Middle Power Class-D Speaker Amplifiers

Class-D Speaker Amplifier for Digital Input

BD5451EFV

No.11075EAT17

●Description

BD5451EFV is a Class D Speaker Amplifier designed for Flat-panel TVs in particular for space-saving and low-power consumption, delivers an output power of 15W+15W. This IC employs state-of-the-art Bipolar, CMOS, and DMOS (BCD) process technology that eliminates turn-on resistance in the output power stage and internal loss due to line resistances up to an ultimate level. With this technology, the IC can achieve high efficiency of 90% (15W+15W output with 8Ω load). In addition, the IC is packaged in a compact reverse heat radiation type power package to achieve low power consumption and low heat generation and eliminates necessity of external heat-sink up to s a total output power of 30W. This product satisfies both needs for drastic downsizing, low-profile structures and many function, high quality playback of sound system.

●Features

1) This IC has one system of digital audio interface.
(I^2S format, SDATA: 16 / 20 / 24bit, LRCLK: 32kHz / 44.1kHz / 48kHz, BCLK: 64fs(fixed), MCLK: 256fs(fixed))
2) Low supply current at RESET mode.
3) The decrease in sound quality because of the change of the power supply voltage is prevented with the feedback circuitry of the output. In addition, a low noise and low distortion are achieved.
Eliminate large electrolytic-capacitors for high performance of Power Supply Rejection.
4) S/N of the system can be optimized by adjusting the gain setting among 2 steps. (20dB / 26dB)
5) Available for Monaural mode.
6) Within the wide range of the power supply voltage, it is possible to operate in a single power supply. (10～18V)
7) It contributes to miniaturizing, making to the thin type, and the power saving of the system by high efficiency and low heat.
8) Eliminates pop noise generated when the power supply goes on/off, or when the power supply is suddenly shut off. High quality muting performance is realized by using the soft-muting technology.
9) This IC is a highly reliable design to which it has various protection functions.
(High temperature protection, under voltage protection, Output short protection, Output DC voltage protection and Clock stop protection, (MCLK, BCLK, LRCLK))
10) Small package (HTSSOP-B28 package) contributes to reduction of PCB area.

●Applications

Flat Panel TVs (LCD, Plasma), Home Audio, Desktop PC, Amusement equipments, Electronic Music equipments, etc.

●**Absolute maximum ratings** (Ta=25℃)

Parameter	Symbol	Ratings	Unit	Parameter
Supply voltage	V_{CC}	22	V	Pin 14, 15, 16, 27, 28 ※1 ※2
Power dissipation	P_d	3.3	W	※3
		4.7	W	※4
Input voltage	V_{IN}	-0.3 ～ 4.5	V	Pin 1 ～ 6, 13 ※1
Terminal voltage 1	V_{PIN1}	-0.3 ～ 7.0	V	Pin 8, 11, 12 ※1
Terminal voltage 2	V_{PIN2}	-0.3 ～ 4.5	V	Pin 9 ※1
Terminal voltage 3	V_{PIN3}	22	V	Pin 17, 18, 20 ～ 23, 25, 26 ※1
Open-drain terminal voltage	V_{ERR}	-0.3 ～ 22	V	Pin 10 ※1
Operating temperature range	T_{opr}	-25 ～ +85	℃	
Storage temperature range	T_{stg}	-55 ～ +150	℃	
Maximum junction temperature	T_{jmax}	+150	℃	

※1 The voltage that can be applied reference to GND (Pin 7, 19, 24).
※2 Do not, however exceed Pd and Tjmax=150℃.
※3 70mm×70mm×1.6mm, FR4, 2-layer glass epoxy board (Copper on bottom layer : 70mm×70mm)
Derating in done at 26.4mW/℃ for operating above Ta=25℃. There are thermal via on the board.
※4 70mm×70mm×1.6mm, FR4, 4-layer glass epoxy board (Copper on bottom layer : 70mm×70mm)
Derating in done at 37.6mW/℃ for operating above Ta=25℃. There are thermal via on the board.

●**Operating conditions** (Ta=25℃)

Parameter	Symbol	Ratings	Unit	Parameter
Supply voltage	V_{CC}	10 ～ 18	V	Pin 14, 15, 16, 27, 28 ※1 ※2
Minimum load impedance	R_L	3.6	Ω	VCC ≦ 18V ※5
		3.2		VCC ≦ 16V ※5

※5 Do not, however exceed Pd.
※ No radiation-proof design.

●Electrical characteristics

(Unless otherwise specified Ta=25℃, Vcc=12V, f=1kHz, R_L=8Ω, RSTX=3.3V, MUTEX=3.3V, Gain=20dB, fs=48kHz
Output LC filter: L=10μH, C=0.1μF)

