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6ch Electronic Volume for 5.1ch Car Theater

BD3433K

General Description

BD3433K is a 6ch electronic volume device for 5.1ch Car Theater. It incorporates various functions such as 6ch input selector (front/rear independently-controlled), input gain amp (front/rear independently-controlled), 6ch independently-controlled electronic volume (capable of soft switching), 6ch output gain amp (2-line outputs), differential input for monophonic signals, electronic volume for monophonic signals (capable of soft switching), and mixing circuit for monophonic signals. It also provides high performance functions to achieve low distortion, low noise and a high voltage output of 5.6Vrms. QFP44 package which offers savings in space and components is used to be suited for applications such as car audio and car navigation.

Features

- High output voltage of 5.6Vrms is achievable
  Provided with 2 lines of outputs to the built-in power amp and the pre-out.
- Reduces volume switching noise by installing the advanced 6ch independently-controlled electronic volume with soft switching.
- High performance capabilities such as low distortion rate (0.001%), low noise (3µVrms)
- Different signals from different sources can be outputted to the front and rear sections independently and this provides an option of rear-seat entertainment.
- Incorporates monophonic differential input circuit suited for inputting navigation voice and telephone speech.
  These monophonic voices can be mixed with the front output signals.
- Energy-saving design resulting in low current consumption, by utilizing the Bi-CMOS process.
  It has the advantage in quality over scaling down the power heat control of the internal regulators.
- 3-wire serial interface supported for both of 3.3V and 5V microcomputers.

Applications

For car audio equipment, car navigation equipment, and hybrid systems.

Key Specifications

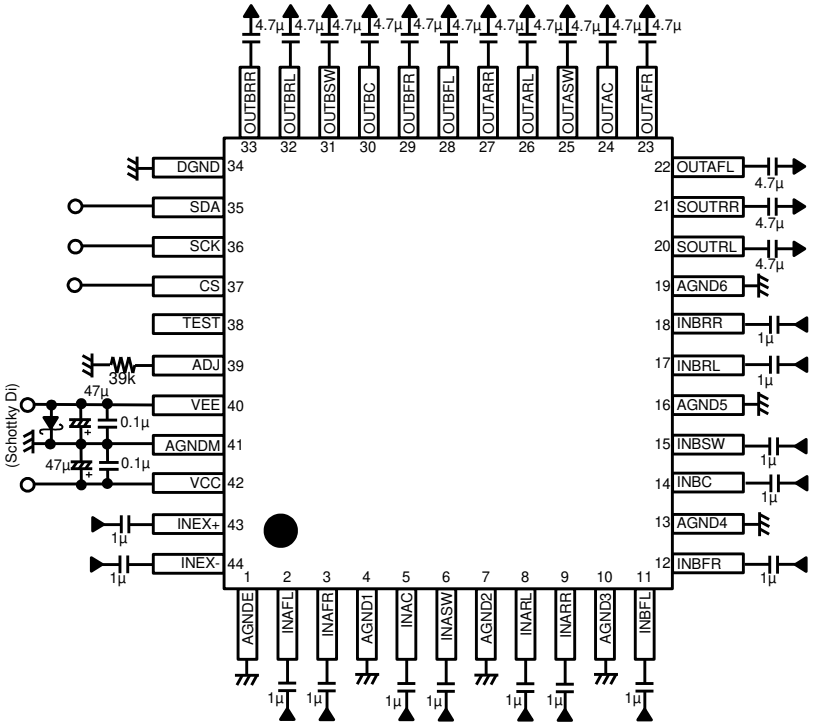
- VCC Power Supply Voltage Range: 7.0V to 9.5V
- VEE Power Supply Voltage Range: -9.5V to -7.0V
- Total Harmonic Distortion: 0.001%(Typ)
- Maximum Input Voltage: 4.25Vrms(Typ)
- Cross-talk Between Channels: 106dB(Typ)
- Output Noise Voltage: 2.5µVrms(Typ)
- Residual Output Noise Voltage: 2µVrms(Typ)
- VCO Oscillation Frequency: 400kHz(Typ)
- Operating Temperature Range: -40°C to +85°C

