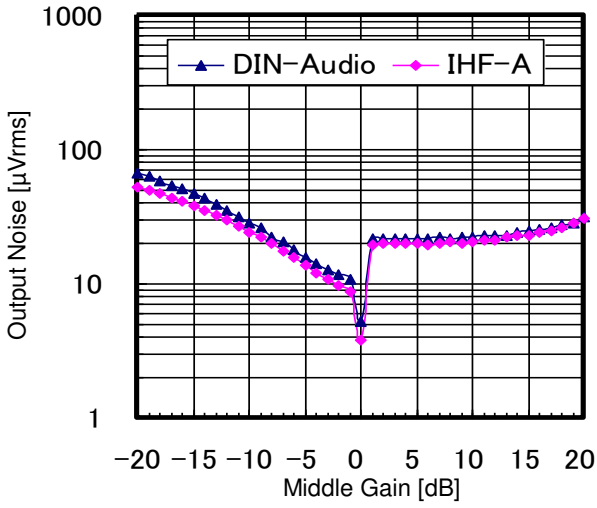

Figure 15. Output Noise vs Middle Gain

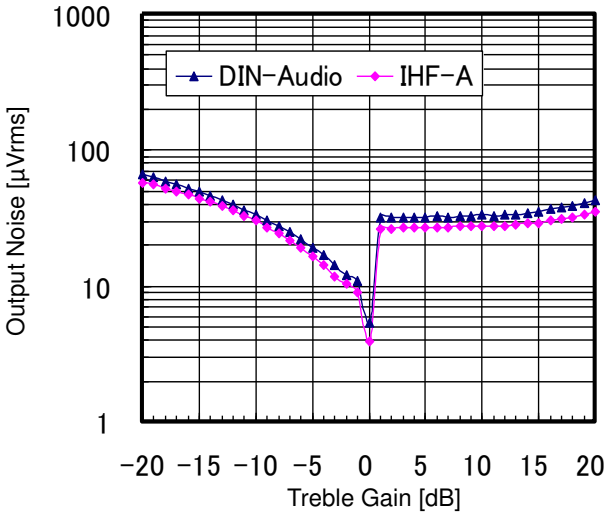

Figure 16. Output Noise vs Treble Gain

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Typical Performance Curves – continued