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
Total circuit						
Circuit current (Reset mode)	I_{CC1}	-	0.1	0.2	mA	Pin 14, 15, 16, 27, 28, No load RSTX=0V, MUTEX=0V
Circuit current (Mute mode)	I_{CC2}	-	15	25	mA	Pin 14, 15, 16, 27, 28, No load RSTX=3.3V, MUTEX=0V
Circuit current (Sampling mode)	I_{CC3}	-	50	80	mA	Pin 14, 15, 16, 27, 28, No load RSTX=3.3V, MUTEX=3.3V
Open-drain terminal Low level voltage	V_{ERR}	-	-	0.8	V	Pin 10, I_O=0.5mA
Regulator output voltage 1	V_{REG_G}	4.7	5.0	5.3	V	Pin 11
Regulator output voltage 2	V_{REG_3}	3.0	3.3	3.6	V	Pin 9
High level input voltage	V_{IH}	2.0	-	3.3	V	Pin 1 ～ 6, 13
Low level input voltage	V_{IL}	0	-	0.9	V	Pin 1 ～ 6, 13
Input current (Input pull-down terminal)	I_{IH}	50	66	95	μA	Pin 1 ～ 6, 13, V_{IN} = 3.3V
Speaker Output						
Maximum output power 1	P_{O1}	-	10	-	W	THD+n=10% GAIN=20dB ※6
Maximum output power 2	P_{O2}	-	15	-	W	VCC=15V, THD+n=10% GAIN =26dB ※6
Voltage gain	G_{V20}	19	20	21	dB	P_O=1W, Gain=20dB ※6
	G_{V26}	25	26	27	dB	P_O=1W, Gain=26dB ※6
Total harmonic distortion	THD	-	0.07	-	%	P_O=1W, BW=20～20kHz ※6
Crosstalk	CT	66	80	-	dB	P_O=1W, BW=IHF-A ※6
PSRR	PSRR	-	70	-	dB	Vropple=1Vrms, f= 1kHz ※6
Output noise voltage (Sampling mode)	V_{NO}	-	100	200	μVrms	-∞dBFS, BW=IHF-A ※6
PWM sampling frequency	f_{PWM1}	-	256	-	kHz	fs=32kHz ※6
	f_{PWM2}	-	352.8	-	kHz	fs=44.1kHz ※6
	f_{PWM3}	-	384	-	kHz	fs=48kHz ※6

※6 These items show the typical performance of device and depend on board layout, parts, and power supply.
The standard value is in mounting device and parts on surface of ROHM's board directly.

●**Electrical characteristic curves** (VCC=12V, Ta=25°C, RL=8Ω, Gain=26dB, fin=1kHz, fs=48kHz)
Measured by ROHM designed 4 layer board.