Package

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

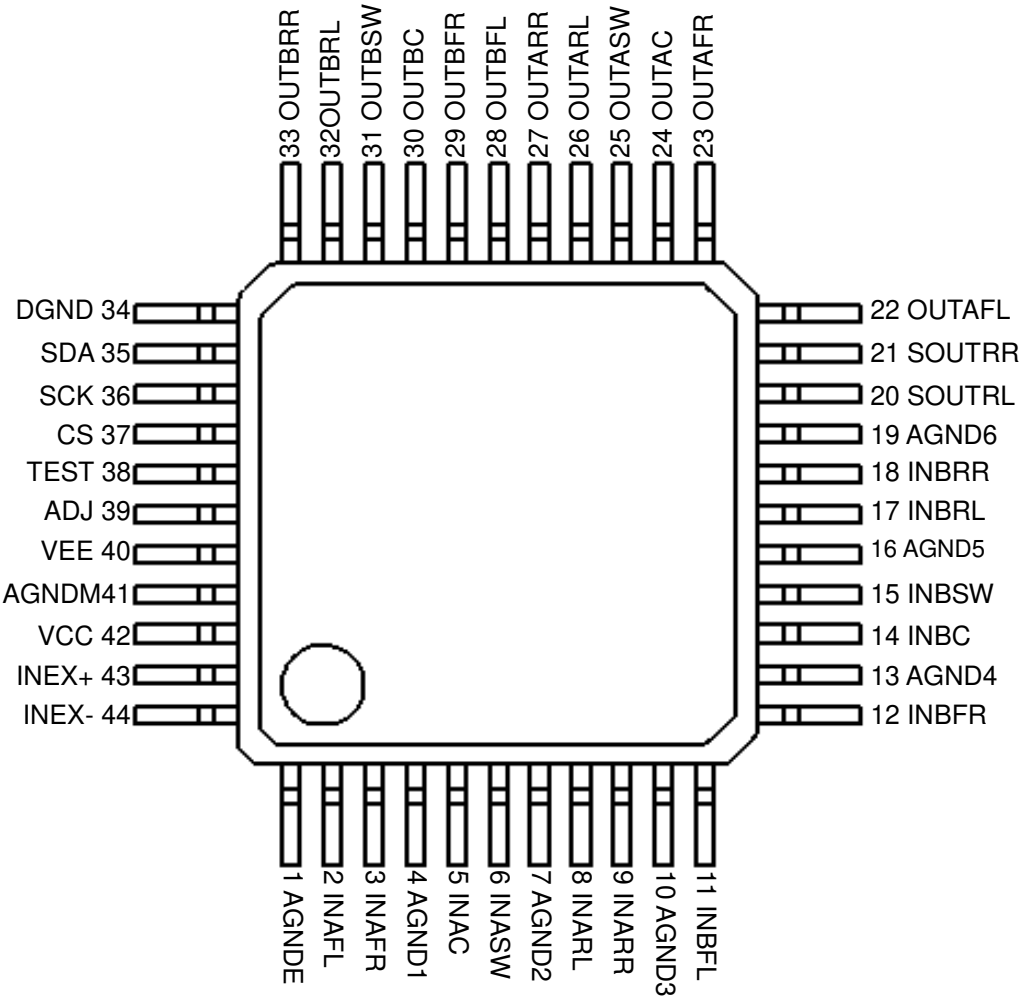
QFP44
14.00mm x 14.00mm x 2.25mm

Typical Application Circuit



Pin Configuration

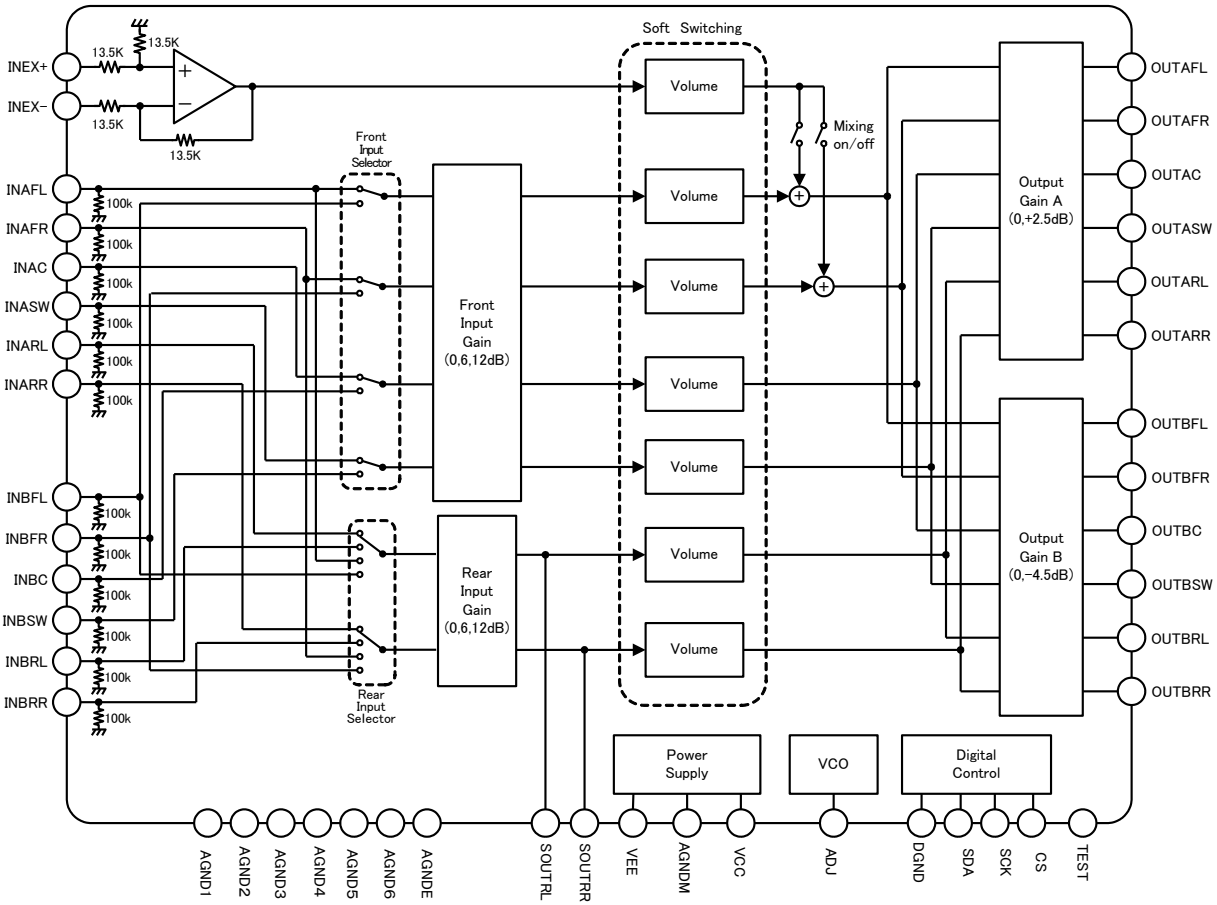
TOP VIEW



Pin Descriptions

Pin No	Pin Name	I/O	Function	Pin No	Pin Name	I/O	Function
1	AGNDE	-	Signal series GND	23	OUTAFR	O	Signal output A for front R ch
2	INAFL	I	Signal input A for front L ch	24	OUTAC	O	Signal output A for center ch
3	INAFR	I	Signal input A for front R ch	25	OUTASW	O	Signal output A for subwoofer ch
4	AGND1	-	Signal series GND	26	OUTARL	O	Signal output A for rear L ch
5	INAC	I	Signal input A for centre	27	OUTARR	O	Signal output A for rear R ch
6	INASW	I	Signal input A for subwoofer	28	OUTBFL	O	Signal output B for front L ch
7	AGND2	-	Signal series GND	29	OUTBFR	O	Signal output B for front R ch
8	INARL	I	Signal input A for rear L ch	30	OUTBC	O	Signal output B for center ch
9	INARR	I	Signal input for A rear R ch	31	OUTBSW	O	Signal output B for subwoofer ch
10	AGND3	-	Signal series GND	32	OUTBRL	O	Signal output B for rear L ch
11	INBFL	I	Signal input B for front L ch	33	OUTBRR	O	Signal output B for rear R ch
12	INBFR	I	Signal input B for front R ch	34	DGND	-	Digital series ground
13	AGND4	-	Signal series GND	35	SDA	I	Micro controller interface (serial data signal input)
14	INBC	I	Signal input B for center	36	SCK	I	Micro controller interface (serial clock signal input)
15	INBSW	I	Signal input B for subwoofer	37	CS	I	Micro controller interface (chip select signal input)
16	AGND5	-	Signal series GND	38	TEST	O	Testing terminal
17	INBRL	I	Signal input B for rear L ch	39	ADJ	-	VCC oscillating frequency adjustment
18	INBRR	I	Signal input B for rear R ch	40	VEE	-	Power (negative voltage) input
19	AGND6	-	Signal series GND	41	AGNDM	-	Analog series GND
20	SOUTRL	O	Signal output for rear L ch	42	VCC	-	Power (positive voltage) input
21	SOUTRR	O	Signal output for rear R ch	43	INEX+	I	Monaural source signal input
22	OUTAFL	O	Signal output A for front L ch	44	INEX-	I	Monaural source signal input

Block Diagram



Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Rating	Unit	Terminal
Terminal Applied Voltage	V_{CC}-GND	10	V	(Note 1)
	V_{EE}-GND	-10		(Note 1)
	V_{LGC}	5.5		Control terminal (CS/SCK/SDA) (Note 1)
Power Dissipation	Pd	0.85	W	(Note 2)
Operating Temperature	Topr	-40 to +85	°C	
Storage Temperature	Tstg	-55 to +125	°C	

(Note 1) Maximum applied voltage based on GND.
(Note 2) Derate by 8.5mW/°C for Ta>25°C.
Mounted on (Material: FR4 glass epoxy board (beaten-copper area <3%), size:70mm x 70mm x 1.6mm)
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 (Ta=25°C)

Parameter	Symbol	Terminal	Min	Typ	Max	Unit	Conditions
Power Supply Voltage	V_{CC}	V_{CC}-GND	7.0	9	9.5	V	(Note 1)
	V_{EE}	V_{EE}-GND	-9.5	-9	-7.0	V	

(Note 1) When it is within operating temperature, basic circuit function is guaranteed within operating voltage. However, setting constant and element, voltage setting, and temperature setting are required when in operation. Other than the conditions stipulated within the range, the standard value of electrical characteristics could not be guaranteed, while original function is retained.