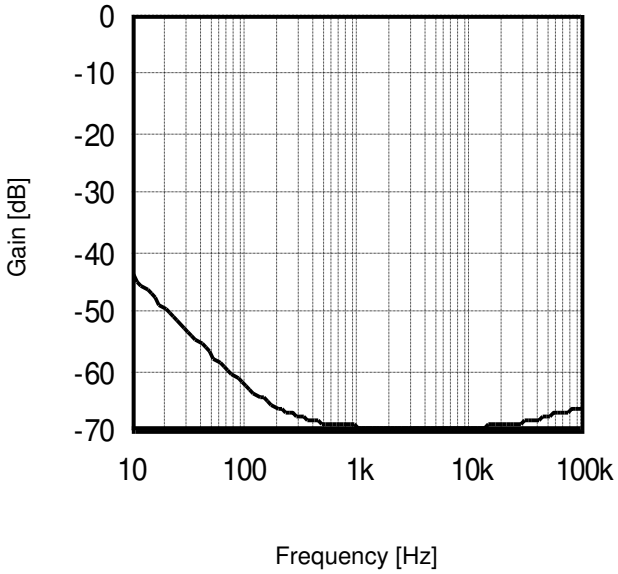

Figure 17. CMRR vs Frequency

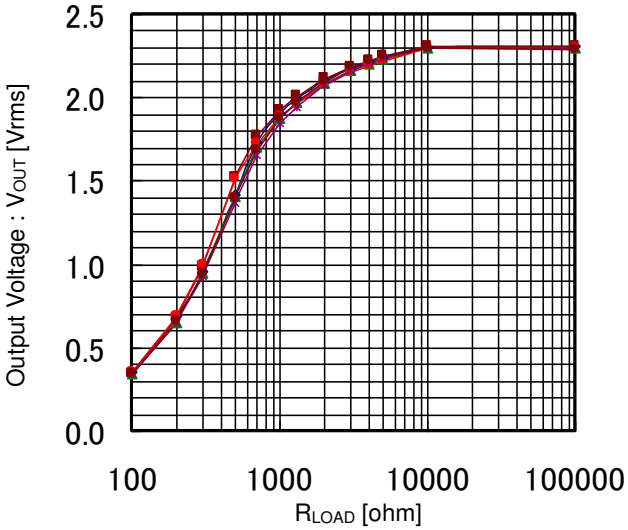

Figure 18. Output Voltage vs R_{LOAD}

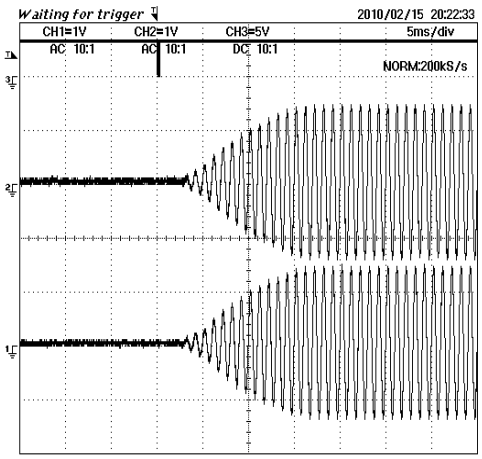

Figure 19. Advanced Switch 1

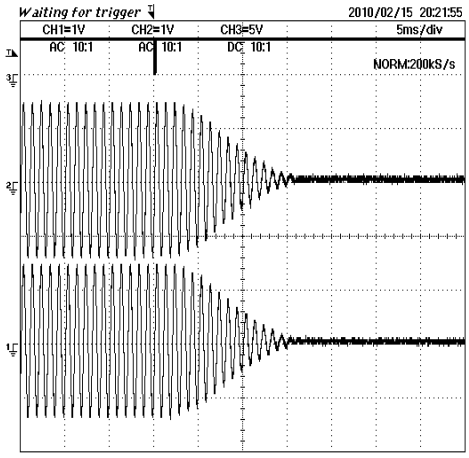

Figure 20. Advanced Switch 2

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Timing Chart

CONTROL SIGNAL SPECIFICATION

(1) Electrical Specifications and Timing for Bus Lines and I/O Stages

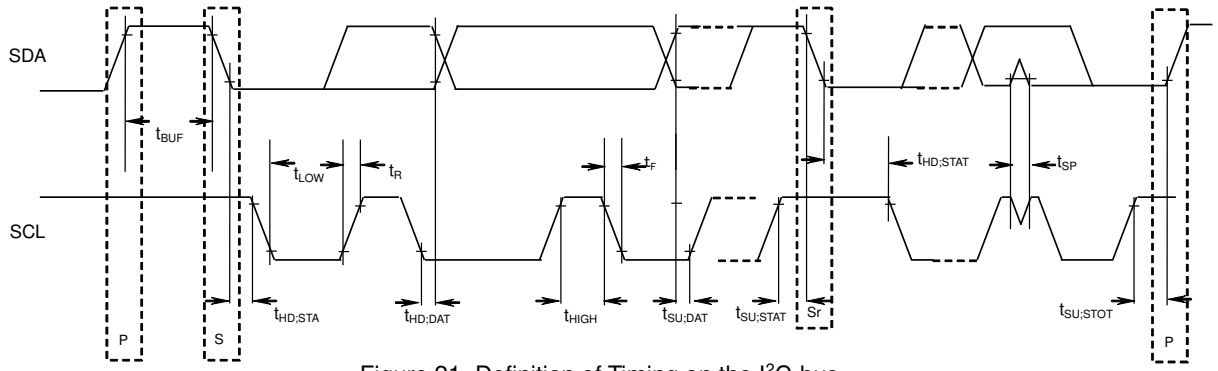


Figure 21. Definition of Timing on the I²C-bus

Table 1 Characteristics of the SDA and SCL bus lines for I²C-bus devices
(Unless specified particularly, Ta=25°C, V_{CC}=8.5V)

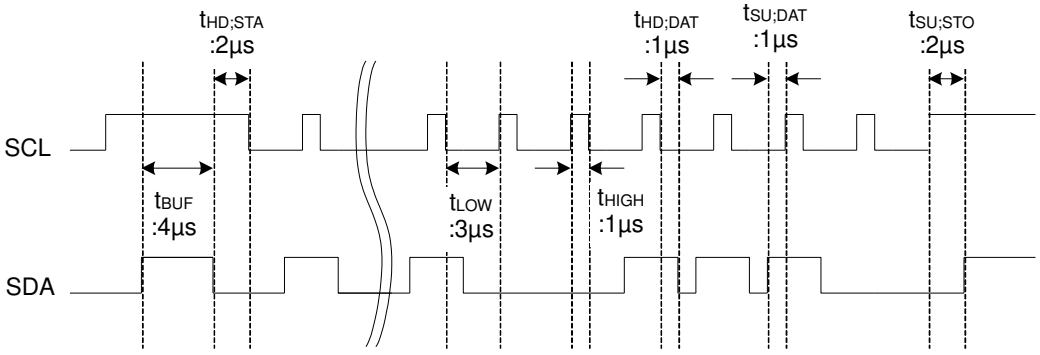
	Parameter	Symbol	Fast-mode I²C-bus		Unit
			Min	Max	
1	SCL clock frequency	f_{SCL}	0	400	kHz
2	Bus free time between a STOP and START condition	t_{BUF}	1.3	-	µS
3	Hold time (repeated) START condition. After this period, the first clock pulse is generated	$t_{HD;STA}$	0.6	-	µS
4	LOW period of the SCL clock	t_{LOW}	1.3	-	µS
5	HIGH period of the SCL clock	t_{HIGH}	0.6	-	µS
6	Set-up time for a repeated START condition	$t_{SU;STA}$	0.6	-	µS
7	Data hold time:	$t_{HD;DAT}$	0.06 (Note)	-	µS
8	Data set-up time	$t_{SU;DAT}$	120	-	ns
9	Set-up time for STOP condition	$t_{SU;STO}$	0.6	-	µS

All values referred to VIH Min and VIL Max Levels (see Table 2).

(Note) The device must internally provide a hold time of at least 300 ns for the SDA signal (referred to the VIH Min of the SCL signal) in order to bridge the undefined region of the falling edge of SCL.
About 7($t_{HD;DAT}$), 8($t_{SU;DAT}$), make the setup in which the margin is fully in .