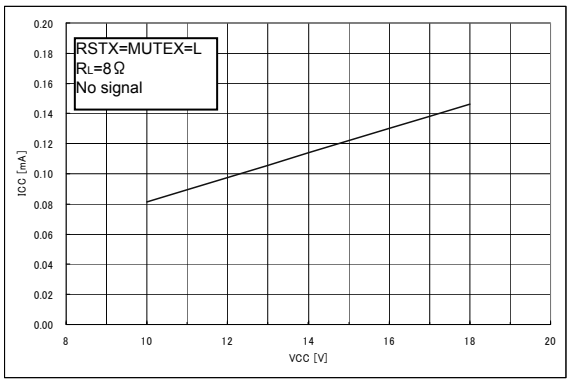


Fig.1
Current consumption - Power supply voltage

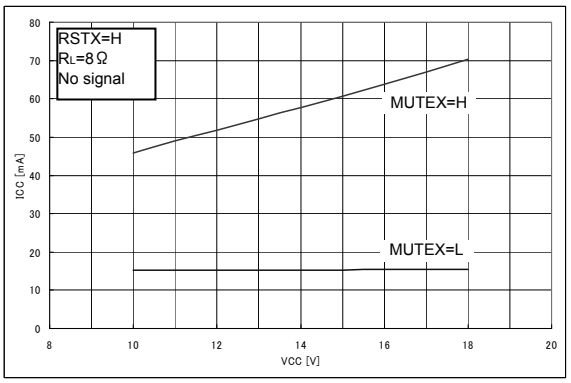


Fig.2
Current consumption - Power supply voltage

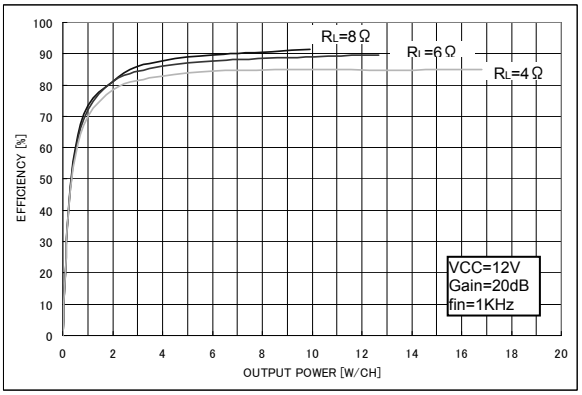


Fig.3
Efficiency - Output power

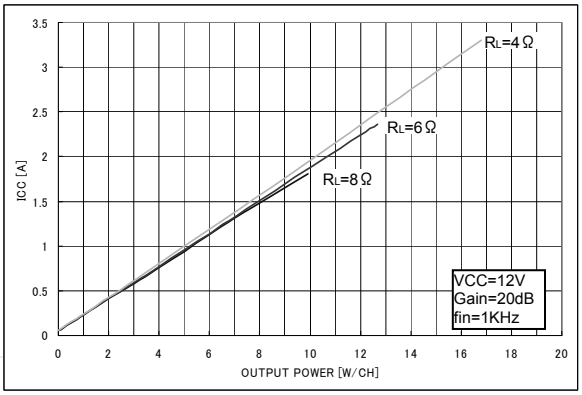


Fig.4
Current consumption - Output power

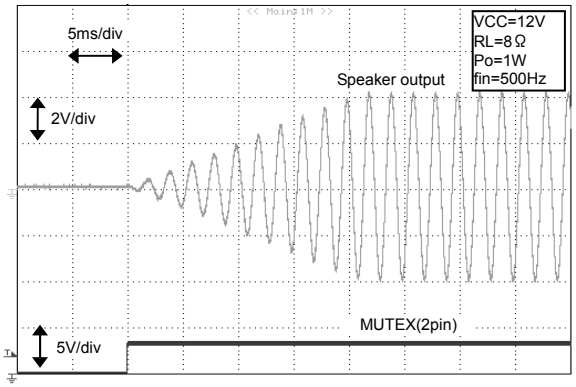


Fig.5
Wave form when releasing soft-mute

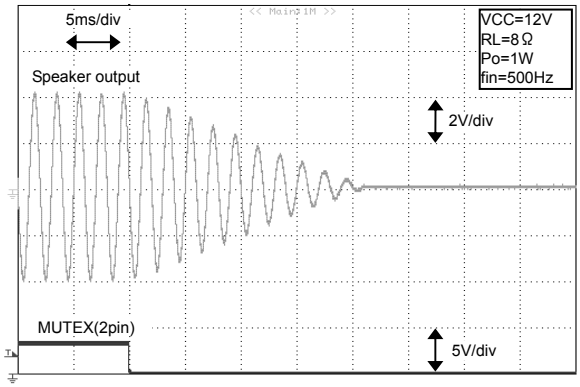


Fig.6
Wave form when activating soft-mute

●**Electrical characteristics** (VCC=12V, Gain=26dB, fin=1kHz, fs=48kHz)
Measured by ROHM designed 4 layer board.