Electrical Characteristics

Abbreviations:

"Giaj" : Setting value of Input gain adjustor
"Vol.Ex" : Setting value of volume for monaural signal
"Goajb" : Setting value of output gain adjustor B
"Vol" : Setting value of volume (1ch to 6ch)
"Goaja" : Setting value of output gain adjustor A
"Mix" : ON/OFF setting for mixing switch.

Measurement condition (Unless specified otherwise) :
Ta=25°C, V_{CC}=9V, V_{EE}=-9V, V_{IN}=1Vrms/1kHz, Load resistance=10kΩ, Load capacitance=10pF,
Giaj=0dB, Vol=0dB, Goaja=0dB, Goajb=0dB, Vol.Ex=-∞dB, Mix=OFF

1. General Characteristics

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Current Consumption	I_{CC}	-	10	17	mA	
	I_{EE}	-17	-9	-		
VCO Oscillation Frequency	f_{VCO}	-	400	-	kHz	
Ripple Rejection	RRc	40	85	-	dB	Ripple = 0.1Vrms/ 1kHz (Input terminal AC short)
	RRe	30	70	-	dB	Ripple= 0.1Vrms/ 1kHz (Input terminal AC short)
Reset Operation Voltage	V_{RS}	-	3.4	-	V	Initialize all register data by $V_{CC} < V_{RS}$ to $V_{CC} > V_{RS}$
Required Time for Power ON Reset	t_{POR}	20	-	-	µsec	Minimum required time to reach 3V after VCC voltage ON.

2. Logic Circuit

Parameter	Symbol	Min	Typ	Max	Unit	Terminal
"H" Level Input Voltage	V_{IH}	2.3	-	5.5	V	CS, SCK, SDA
"L" Level Input Voltage	V_{IL}	0	-	1.0	V	CS, SCK, SDA
Input Clock Frequency	f_{SCK}	-	-	1.5	MHz	SCK

Electrical Characteristics – continued

3. Volume Circuit

Parameter	Symbol	Min	Typ	Max	Unit	Conditions	
Voltage Gain	G_V	-1	0	+1	dB		
Bandwidth	f_W	100	-	-	kHz	Frequency, which drop -1dB towards 1kHz	
Slew Rate	SR	-	1.65	-	V/µsec		
Maximum Input Voltage	V_{IM}	3.8	4.25	-	Vrms	THD+N = 1% , Vol = -10dB	
Maximum Output Voltage	V_{OM1}	3.8	4.25	-	Vrms	THD+N = 1% Vol = +10dB	
	V_{OM2}	5	5.6	-			Goaja=+2.5dB
	V_{OM3}	2.2	2.5	-			Goajb=-4.5dB
Input Impedance	R_{IN_V}	70k	100k	130k	Ω		
Output Impedance	R_{OUT}	-	-	50	Ω		
Input Gain Setting Value Error	E_{GI}	-1	0	+1	dB	Output reference is Giaj=0dB Giaj=6dB, 12dB, V_{IN}=0.1Vrms	
Volume Setting Value Error	E_{V1}	-1.0	0	+1.0	dB	Vol=0dB Output standard	Vol=+23dB to +1dB, -1dB to -20dB (+23dB to +1dB at V_{IN}=0.1Vrms)
	E_{V2}	-1.5	0	+1.5			Vol=-21dB to -40dB
	E_{V3}	-2.0	0	+2.0			Vol=-41dB to -60dB
	E_{V4}	-3.0	0	+3.0			Vol=-61dB to -79dB
Volume Maximum Attenuation	V_{MU}	-	-108	-85	dB	Vol=-∞dB (mute) , BW=20Hz to 20kHz	
Output Gain Setting Value Error	E_{GOA}	-1	0	+1	dB	Goaja= Goajb=0dB Output standard	Goaja=+2.5dB
	E_{GOB}	-1	0	+1			Goajb=-4.5dB
Gain Balance Between Channels	CB	-1	0	+1	dB		
Cross-talk Between Channels	CTC	85	106	-	dB	BW=20Hz to 20kHz (Input terminal AC short)	
Output Noise Voltage	V_{NO}	-	2.5	10	µVrms	BW=A-Weight (Input terminal AC short)	Vol=0dB
Residual Output Noise Voltage	V_{NR}	-	2	10			Vol=-∞dB
THD+N	THD	-	0.001	0.05	%	BW=20Hz to 20kHz, V_{OUT}=1Vrms	
Soft Switching Transition Time	t_{SS1}	-	0.64	-	msec /dB	Soft switching : ON	0.64 msec/dB
	t_{SS2}	-	1.28	-			1.28 msec/dB
	t_{SS3}	-	2.56	-			2.56 msec/dB
	t_{SS4}	-	5.12	-			5.12 msec/dB

Electrical characteristics – continued

4. Monaural Signal Circuit

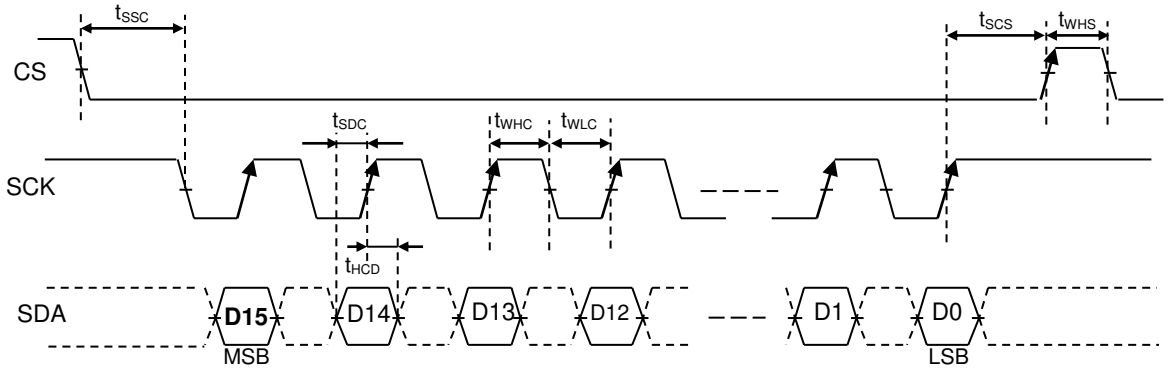
Common condition unless specified otherwise :
Vol=-∞dB, Giaj=Goaja= Goajb=0dB, Vol.Ex=0dB, Mix=ON