Table 2 Characteristics of the SDA and SCL I/O stages for I²C-bus devices

	Parameter	Symbol	Fast-mode devices		Unit
			Min	Max	
10	LOW level input voltage:	V_{IL}	-0.3	+1	V
11	HIGH level input voltage:	V_{IH}	2.3	5	V
12	Pulse width of spikes which must be suppressed by the input filter.	t_{SP}	0	50	ns
13	LOW level output voltage: at 3mA sink current	V_{OL1}	0	0.4	V
14	Input current each I/O pin with an input voltage between 0.4V and 4.5V.	I_I	-10	+10	µA



SCL clock frequency : 250kHz

Figure 22. A Command Timing Example in the I²C Data Transmission

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(2) I²C BUS FORMAT

	MSB LSB		MSB LSB		MSB LSB		
S	Slave Address	A	Select Address	A	Data	A	P
1bit	8bit	1bit	8bit	1bit	8bit	1bit	1bit

S = Start conditions (Recognition of start bit)
Slave Address = Recognition of slave address. 7 bits in upper order are voluntary. The least significant bit is "L" due to writing.
A = ACKNOWLEDGE bit (Recognition of acknowledgement)
Select Address = Select every of volume, bass and treble.
Data = Data on every volume and tone.
P = Stop condition (Recognition of stop bit)

(3) I²C BUS Interface Protocol

(a) Basic Form

S	Slave Address	A	Select Address	A	Data	A	P
	MSB LSB		MSB LSB		MSB LSB		

(b) Automatic Increment (Select Address increases (+1) according to the number of data.

S	Slave Address	A	Select Address	A	Data1	A	Data2	A	····	DataN	A	P
	MSB LSB		MSB LSB		MSB LSB		MSB LSB			MSB LSB		

(Example) ①Data1 shall be set as data of address specified by Select Address.
②Data2 shall be set as data of address specified by Select Address +1.
③DataN shall be set as data of address specified by Select Address +N-1.

(c) Configuration Unavailable for Transmission (In this case, only Select Address1 is set.

S	Slave Address	A	Select Address1	A	Data	A	Select Address 2	A	Data	A	P
	MSB LSB		MSB LSB		MSB LSB		MSB LSB		MSB LSB		

(Note) If any data is transmitted as Select Address 2 next to data, it is recognized as data, not as Select Address 2.

(4) Slave Address

MSB							LSB	
A6	A5	A4	A3	A2	A1	A0	R/W	
1	0	0	0	0	0	0	0	80H

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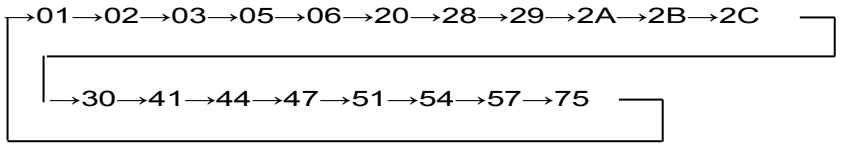
(5) Select Address & Data

Items	Select Address (hex)	MSB Data LSB							
		D7	D6	D5	D4	D3	D2	D1	D0
Initial setup 1	01	Advanced switch ON/OFF	0	Advanced switch time of Input Gain/Volume Tone/Fader/Loudness		0	1	Advanced switch time of Mute	
Initial setup 2	02	0	0	Subwoofer Output Select		0	0	0	0
Initial setup 3	03	0	0	0	Loudness fo		0	0	1
Input Selector	05	Full-diff Type	0	0	Input selector				
Input gain	06	Mute ON/OFF	0	0	Input Gain				
Volume gain	20	Volume Gain / Attenuation							
Fader 1ch Front	28	Fader Attenuation							
Fader 2ch Front	29	Fader Attenuation							
Fader 1ch Rear	2A	Fader Attenuation							
Fader 2ch Rear	2B	Fader Attenuation							
Fader Subwoofer	2C	Fader Attenuation							
Test Mode	30	1	1	1	1	1	1	1	1
Bass setup	41	0	0	Bass fo		0	0	Bass Q	
Middle setup	44	0	0	Middle fo		0	0	Middle Q	
Treble setup	47	0	0	Treble fo		0	0	0	Treble Q
Bass gain	51	Bass Boost/ Cut	0	0	Bass Gain				
Middle gain	54	Middle Boost/ Cut	0	0	Middle Gain				
Treble gain	57	Treble Boost/ Cut	0	0	Treble Gain				
Loudness Gain	75	0	Loudness Hicut		Loudness Gain				
System Reset	FE	1	0	0	0	0	0	0	1

Advanced switch

Note

1. The Advanced Switch works in the latch part while changing from one function to another.
2. Upon continuous data transfer, the Select Address rolls over because of the automatic increment function, as shown below.



3. Advanced switch is not used for functions of input selector and subwoofer output select etc. Therefore, please turn on MUTE when changing the settings of this side of a set.
4. When using Mute function of this IC at the time of changing input selector, please switch mute ON/OFF while waiting for advanced-mute time.

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Select address 01 (hex)

Time	MSB	Advanced switch time of Mute					LSB
	D7	D6	D5	D4	D3	D2	D1	D0
0.6msec	Advanced Switch ON/OFF	0	Advanced switch time of Input gain/Volume Tone/Fader/Loudness		0	1	0	0
1.0msec							0	1
1.4msec							1	0
3.2msec							1	1

Time	MSB	Advanced switch time of Input gain/Volume/Tone/Fader/Loudness					LSB
	D7	D6	D5	D4	D3	D2	D1	D0
4.7 msec	Advanced Switch ON/OFF	0	0	0	0	1	Advanced switch Time of Mute	
7.1 msec			0	1				
11.2 msec			1	0				
14.4 msec			1	1				

Mode	MSB	Advanced switch ON/OFF					LSB
	D7	D6	D5	D4	D3	D2	D1	D0
OFF	0	0	Advanced switch time of Input gain/Volume Tone/Fader/Loudness		0	1	Advanced switch Time of Mute	
ON	1							

Select address 02(hex)

Mode	MSB	Subwoofer Output Select					LSB
	D7	D6	D5	D4	D3	D2	D1	D0
Sub	0	0	0	0	0	0	0	0
Front			0	1				
Rear			1	0				
Prohibition			1	1				