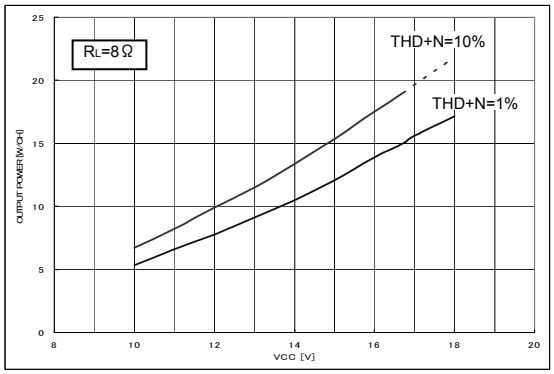


Fig.7
Output power – Power supply voltage

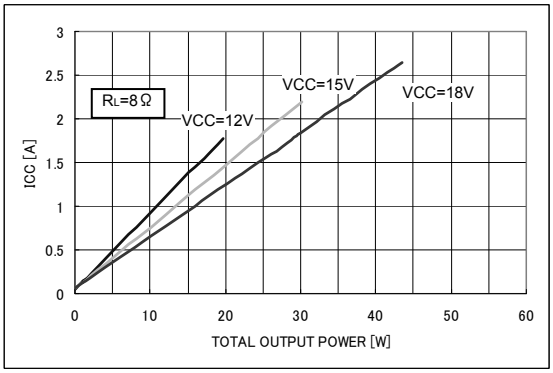


Fig.8
Current consumption - Output power

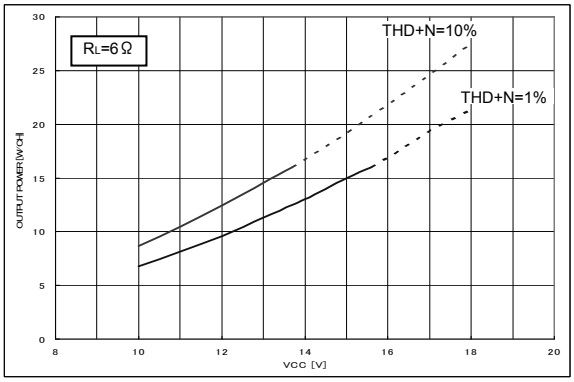


Fig.9
Output power – Power supply voltage

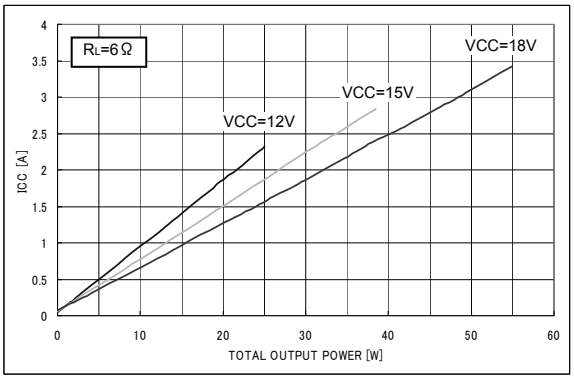


Fig.10
Current consumption - Output power

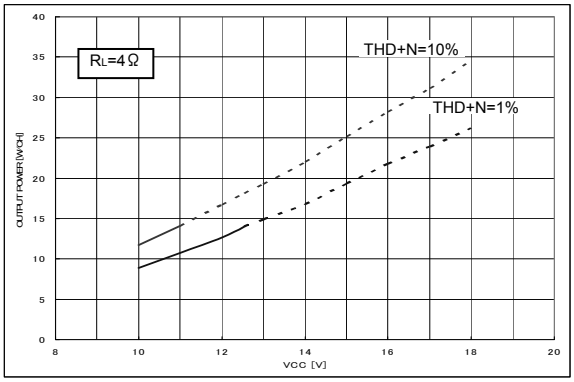


Fig.11
Output power – Power supply voltage

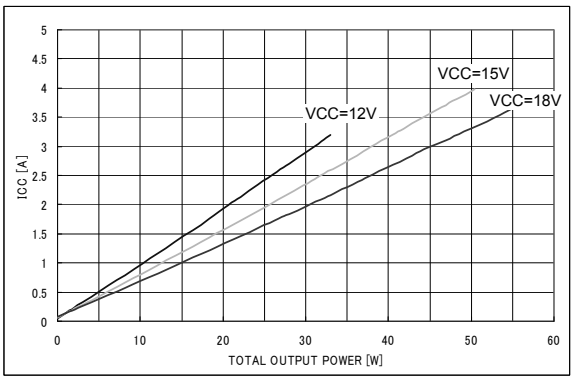


Fig.12
Current consumption - Output power

※Dotted line means internal dissipation is over package power.

●**Electrical characteristic curves**(VCC=12V, Ta=25℃, R_L=8Ω, Gain=20dB, fin=1kHz, fs=48kHz)
Measured by ROHM designed 4layer board.