Parameter	Symbol	Min	Typ	Max	Unit	Conditions	
Voltage Gain	G_{Ve}	-1.0	0	+1.0	dB	Phase inversion between input and output	
Maximum Input Voltage	V_{IMe}	3.8	4.25	-	Vrms	THD+N=1%, Vol.Ex=-10dB	
Input Impedance	R_{INe}	19	27	35	kΩ		
Volume Setting Value Error	E_{Ve1}	-1.0	0	+1.0	dB	Vol.Ex = 0dB Output standard	Vol=+15dB to +1dB, -1dB to -20dB, (+15dB +1dB at V_{IN}=0.1Vrms)
	E_{Ve2}	-1.5	0	+1.5			Vol=-21dB to -40dB
	E_{Ve3}	-2.0	0	+2.0			Vol=-41dB to -60dB
	E_{Ve4}	-3.0	0	+3.0			Vol=-61dB to -63dB
Volume Maximum Attenuation	V_{MUe}	-	-108	-85	dB	Vol.Ex=-∞dB (mute) , BW=20Hz to 20kHz	
Output Noise Voltage	V_{NOe}	-	4.5	15	μVrms	BW=A-Weight (Input terminal AC short)	Vol.Ex = 0dB
Residual Noise Voltage	V_{NRe}	-	3.5	10			Vol.Ex = -∞dB
THD+N	THDe	-	0.002	0.05	%	BW=20Hz to 20kHz, V_{OUT}=1Vrms	
Common-Mode Signal Rejection Ratio	CMRR	40	60	-	dB	BW=20Hz to 20kHz	
Soft Switching Transition Time	t_{SSE1}	-	0.64	-	msec /dB	Soft switching: ON	0.64 msec/dB
	t_{SSE2}	-	1.28	-			1.28 msec/dB
	t_{SSE3}	-	2.56	-			2.56 msec/dB
	t_{SSE4}	-	5.12	-			5.12 msec/dB

Application Information

1. Control Signal Specification

(1) Timing Chart



Item	Symbol	Min	Typ	Max	Unit	
Input Clock Frequency	f_{SCK}	-	-	1.5	MHz	
SCK “High” Interval Width	t_{WHC}	200	-	-	nsec	*
SCK “Low” Interval Width	t_{WLC}	200	-	-	nsec	*
CS “High” Interval Width	t_{WHS}	200	-	-	nsec	*
CS↓ - SCK↓ (Condition of Starting Data Transmission) Set up Time	t_{SSC}	400	-	-	nsec	*
SCK↓ - CS↓ (Condition of Starting Data Transmission) Set up Time	t_{SCS}	400	-	-	nsec	*
SDA - SCK↑ (Condition of Starting Data Receiving) Set up Time	t_{SDC}	80	-	-	nsec	*
SCK↑ - SDA (Condition of Starting Data Receiving) Hold Time	t_{HCD}	80	-	-	nsec	*

(a) When CS is “Low”, micro computer control data (SCK/SDA) is enabled. (It doesn’t work when CS is “High”),
(b) Data (SDA) is read at the leading edge of clock (SCK).
(c) Latch reads at the leading edge of CS. (SCK has to be kept as “High” after D0 acquisition)
(d) Timing where * mark is not guaranteed by the delivery inspection, but theoretical values on IC design.

(2) Control Data Format Basic Structure Table

("x" ・・・ don't care bit. Either 0 or 1)

Command No.	Command name	(MSB)		Data Transmission Description (Command + Setting data =16 bit)													(LSB)
		Command				Function Description											
		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	Backup area	**0**	**0**	**0**	**0**	x	x	x	x	x	x	x	x	x	x	x	x
1	Selector Input gain Output gain	**0**	**0**	**0**	**1**	x	x	Output Gain B	Output Gain A	Input Sel Rear		Input Gain Rear		x	Input Sel Front	Input Gain Front	
2	Backup area	**0**	**0**	**1**	**0**	x	x	x	x	x	x	x		x	x	x	
3	Monaural Signal	**0**	**0**	**1**	**1**	Mix FRch	Mix FLch	Transition Time		Switching Pattern	Volume gain						
4	Backup area	**0**	**1**	**0**	**0**	x	x	x	x	x	x	x	x	x	x	x	x
5	Backup area	**0**	**1**	**0**	**1**	x	x	x	x	x	x	x	x	x	x	x	x
6	Backup area	**0**	**1**	**1**	**0**	x	x	x	x	x	x	x	x	x	x	x	x
7	Test sequence	**0**	**1**	**1**	**1**	0	0	0	0	0	0	0	0	0	0	0	0
8	Volume Front Lch	**1**	**0**	**0**	**0**	x	x	Transition Time		Switching Pattern	Volume gain						
9	Volume Front Rch	**1**	**0**	**0**	**1**	x	x	Transition Time		Switching Pattern	Volume gain						
10	Volume Center ch	**1**	**0**	**1**	**0**	x	x	Transition Time		Switching Pattern	Volume gain						
11	Volume Subwoofer ch	**1**	**0**	**1**	**1**	x	x	Transition Time		Switching Pattern	Volume gain						
12	Volume Rear Lch	**1**	**1**	**0**	**0**	x	x	Transition Time		Switching Pattern	Volume gain						
13	Volume Rear Rch	**1**	**1**	**0**	**1**	x	x	Transition time		Switching Pattern	Volume gain						
14	Backup area	**1**	**1**	**1**	**0**	x	x	x	x	x	x	x	x	x	x	x	x
15	Backup area	**1**	**1**	**1**	**1**	x	x	x	x	x	x	x	x	x	x	x	x

In changing command setting value, enable to select command from No.0 to No.15
Transmission has to be every 16bit as above format.

(3) Initial Value when Power Source is ON.

When power is ON, built-in power on reset circuit initializes setting data to bit "0" (Low) within the IC. However, just in case of set design stage, initial data has to be sent to all addresses when turning power ON, and mute setting is recommended during this initial data transmission.

(4) Preventive Measure for Malfunction by Electrostatic Surge

The IC's logic circuit has shift registers to retain 16bit serial data which is external input from micon etc. The data, which is retained by shift registers, will be synchronized with CS signal leading edge, then is latched to each function. Therefore, if electrostatic surge is applied to the logic signal terminal (CS, SCK, SDA), inappropriate latch may cause malfunction of internal circuit. As a preventive measure for malfunction, 0000(hex) data transmission for command No.0 (backup area), at the end of every data transmission to specific command to initialize shift register in the IC is recommended.