Select address 03(hex)

f0	MSB	Loudness fo					LSB
	D7	D6	D5	D4	D3	D2	D1	D0
250Hz	0	0	0	0	0	0	0	1
400Hz				0	1			
800Hz				1	0			
Prohibition				1	1			

: Initial Condition

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Select address 05(hex)

Mode			MSB			Input Selector				LSB
	OUTF1	OUTF2	D7	D6	D5	D4	D3	D2	D1	D0
A	A1	A2	Full-diff bias type select	0	0	0	0	0	0	0
B	B1	B2				0	0	0	0	1
C	C1	C2				0	0	0	1	0
D single	DP1	DP2				0	0	0	1	1
E1 single	EP1	EN1				0	1	0	1	0
E2 single	EN2	EP2				0	1	0	1	1
A diff	A1	B1				0	1	1	1	1
C diff	B2	C2				1	0	0	0	0
D diff	DP1	DP2				0	0	1	1	0
E full diff	EP1	EP2				0	1	0	0	0
Input SHORT						0	1	0	0	1
Prohibition						Other setting				

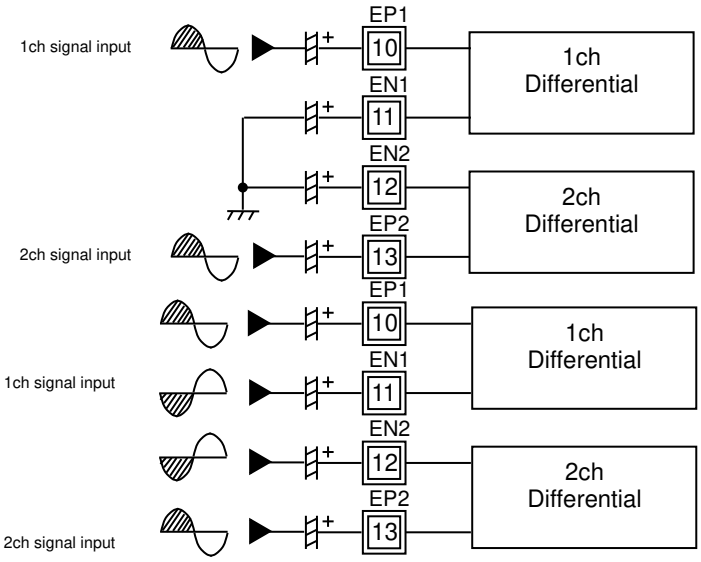
Input SHORT : The input impedance of each input terminal is lowered from 100kΩ(Typ) to 6 kΩ(Typ).
(For quick charge of coupling capacitor)

Mode	MSB			Full-diff Bias Type Select				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
Negative Input	0	0	0	Input Selector				
Bias	1							

: Initial condition

Negative input type

For Ground –isolation type



Bias type

For differential amplifier type

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Select address 06 (hex)

Gain	MSB			Input Gain				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
0dB	Mute ON/OFF	0	0	0	0	0	0	0
1dB				0	0	0	0	1
2dB				0	0	0	1	0
3dB				0	0	0	1	1
4dB				0	0	1	0	0
5dB				0	0	1	0	1
6dB				0	0	1	1	0
7dB				0	0	1	1	1
8dB				0	1	0	0	0
9dB				0	1	0	0	1
10dB				0	1	0	1	0
11dB				0	1	0	1	1
12dB				0	1	1	0	0
13dB				0	1	1	0	1
14dB				0	1	1	1	0
15dB				0	1	1	1	1
16dB				1	0	0	0	0
17dB				1	0	0	0	1
18dB				1	0	0	1	0
19dB				1	0	0	1	1
20dB				1	0	1	0	0
Prohibition				1	1	0	1	1
				:	:	:	:	:
				1	1	1	1	1

Mode	MSB			Mute ON/OFF				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
OFF	0	0	0	Input Gain				
ON	1							

: Initial condition

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Select address 20, 28, 29, 2A, 2B, 2C (hex)

Gain & ATT	MSB Vol, Fader Gain / Attenuation LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
Prohibition	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1
	:	:	:	:	:	:	:	:
	0	1	1	1	0	0	0	0
15dB	0	1	1	1	0	0	0	1
14dB	0	1	1	1	0	0	1	0
13dB	0	1	1	1	0	0	1	1
:	:	:	:	:	:	:	:	:
-77dB	1	1	0	0	1	1	0	1
-78dB	1	1	0	0	1	1	1	0
-79dB	1	1	0	0	1	1	1	1
Prohibition	1	1	0	1	0	0	0	0
	:	:	:	:	:	:	:	:
	1	1	1	1	1	1	1	0
-∞dB	1	1	1	1	1	1	1	1

(Only 0dB to -∞dB are available at address 28, 29, 2A, 2B, 2C)

Select address 41(hex)

Q factor	MSB Bass Q factor LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
0.5	0	0	Bass fo		0	0	0	0
1.0							0	1
1.5							1	0
2.0							1	1

fo	MSB Bass fo LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
60Hz	0	0	0	0	0	0	Bass Q factor	
80Hz			0	1				
100Hz			1	0				
120Hz			1	1				

Select address 44(hex)

Q factor	MSB Middle Q factor LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
0.75	0	0	Middle fo		0	0	0	0
1.0							0	1
1.25							1	0
1.5							1	1

fo	MSB Middle fo LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
500Hz	0	0	0	0	0	0	Middle Q factor	
1kHz			0	1				
1.5kHz			1	0				
2.5kHz			1	1				

Select address 47 (hex)