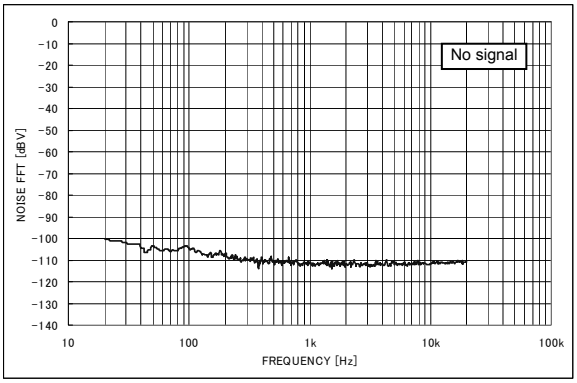


Fig.13
FFT of output noise voltage

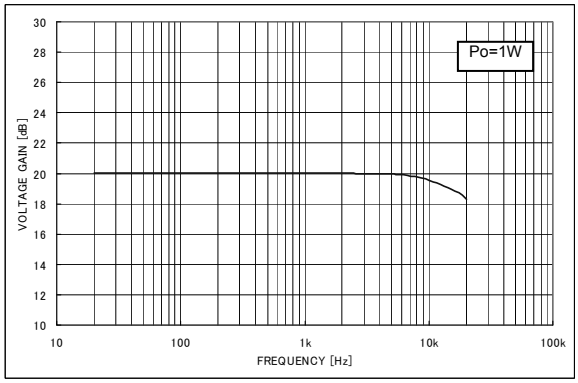


Fig.14
Voltage gain - Frequency

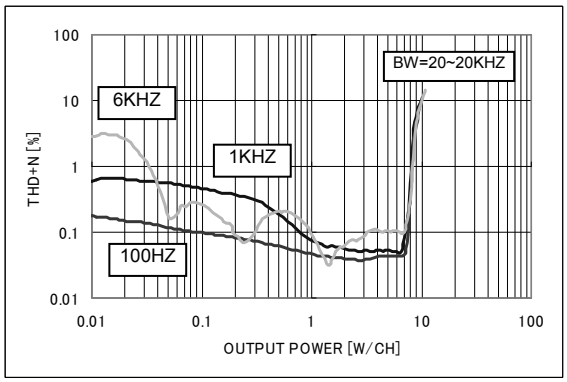


Fig.15
THD+N – Output power

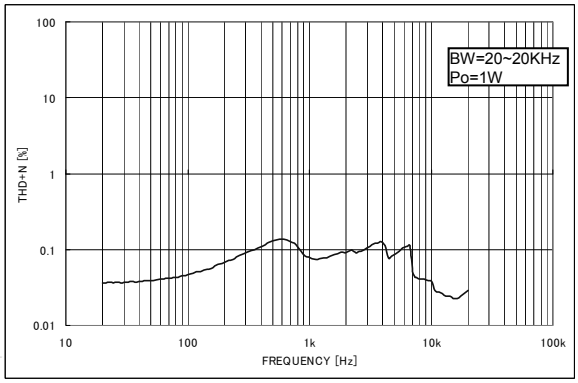


Fig.16
THD+N – Frequency

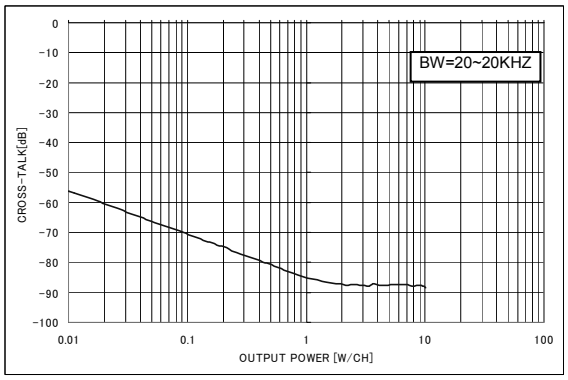


Fig.17
Crosstalk – Output power

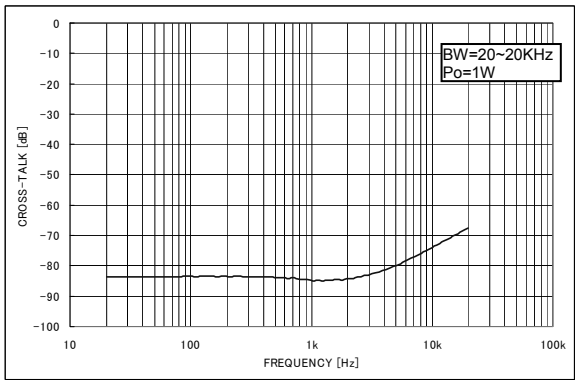


Fig.18
Crosstalk – Frequency

●**Electrical characteristic curves**(VCC=12V, Ta=25℃, R_L=6Ω, Gain=20dB, fin=1kHz, fs=48kHz)
Measured by ROHM designed 4layer board

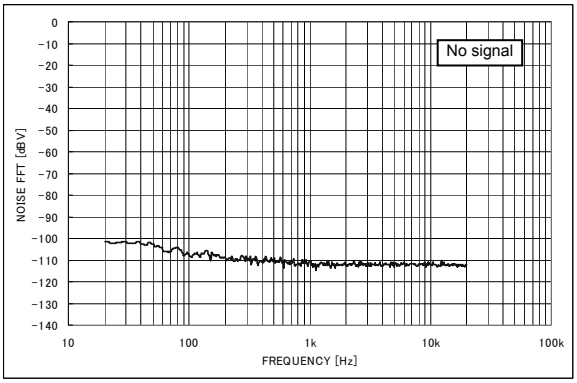


Fig.19
FFT of output noise voltage

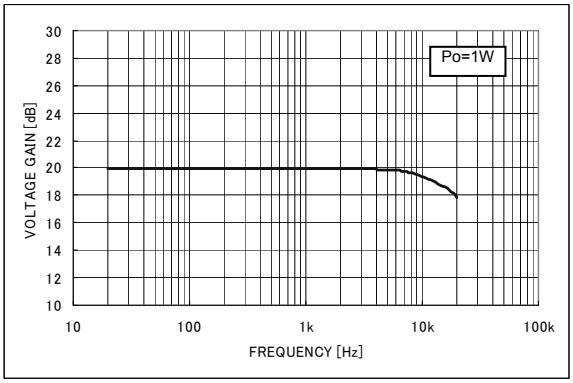


Fig.20
Voltage gain - Frequency

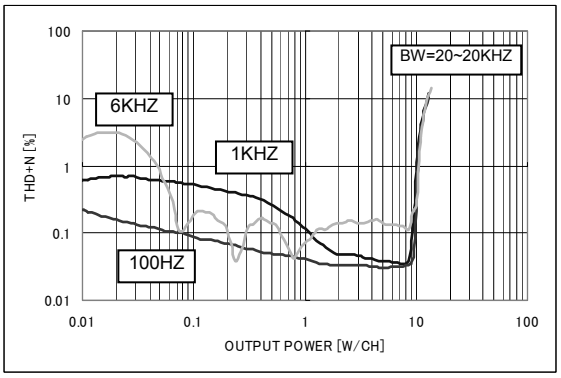


Fig.21
THD+N – Output power

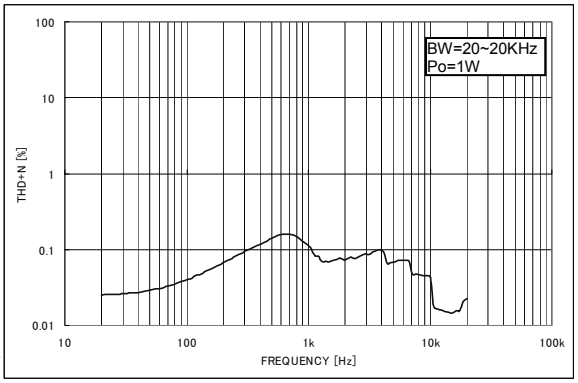


Fig.22
THD+N – Frequency

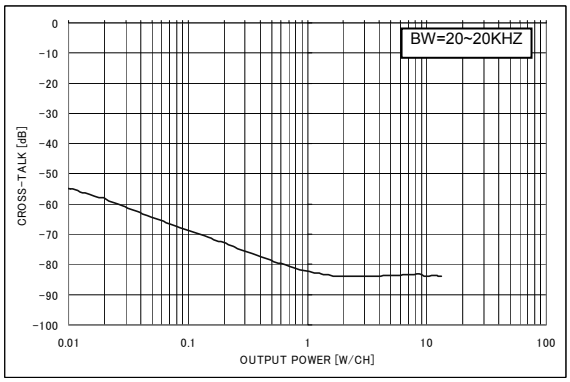


Fig.23
Crosstalk – Output power

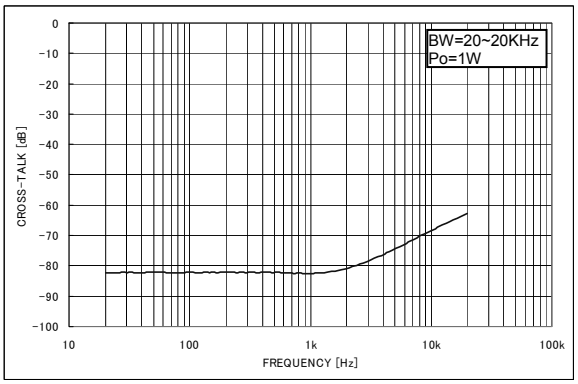


Fig.24
Crosstalk – Frequency

●**Electrical characteristic curves**(VCC=12V, Ta=25℃, R_L=4Ω, Gain=20dB, fin=1kHz, fs=48kHz)
Measured by ROHM designed 4layer board