(5) Command No.1 “Selector, Input Gain, Output Gain” Setting Data Chart

(“x” ・・・ Either 0 or 1)

Function	Setting	(MSB) Transmission data (command + Setting data =16bit) (LSB)															
		Command				Setting data											
		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Command		**0**	**0**	**0**	**1**	x	x	-	-	-	-	-	-	x	-	-	-
Input gain (Front ch Center ch Subwoofer ch)	(Initial value) 0 dB 0 dB +6 dB +12 dB	↑	↑	↑	↑	x	x	**-**	**-**	-	-	-	**-**	x	**-**	**0** **0** **1** **1**	**0** **1** **0** **1**
Input selector (Front ch Center ch Subwoofer ch)	(Initial value) Input A Input B	↑	↑	↑	↑	x	x	-	-	-	-	-	-	x	**0** **1**	**-**	**-**
Input Gain Rear ch	(Initial value) 0 dB 0 dB +6 dB +12 dB	↑	↑	↑	↑	x	x	**-**	**-**	-	-	**0** **0** **1** **1**	**0** **1** **0** **1**	x	**-**	**-**	**-**
Input selector Rear ch	(Initial value) Rear input A Rear input B Front input A Front input B	↑	↑	↑	↑	x	x	-	-	**0** **0** **1** **1**	**0** **1** **0** **1**	-	-	x	**-**	**-**	**-**
Output gain A	(Initial value) 0 dB +2.5 dB	↑	↑	↑	↑	x	x	-	**0** **1**	**-**	**-**	-	-	x	**-**	**-**	**-**
Output gain B	(Initial value) 0 dB -4.5 dB	↑	↑	↑	↑	x	x	**0** **1**	**-**	**-**	**-**	-	-	x	**-**	**-**	**-**

(6) Command No.3 **"Monaural signal circuit"** Setting Data Chart

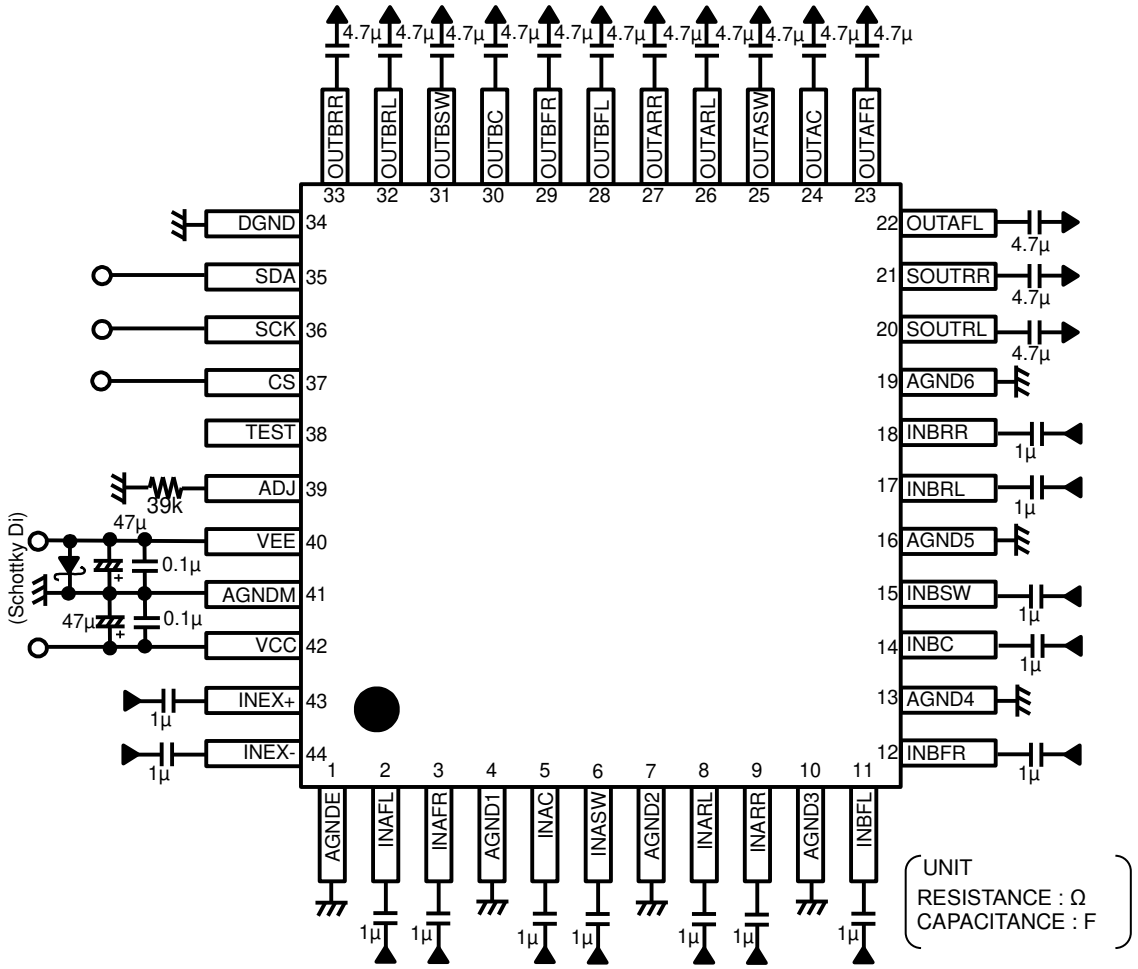
Function	Setting data	(MSB) Transmission data (command + setting data=16bit) (LSB)															
		Command				Setting data											
		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Command		**0**	**0**	**1**	**1**	-	-	-	-	-	-	-	-	-	-	-	-
Volume gain	(Initial value) -∞dB(MUTE)	↑	↑	↑	↑	-	-	-	-	-	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	+15 dB										**1** : : **1**	**1** : : **1**	**1** : : **1**	**1** : : **0**	**1** : : **1**	**1** : : **1**	**1** : : **1**
	+14 dB										**1**	**1**	**1**	**0**	**1**	**1**	**0**
	+13 dB										**1**	**1**	**1**	**0**	**1**	**0**	**1**
	+12 dB										**1**	**1**	**1**	**0**	**1**	**0**	**0**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	+9 dB										**1**	**1**	**1**	**0**	**0**	**0**	**1**
	+8 dB										**1**	**1**	**1**	**0**	**0**	**0**	**0**
	+7 dB										**1**	**1**	**0**	**1**	**1**	**1**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	+2 dB										**1**	**1**	**0**	**1**	**0**	**1**	**0**
	+1 dB										**1**	**1**	**0**	**1**	**0**	**0**	**1**
	0 dB										**1**	**1**	**0**	**1**	**0**	**0**	**0**
	-1 dB										**1**	**1**	**0**	**0**	**1**	**1**	**1**
	-2 dB										**1**	**1**	**0**	**0**	**1**	**1**	**0**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	-7 dB										**1**	**1**	**0**	**0**	**0**	**0**	**1**
	-8 dB										**1**	**1**	**0**	**0**	**0**	**0**	**0**
	-9 dB										**1**	**0**	**1**	**1**	**1**	**1**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	-40 dB										**1**	**0**	**0**	**0**	**0**	**0**	**0**
	-41 dB										**0**	**1**	**1**	**1**	**1**	**1**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	-62 dB										**0**	**1**	**0**	**1**	**0**	**1**	**0**
	-63 dB										**0**	**1**	**0**	**1**	**0**	**0**	**1**
	-∞dB (MUTE)										**Else**						
Volume switching pattern	(Initial value) Secondary Soft switching	↑	↑	↑	↑	-	-	-	-	**0** **1**	-	-	-	-	-	-	-
Volume switching transition time	(Initial value) 0.64(msec/dB) 1.28 (msec/dB) 2.56 (msec/dB) 5.12 (msec/dB)	↑	↑	↑	↑	-	-	**0** **0** **1** **1**	**0** **1** **0** **1**	-	-	-	-	-	-	-	-
Mixing Front Lch	(Initial value) OFF ON	↑	↑	↑	↑	-	**0** **1**	-	-	-	-	-	-	-	-	-	-
Mixing Front Rch	(Initial value) OFF ON	↑	↑	↑	↑	**0** **1**	-	-	-	-	-	-	-	-	-	-	-