Q factor	MSB Treble Q factor LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
0.75	0	0	Treble fo		0	0	0	0
1.25								1

fo	MSB Treble fo LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
7.5kHz	0	0	0	0	0	0	0	Treble Q factor
10kHz			0	1				
12.5kHz			1	0				
15kHz			1	1				

: Initial condition

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Select address 51, 54, 57 (hex)

Gain	MSB Bass/Middle/Treble Gain LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
0dB	Bass/ Middle/ Treble Boost /cut	0	0	0	0	0	0	0
1dB				0	0	0	0	1
2dB				0	0	0	1	0
3dB				0	0	0	1	1
4dB				0	0	1	0	0
5dB				0	0	1	0	1
6dB				0	0	1	1	0
7dB				0	0	1	1	1
8dB				0	1	0	0	0
9dB				0	1	0	0	1
10dB				0	1	0	1	0
11dB				0	1	0	1	1
12dB				0	1	1	0	0
13dB				0	1	1	0	1
14dB				0	1	1	1	0
15dB				0	1	1	1	1
16dB				1	0	0	0	0
17dB				1	0	0	0	1
18dB				1	0	0	1	0
19dB				1	0	0	1	1
20dB				1	0	1	0	0
Prohibition				1	0	1	0	1
				:	:	:	:	:
				1	1	1	1	0
				1	1	1	1	1

Mode	MSB Bass/Middle/Treble Boost/Cut LSB							
	D7	D6	D5	D4	D3	D2	D1	D0
Boost	0	0	0	Bass/Middle/Treble Gain				
Cut	1							

: Initial condition

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Select address 75 (hex)

Mode	MSB			Loudness Hicut				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
Hicut1	0	0	0	Loudness Gain				
Hicut2		0	1					
Hicut3		1	0					
Hicut4		1	1					

Gain	MSB			Loudness Gain				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
0dB	0	Loudness Hicut		0	0	0	0	0
1dB				0	0	0	0	1
2dB				0	0	0	1	0
3dB				0	0	0	1	1
4dB				0	0	1	0	0
5dB				0	0	1	0	1
6dB				0	0	1	1	0
7dB				0	0	1	1	1
8dB				0	1	0	0	0
9dB				0	1	0	0	1
10dB				0	1	0	1	0
11dB				0	1	0	1	1
12dB				0	1	1	0	0
13dB				0	1	1	0	1
14dB				0	1	1	1	0
15dB				0	1	1	1	1
16dB				1	0	0	0	0
17dB				1	0	0	0	1
18dB				1	0	0	1	0
19dB				1	0	0	1	1
20dB				1	0	1	0	0
Prohibition				1	0	1	0	1
				:	:	:	:	:
				1	1	1	1	1

: Initial condition

(6) About Power ON Reset

Built-in IC initialization is made during power ON of the supply voltage. Please send initial data to all addresses at supply voltage on. Also, please turn ON MUTE at the set side until initial data is sent.

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Rise Time of VCC	t_{RISE}	33	-	-	μsec	V_{CC} rise time from 0V to 5V
VCC Voltage of Release Power ON Reset	V_{POR}	-	4.1	-	V	

(7) About External Compulsory Mute Terminal

It is possible to forcibly set Mute from the outside by setting input voltage at the MUTE terminal.

Mute Voltage Condition	Mode
GND to 1.0V	MUTE ON
2.3V to V_{CC}	MUTE OFF

Establish the voltage of MUTE in the condition to be defined.

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Application Information

1. Function and Specifications

<table>
<tr><th>Function</th><th>Specifications</th></tr>
<tr><td>Input selector</td><td>・ (Stereo input)
・ Single-End/Diff/Full-Diff
(Possible to set the number of single-end/diff/full-diff as follows)
<table>
<tr><th></th><th>Single-End</th><th>Differential</th><th>Full-Differential</th></tr>
<tr><td>Mode 1</td><td>0</td><td>3</td><td>1</td></tr>
<tr><td>Mode 2</td><td>1</td><td>2</td><td>1</td></tr>
<tr><td>Mode 3</td><td>3</td><td>1</td><td>1</td></tr>
<tr><td>Mode 4</td><td>4</td><td>0</td><td>1</td></tr>
<tr><td>Mode 5</td><td>5</td><td>1</td><td>0</td></tr>
<tr><td>Mode 6</td><td>6</td><td>0</td><td>0</td></tr>
</table>
Table.3 Combination of input selector</td></tr>
<tr><td>Input gain</td><td>・ +20dB to 0dB (1dB step)
・ Possible to use “Advanced switch” for prevention of switching noise.</td></tr>
<tr><td>Mute</td><td>・ Possible to use “Advanced switch” for prevention of switching noise.</td></tr>
<tr><td>Volume</td><td>・ +15dB to -79dB (1dB step), -∞dB
・ Possible to use “Advanced switch” for prevention of switching noise.</td></tr>
<tr><td>Bass</td><td>・ +20dB to -20dB (1dB step)
・ Q=0.5, 1, 1.5, 2
・ fo=60, 80, 100, 120Hz
・ Possible to use “Advanced switch” when changing gain</td></tr>
<tr><td>Middle</td><td>・ +20dB to -20dB (1dB step)
・ Q=0.75, 1, 1.25, 1.5
・ fo=500, 1k, 1.5k 2.5kHz
・ Possible to use “Advanced switch” when changing gain</td></tr>
<tr><td>Treble</td><td>・ +20dB to -20dB (1dB step)
・ Q=0.75, 1.25
・ fo=7.5k, 10k, 12.5k, 15kHz
・ Possible to use “Advanced switch” when changing gain</td></tr>
<tr><td>Fader</td><td>・ 0dB to -79dB, -∞dB
・ Possible to use “Advanced switch” for prevention of switching noise.</td></tr>
<tr><td>Loudness</td><td>・ 20dB to 0dB(1dB step)
・ fo=250/400/800Hz
・ Possible to use “Advanced switch” for prevention of switching noise.</td></tr>
</table>