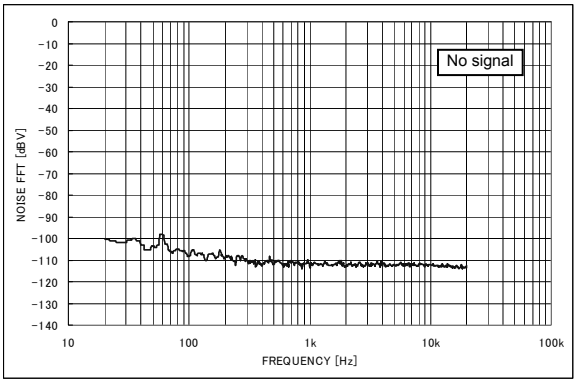


Fig.25
FFT of output noise voltage

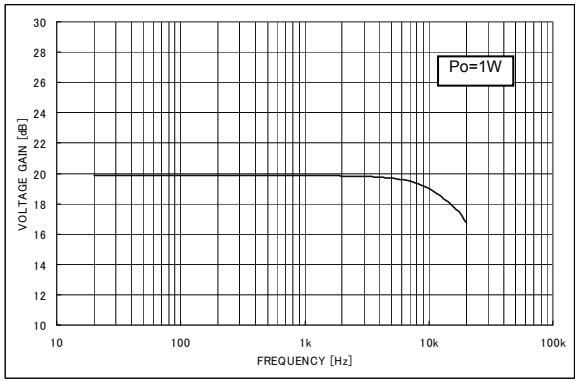


Fig.26
Voltage gain - Frequency

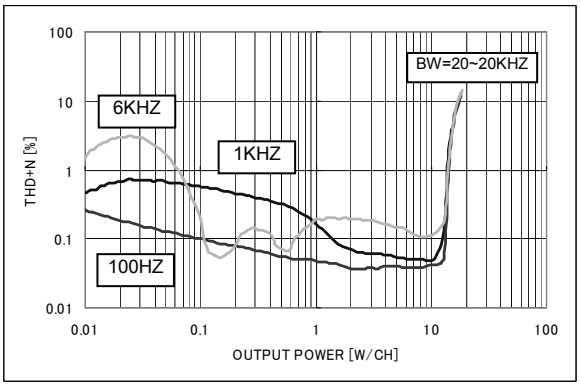


Fig.27
THD+N – Output power

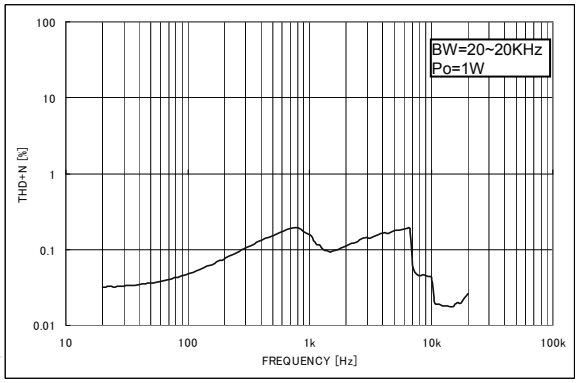


Fig.28
THD+N – Frequency

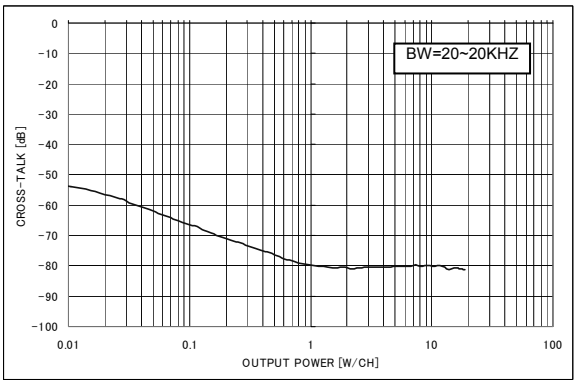


Fig.29