(7) Command No.8 **"Volume front L ch"**
Command No.9 **"Volume front R ch"**
Command No.10 **"Volume center ch"**
Command No.11 **"Volume subwoofer ch"**
Command No.12 **"Volume rear L ch"**
Command No.13 **"Volume rear R ch"**

Setting data chart ("x" ・・・ Either 0 or 1)

Function	Setting	(MSB) Transmission data (command + setting data=16bit) (LSB)															
		Command				Setting data											
		D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Command	Volume FL ch	**1**	**0**	**0**	**0**	x	x	-	-	-	-	-	-	-	-	-	x
	Volume FR ch	**1**	**0**	**0**	**1**												
	Volume C ch	**1**	**0**	**1**	**0**												
	Volume SW ch	**1**	**0**	**1**	**1**												
	Volume RL ch	**1**	**1**	**0**	**0**												
	Volume RR ch	**1**	**1**	**0**	**1**												
Volume gain	(Initial Value) -∞dB(MUTE)										**0**	**0**	**0**	**0**	**0**	**0**	**0**
	+23 dB										**1**	**1**	**1**	**1**	**1**	**1**	**1**
	+22 dB										**1**	**1**	**1**	**1**	**1**	**1**	**0**
	+21 dB										**1**	**1**	**1**	**1**	**1**	**0**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	+9 dB										**1**	**1**	**1**	**0**	**0**	**0**	**1**
	+8 dB										**1**	**1**	**1**	**0**	**0**	**0**	**0**
	+7 dB										**1**	**1**	**0**	**1**	**1**	**1**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	+2 dB										**1**	**1**	**0**	**1**	**0**	**1**	**0**
	+1 dB										**1**	**1**	**0**	**1**	**0**	**0**	**1**
	0 dB	↑	↑	↑	↑	x	x	-	-	-	**1**	**1**	**0**	**1**	**0**	**0**	**0**
	-1 dB										**1**	**1**	**0**	**0**	**1**	**1**	**1**
	-2 dB										**1**	**1**	**0**	**0**	**1**	**1**	**0**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	-7 dB										**1**	**1**	**0**	**0**	**0**	**0**	**1**
	-8 dB										**1**	**1**	**0**	**0**	**0**	**0**	**0**
	-9 dB										**1**	**0**	**1**	**1**	**1**	**1**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	-40 dB										**1**	**0**	**0**	**0**	**0**	**0**	**0**
	-41 dB										**0**	**1**	**1**	**1**	**1**	**1**	**1**
	:										:	:	:	:	:	:	:
	:										:	:	:	:	:	:	:
	-78 dB										**0**	**0**	**1**	**1**	**0**	**1**	**0**
	-79 dB										**0**	**0**	**1**	**1**	**0**	**0**	**1**
	-∞dB (MUTE)										**Else**						
Volume switching Pattern	(Initial value) Secondary	↑	↑	↑	↑	x	x	-	-	**0**	-	-	-	-	-	-	x
	Soft switching									**1**							
Volume switching transition time	(Initial value) 0.64 (msec/dB)	↑	↑	↑	↑	x	x	**0**	**0**	-	-	-	-	-	-	-	x
	1.28 (msec/dB)							**0**	**1**								
	2.56 (msec/dB)							**1**	**0**								
	5.12 (msec/dB)							**1**	**1**								

2. Application Circuit Example

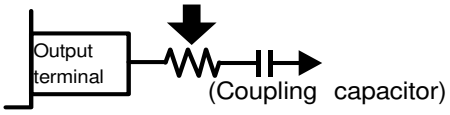


【1 : Oscillation countermeasure】

・ Using higher capacity than 10pF may cause oscillation.
As oscillation countermeasure, insert series resistor to terminal directly as below.

Capacity	Terminal Direct-mount type Series resister
C < 10pF	(Not necessary)
10pF < C < 100pF	100Ω
100pF < C < 1000pF	100Ω

Resistor for oscillation countermeasure



【2 : Mounting pattern】

・ Wire a GND line to the GND point which becomes a standard by the independence.

・ Wiring pattern of CS, SCK and SDA should be away from the analog lines to avoid cross-talk.

・ Input lines should not be parallel if possible. The lines should be shielded, if they are adjacent to each other.

・ Please connect the resistor (39kΩ) for adjusting VCO frequency to ADJ terminal in the shortest distance possible.

(1) Volume Control Description

(Bold with underline is initial setting value)

(a) Volume setting value

(For 5.1ch signal) : +23dB to -79dB, **−∞dB(mute)**, 1dB/step

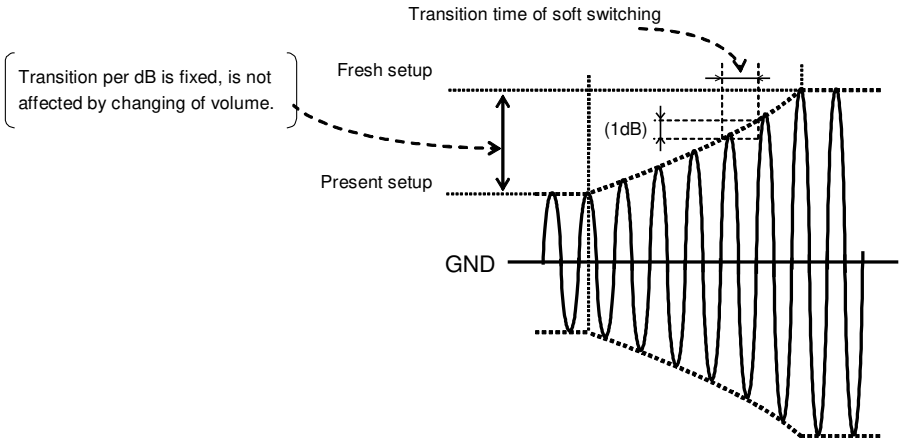
(For Monaural signal) : +15dB to -63dB, **−∞dB(mute)**, 1dB/step