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2. Volume / Fader volume attenuation of the details

(dB)	D7	D6	D5	D4	D3	D2	D1	D0	(dB)	D7	D6	D5	D4	D3	D2	D1	D0
+15	0	1	1	1	0	0	0	1	-33	1	0	1	0	0	0	0	1
+14	0	1	1	1	0	0	1	0	-34	1	0	1	0	0	0	1	0
+13	0	1	1	1	0	0	1	1	-35	1	0	1	0	0	0	1	1
+12	0	1	1	1	0	1	0	0	-36	1	0	1	0	0	1	0	0
+11	0	1	1	1	0	1	0	1	-37	1	0	1	0	0	1	0	1
+10	0	1	1	1	0	1	1	0	-38	1	0	1	0	0	1	1	0
+9	0	1	1	1	0	1	1	1	-39	1	0	1	0	0	1	1	1
+8	0	1	1	1	1	0	0	0	-40	1	0	1	0	1	0	0	0
+7	0	1	1	1	1	0	0	1	-41	1	0	1	0	1	0	0	1
+6	0	1	1	1	1	0	1	0	-42	1	0	1	0	1	0	1	0
+5	0	1	1	1	1	0	1	1	-43	1	0	1	0	1	0	1	1
+4	0	1	1	1	1	1	0	0	-44	1	0	1	0	1	1	0	0
+3	0	1	1	1	1	1	0	1	-45	1	0	1	0	1	1	0	1
+2	0	1	1	1	1	1	1	0	-46	1	0	1	0	1	1	1	0
+1	0	1	1	1	1	1	1	1	-47	1	0	1	0	1	1	1	1
0	1	0	0	0	0	0	0	0	-48	1	0	1	1	0	0	0	0
-1	1	0	0	0	0	0	0	1	-49	1	0	1	1	0	0	0	1
-2	1	0	0	0	0	0	1	0	-50	1	0	1	1	0	0	1	0
-3	1	0	0	0	0	0	1	1	-51	1	0	1	1	0	0	1	1
-4	1	0	0	0	0	1	0	0	-52	1	0	1	1	0	1	0	0
-5	1	0	0	0	0	1	0	1	-53	1	0	1	1	0	1	0	1
-6	1	0	0	0	0	1	1	0	-54	1	0	1	1	0	1	1	0
-7	1	0	0	0	0	1	1	1	-55	1	0	1	1	0	1	1	1
-8	1	0	0	0	1	0	0	0	-56	1	0	1	1	1	0	0	0
-9	1	0	0	0	1	0	0	1	-57	1	0	1	1	1	0	0	1
-10	1	0	0	0	1	0	1	0	-58	1	0	1	1	1	0	1	0
-11	1	0	0	0	1	0	1	1	-59	1	0	1	1	1	0	1	1
-12	1	0	0	0	1	1	0	0	-60	1	0	1	1	1	1	0	0
-13	1	0	0	0	1	1	0	1	-61	1	0	1	1	1	1	0	1
-14	1	0	0	0	1	1	1	0	-62	1	0	1	1	1	1	1	0
-15	1	0	0	0	1	1	1	1	-63	1	0	1	1	1	1	1	1
-16	1	0	0	1	0	0	0	0	-64	1	1	0	0	0	0	0	0
-17	1	0	0	1	0	0	0	1	-65	1	1	0	0	0	0	0	1
-18	1	0	0	1	0	0	1	0	-66	1	1	0	0	0	0	1	0
-19	1	0	0	1	0	0	1	1	-67	1	1	0	0	0	0	1	1
-20	1	0	0	1	0	1	0	0	-68	1	1	0	0	0	1	0	0
-21	1	0	0	1	0	1	0	1	-69	1	1	0	0	0	1	0	1
-22	1	0	0	1	0	1	1	0	-70	1	1	0	0	0	1	1	0
-23	1	0	0	1	0	1	1	1	-71	1	1	0	0	0	1	1	1
-24	1	0	0	1	1	0	0	0	-72	1	1	0	0	1	0	0	0
-25	1	0	0	1	1	0	0	1	-73	1	1	0	0	1	0	0	1
-26	1	0	0	1	1	0	1	0	-74	1	1	0	0	1	0	1	0
-27	1	0	0	1	1	0	1	1	-75	1	1	0	0	1	0	1	1
-28	1	0	0	1	1	1	0	0	-76	1	1	0	0	1	1	0	0
-29	1	0	0	1	1	1	0	1	-77	1	1	0	0	1	1	0	1
-30	1	0	0	1	1	1	1	0	-78	1	1	0	0	1	1	1	0
-31	1	0	0	1	1	1	1	1	-79	1	1	0	0	1	1	1	1
-32	1	0	1	0	0	0	0	0	-∞	1	1	1	1	1	1	1	1

Fader Volume only 0dB to -∞dB are available.