Crosstalk – Output power

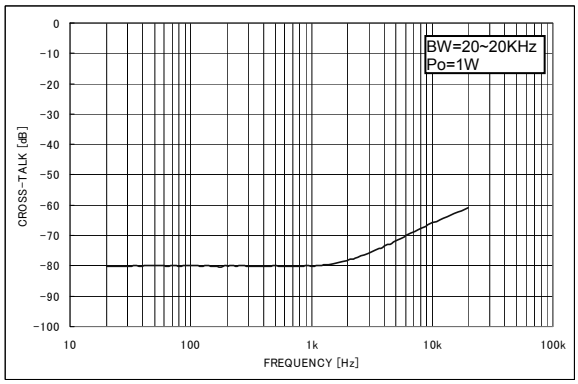
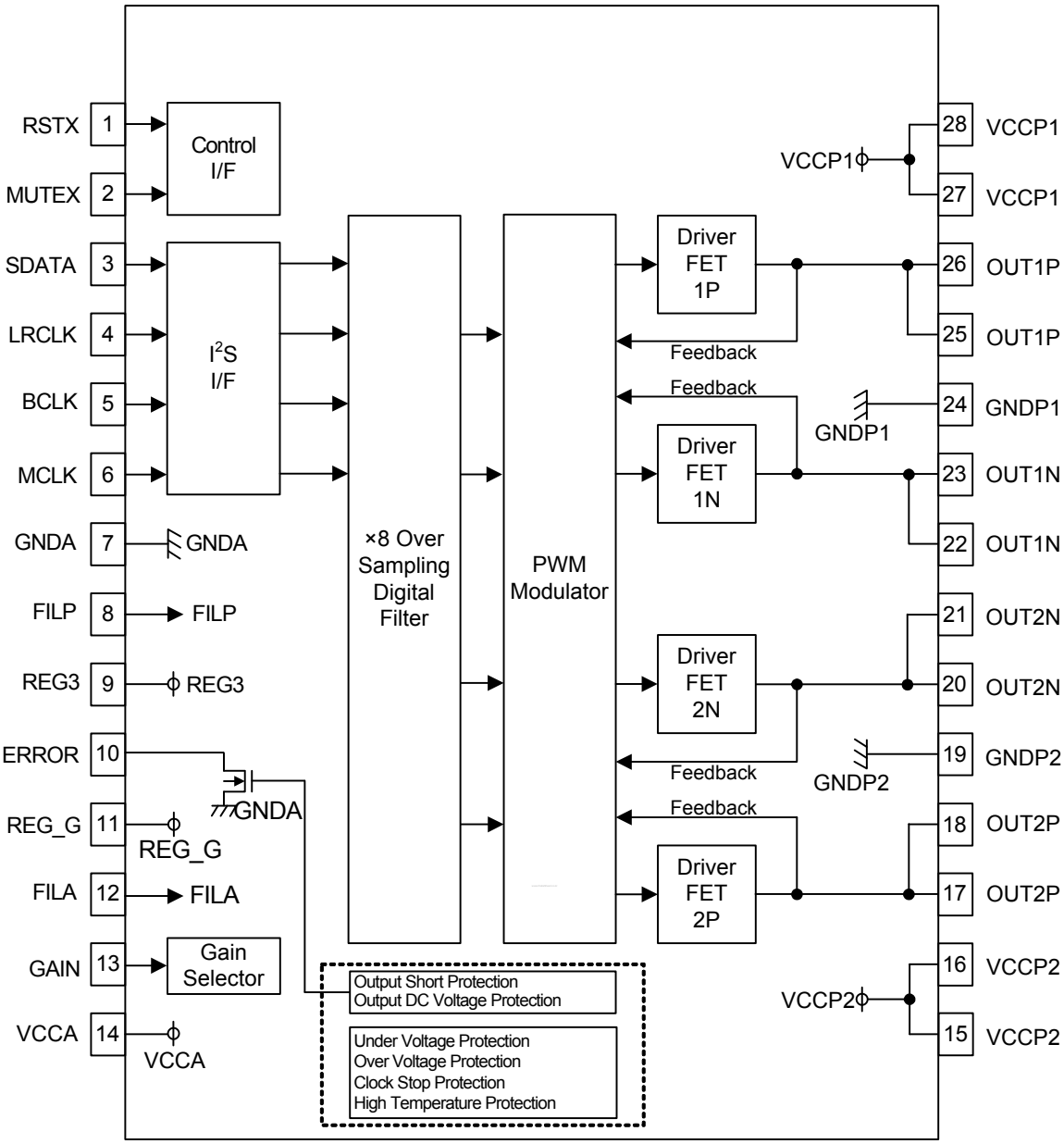
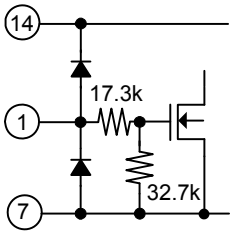
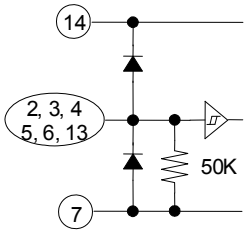
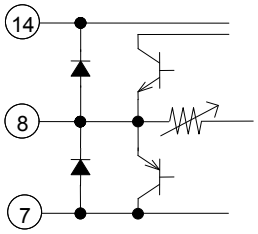
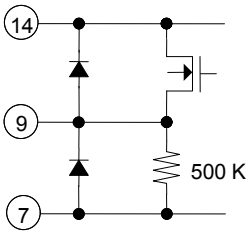
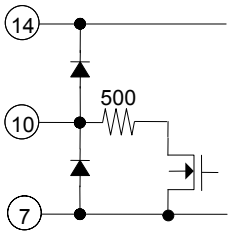
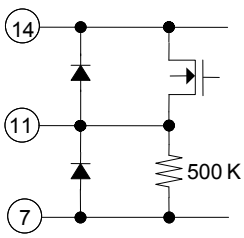