(b) Selection of switching formula :

Secondary switching, soft switching

(c) Soft switching transition time (Transition time/dB) :

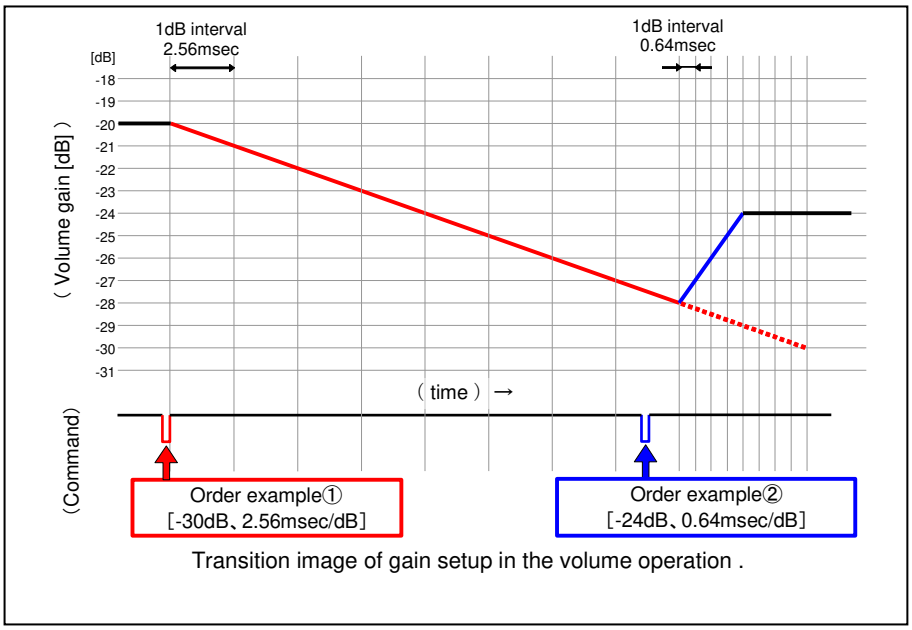
0.64 / 1.28 / 2.56 / 5.12 [msec/dB] (*)



(2) In case of receiving following setting command during volume changing

Terminate current transition and start next transition.

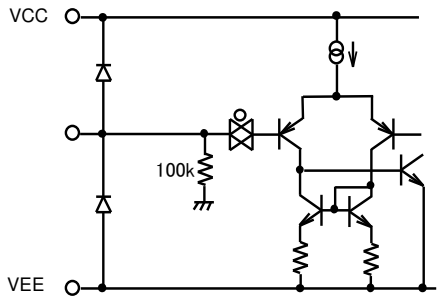
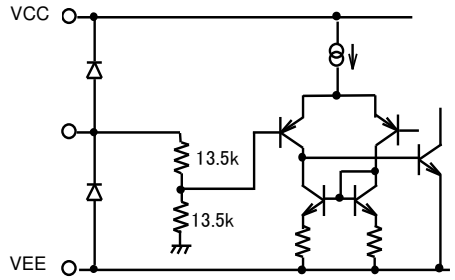
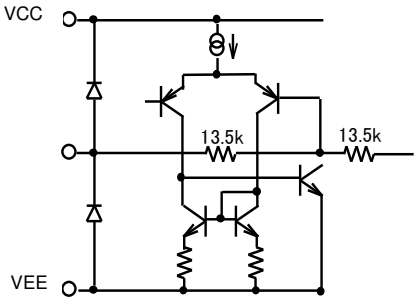
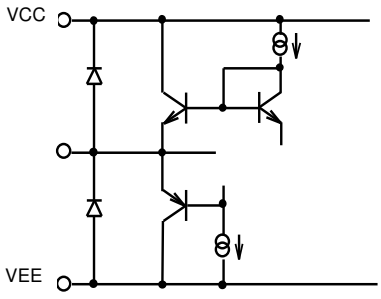
Switching volume can be done with only 1dB/step, so termination or restart of transition is on timing of 1dB/step basis.



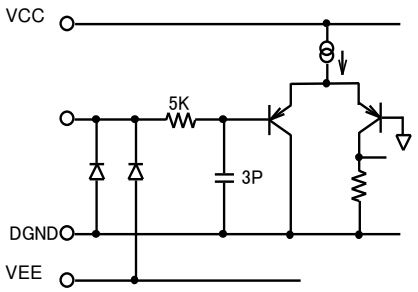
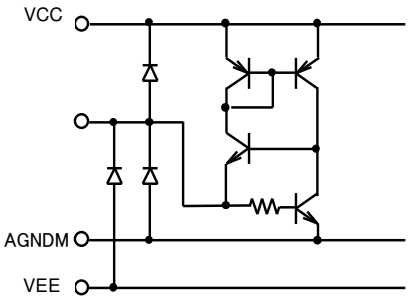
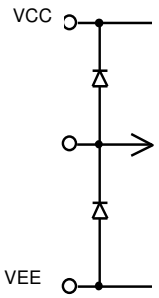
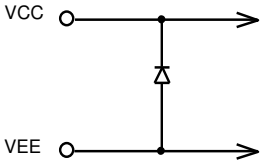
Transition image of gain setup in the volume operation .

(Figure notes) When setting command example1, volume gain drops from -20dB to -30dB with 2.56msec/dB. In the figure, when setting command example 2 during a transition from -27dB to -28dB, command example 2 will be set when it reaches -28dB because termination or restart can be done every 1dB unit.

I/O Equivalent Circuits

Terminal Number	Terminal Name	I/O	Terminal Voltage	Terminal Equivalent Circuits
2 3 5 6 8 9 11 12 14 15 17 18	INAFL INAFR INAC INASW INARL INARR INBFL INBFR INBC INBSW INBRL INBRR	I	0V	
43	INEX+	I	0V	
44	INEX-	I	0V	
20 21 22 23 24 25 26 27 28 29 30 31 32 33	SOUTRL SOUTRR OUTAFL OUTAFR OUTAC OUTASW OUTARL OUTARR OUTBFL OUTBFR OUTBC OUTBSW OUTBRL OUTBRR	O	0V	

I/O Equivalent Circuits – continued

Terminal Number	Terminal Name	I/O	Terminal Voltage	Terminal Equivalent Circuits
35 36 37	SDA SCK CS	I	-	
39	ADJ	-	0.7V	
1 4 7 10 13 16 19 34 41	AGNDE AGND1 AGND2 AGND3 AGND4 AGND5 AGND6 DGND AGNDM	-	0V	
42 40	VCC VEE	-	8.3V -8.3V	

Operational Notes

1. **Reverse Connection of Power Supply**
Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **VEE Voltage**
Ensure that no pins are at a voltage below that of the VEE pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Thermal Consideration**
Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

6. **Recommended Operating Conditions**
These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. **Inrush Current**
When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. **Operation Under Strong Electromagnetic Field**
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. **Testing on Application Boards**
When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. **Inter-pin Short and Mounting Errors**
Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

11. **Unused Input Pins**
Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

12. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When VEE > Pin A and VEE > Pin B, the P-N junction operates as a parasitic diode.
When VEE > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the VEE voltage to an input pin (and thus to the P substrate) should be avoided.