: Initial condition

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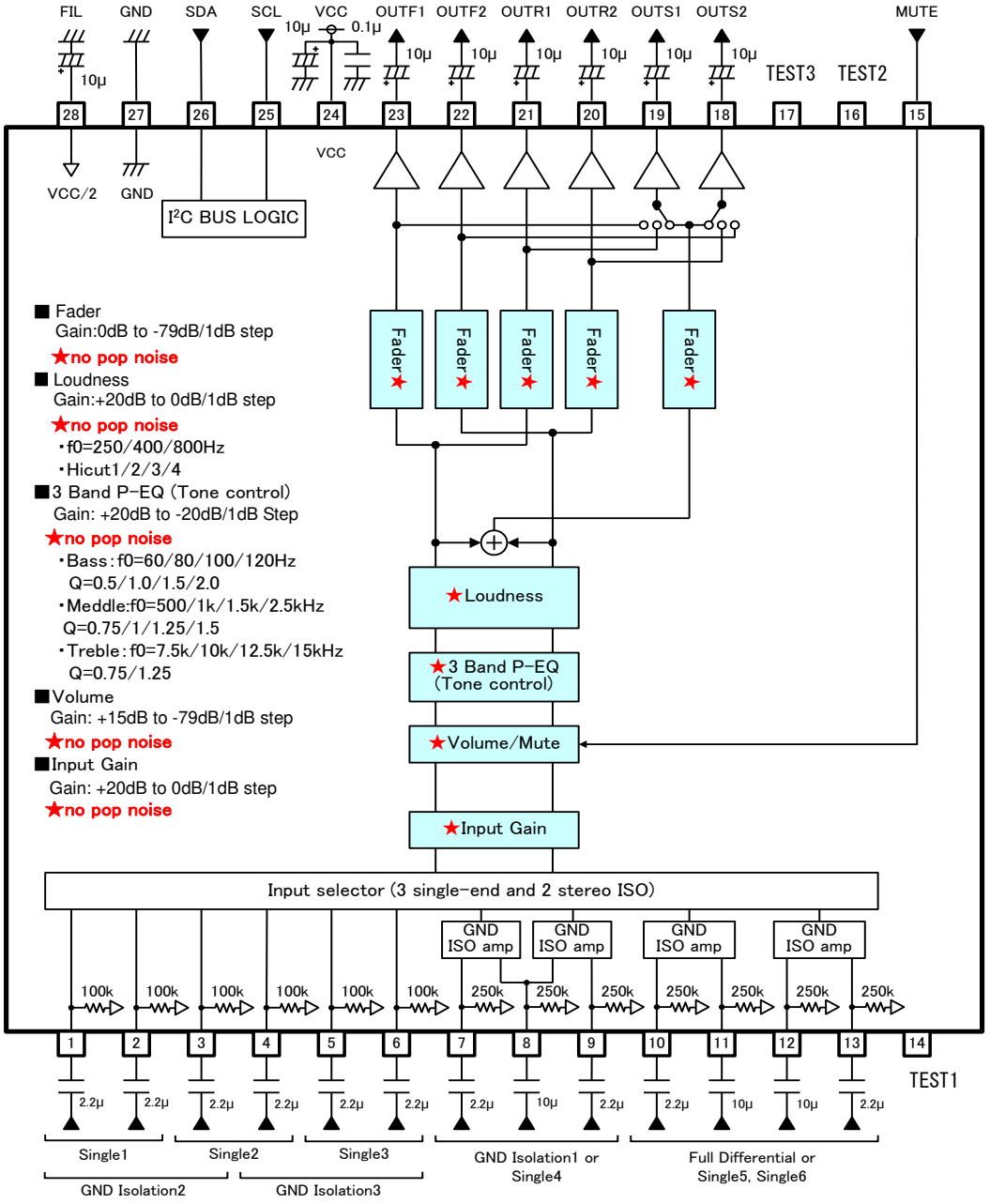
3. Application Circuit



(Note 1)About single input 1 to 3, it is possible to change from single input to GND Isolation input 2,3.

(Note 2)About GND Isolation1 and Full Differential, it is possible to change from differential input to single input 4 to 6.

Unit
R : [Ω]
C : [F]

Notes on wiring

① Please connect the decoupling capacitor of the power supply in the shortest possible distance to GND.
② GND lines should be one-point connected.
③ Wiring pattern of Digital shall be away from that of analog unit and crosstalk should not be acceptable.
④ If possible, SCL and SDA lines of the I²C BUS should not be parallel.
The lines should be shielded, if they are adjacent to each other.
⑤ If possible, analog input lines should not be parallel. The lines should be shielded, if they are adjacent to each other.
⑥ About TEST pin(14,16,17pin), should be OPEN.

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Power Dissipation

About the thermal design of the IC

Characteristics of an IC are greatly affected by the temperature at which it is used. Exceeding absolute maximum ratings may degrade and destroy the device. Careful consideration must be given to the heat of the IC from the two standpoints of immediate damage and long-term reliability of operation.