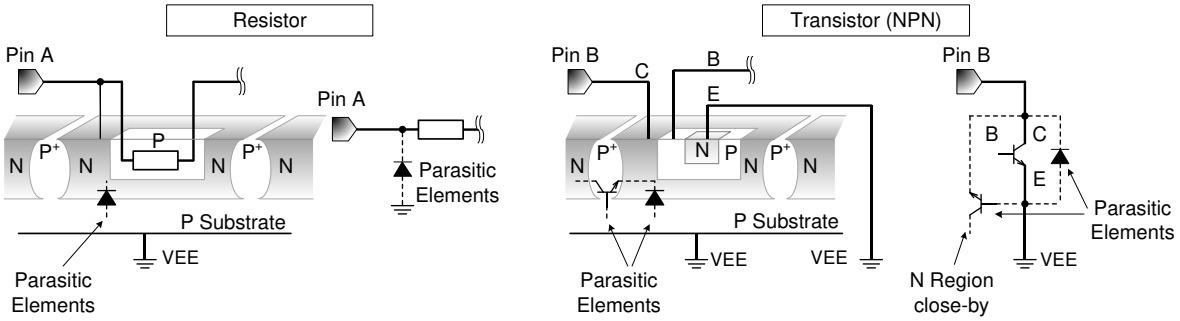
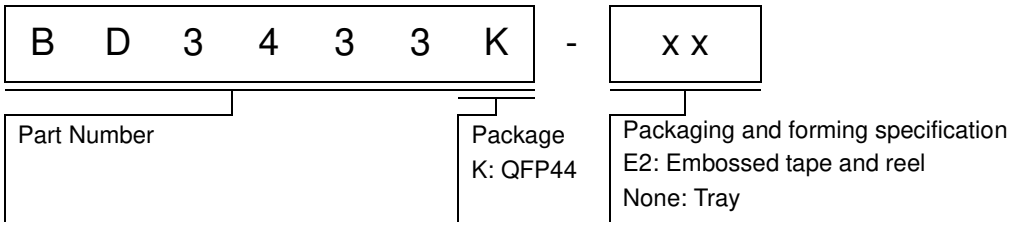
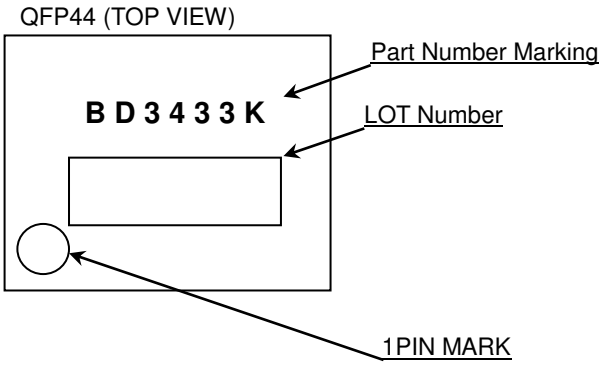


Figure 1. Example of monolithic IC structure

Ordering Information

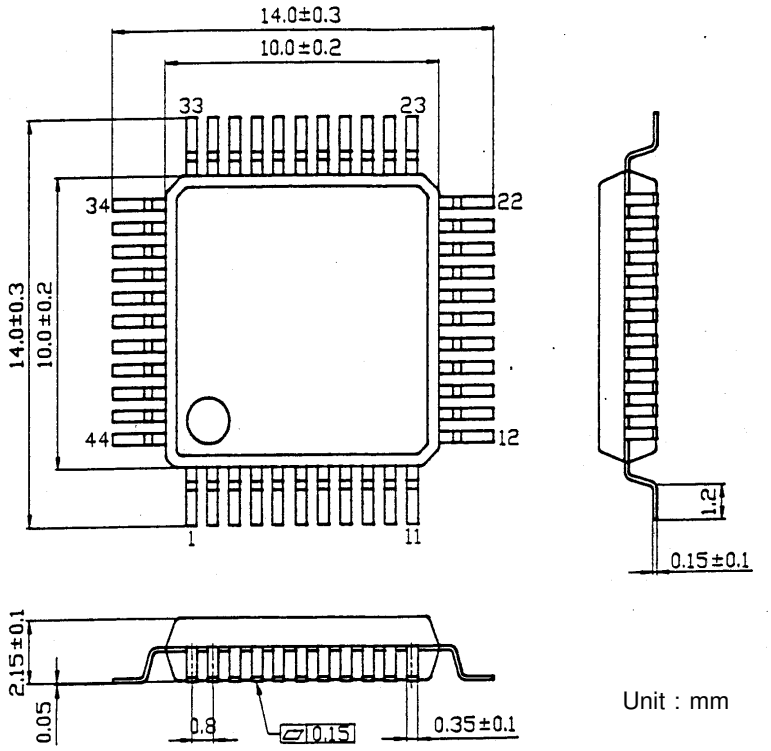


Marking Diagram



Physical Dimension, Tape and Reel Information

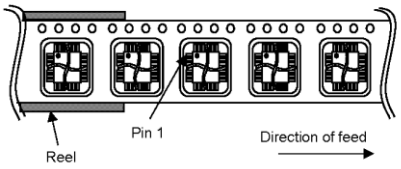
Package Name	QFP44



Unit : mm

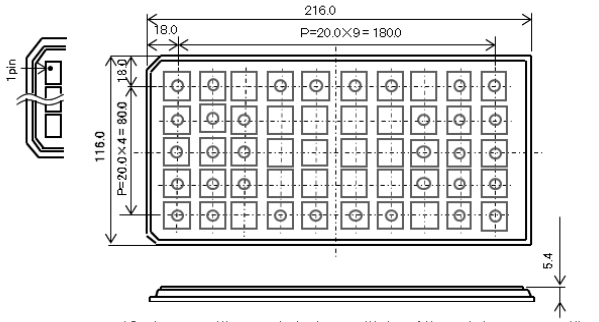
< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	1000pcs
Direction of feed	E2 The direction is the pin 1 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



< Tray Information >

Tray	Tray
Quantity	1000pcs
Direction of feed	Direction of products is fixed in a tray



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

Revision History

Date	Revision	Changes
16.Dec.2015	001	New Release

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1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   - [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   - [b] the temperature or humidity exceeds those recommended by ROHM
   - [c] the Products are exposed to direct sunshine or condensation
   - [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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