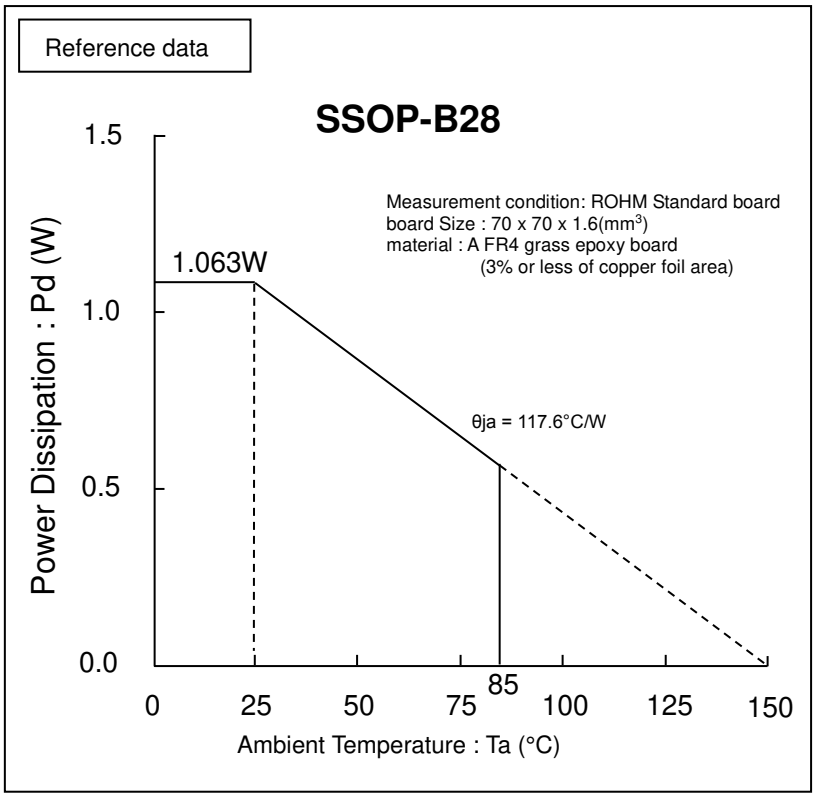

Figure 23. Temperature Derating Curve

(Note) Values are actual measurements and are not guaranteed.

Power dissipation values vary according to the board on which the IC is mounted.

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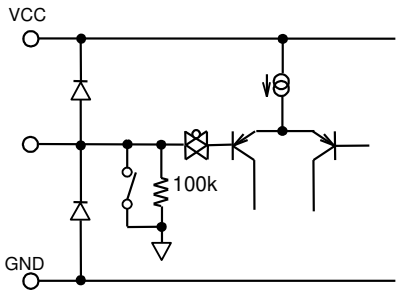
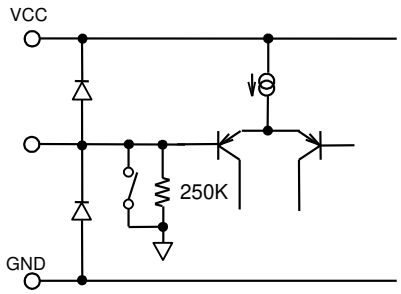
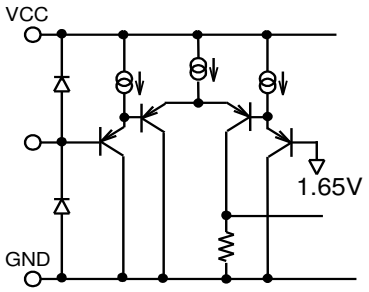
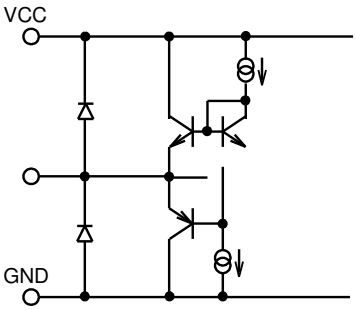
I/O Equivalent Circuits

Terminal No.	Terminal Name	Terminal Voltage	Equivalent Circuit	Terminal Description
1 2 3 4 5 6	A1 A2 B1 B2 C1 C2	4.25		A terminal for signal input. The input impedance is 100kΩ (Typ).
7 8 9 10 11 12 13	DP1 DN DP2 EP1 EN1 EN2 EP2	4.25		Input terminal available to single/Differential mode. The input impedance is 250kΩ (Typ).
15	MUTE	-		A terminal for external compulsory mute. If terminal voltage is High level, the mute is OFF. And if the terminal voltage is Low level, the mute is ON.
18 19 20 21 22 23	OUTS2 OUTS1 OUTR2 OUTR1 OUTF2 OUTF1	4.25		A terminal for fader and Subwoofer output.

Values in the pin explanation and input/output equivalent circuit are for reference purposes only. It is not a guaranteed value.

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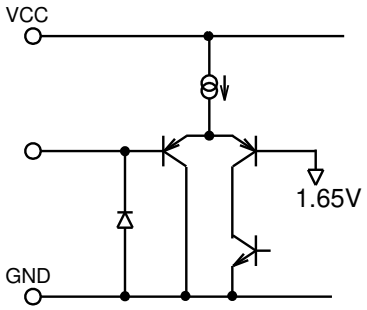
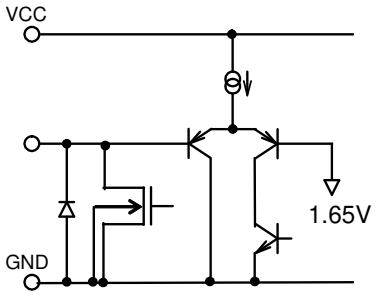
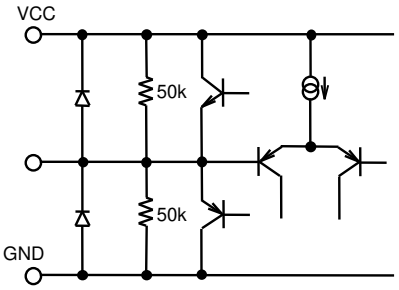
I/O Equivalent Circuits – continued

Terminal No.	Terminal Name	Terminal Voltage	Equivalent Circuit	Terminal Description
24	VCC	8.5		Power supply terminal.
25	SCL	-		A terminal for clock input of I²C BUS communication.
26	SDA	-		A terminal for data input of I²C BUS communication.
27	GND	0		Ground terminal.
28	FIL	4.25		Voltage for reference bias of analog signal system. The simple pre-charge circuit and simple discharge circuit for an external capacitor are built in.
14 16 17	TEST	-		TEST terminal

Values in the pin explanation and input/output equivalent circuit are for reference purposes only. It is not a guaranteed value.

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