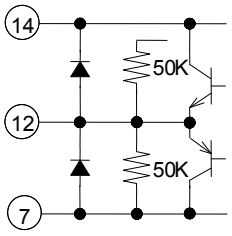
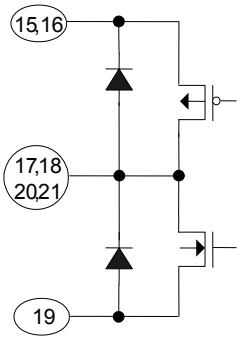
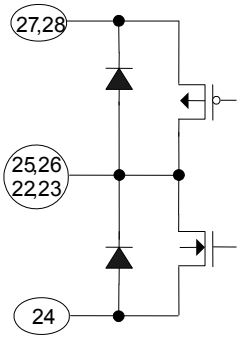
Fig.30
Crosstalk – Frequency

●Pin configuration and Block diagram



●Pin function explanation (Provided pin voltages are typ. Values)

Pin No.	Pin name	Pin voltage	Pin explanation	Internal equivalence circuit
1	RSTX	0V	Reset pin for Digital circuit H: Reset OFF L: Reset ON	
2	MUTEX	0V	Speaker output mute control pin H: Mute OFF L: Mute ON	
3 4 5 6	SDATA LRCLK BCLK MCLK		Digital audio signal input pin	
12	GAIN		Gain setting terminal L: 20dB H: 26dB	
7	GNDA	0V	GND pin for Analog signal	–
8	FILP	1.75V~2.55V	Bias pin for PWM signal Please connect the capacitor.	
9	REG3	3.3V	Internal power supply pin for Digital circuit Please connect the capacitor.	
10	ERROR	3.3V	Error flag pin Please connect pull-up resister. H: While Normal L: While Error	
11	REG_G	5.2V	Internal power supply pin for Gate driver Please connect the capacitor.	

Pin No.	Pin name	Pin voltage	Pin explanation	Internal equivalence circuit
12	FILA	2.5V	Bias pin for PWM signal. Please connect the capacitor.	
14	VCCA	Vcc	Power supply pin for Analog signal	—
15,16	VCCP2	Vcc	Power supply pin for ch2 PWM signal Please connect the capacitor.	
17,18	OUT2P	Vcc～0V	Output pin of ch2 positive PWM Please connect to Output LPF.	
19	GNDP2	0V	GND pin for ch2 PWM signal	
20,21	OUT2N	Vcc～0V	Output pin of ch2 negative PWM Please connect to Output LPF.	
22,23	OUT1N	Vcc～0V	Output pin of ch1 negative PWM Please connect to Output LPF.	
24	GNDP1	0V	GND pin for ch1 PWM signal	
25,26	OUT1P	Vcc～0V	Output pin of ch1 posotive PWM Please connect to Output LPF.	
27,28	VCCP1	—	Power supply pin for ch1 PWM signal Please connect the capacitor.	

●Terminal setting

(1) Gain pin function

GAIN (13pin)	Speaker output gain
L	20dB
H	26dB

(2) RSTX pin, MUTEX pin function

RSTX (1pin)	MUTEX (2pin)	Normalcy		Error detecting	
		PWM output (OUT1P, 1N, 2P, 2N)	ERROR Output	PWM output (OUT1P, 1N, 2P, 2N)	ERROR Output
L	L or H	HiZ_L (Reset mode)	H	HiZ_L (Reset mode)	H
H	L	HiZ_L (MUTE ON)	H	HiZ_L (MUTE ON)	L
H	H	Normal operation (MUTE OFF)	H	HiZ_L (MUTE ON)	L

※RSTX(1pin)terminal, MUTEX(2pin)terminal are internally pulled down by 50 kΩ(Typ.)

※With RSTX=L data of every register within IC (I^2S / I/F part, ×8 over sampling digital filter part, latch circuit when detecting ERROR) becomes unnecessary.

●Input digital audio signal sampling frequency (fs) explanation

PWM sampling frequency, Soft-start, Soft-mute time, and the detection time of the DC voltage protection in the speaker depends on sampling frequency (fs) of the digital audio input.

Sampling frequency of the digital audio input (fs)	PWM sampling frequency (fpwm)	Soft-start / Soft-mute time	DC voltage protection in the speaker detection time
32kHz	256kHz	32msec.	64msec.
44.1kHz	352.8kHz	23msec.	46msec.
48kHz	384kHz	21.5msec.	43msec.

●For voltage gain (Gain setting)

BD5451EFV prescribe voltage gain at speaker output (BTL output) under the definition 0dBV (1Vrms) as full scale input of the digital audio input signal. For example, digital audio input signal = -20dBFS (0.1Vrms), Gain setting = 20dB, Load resistance R_L = 8Ω will give speaker output (BTL output) amplitude as Vo=1Vrms. (Output power Po = Vo^2/R = 0.125W)

●Format of digital audio input

- MCLK: It is System Clock input signal.
  It will input LRCLK, BCLK, SDATA that synchronizes with this clock that are 256 times of sampling frequency (256fs).

- LRCLK: It is L/R clock input signal.
  It corresponds to 32kHz / 44.1kHz / 48kHz with those clock (fs) that are same to the sampling frequency (fs) .
  The data of a left channel and a right channel for one sample is input to this section.

- BCLK: It is Bit Clock input signal.
  It is used for the latch of data in every one bit by sampling frequency's 64 times sampling frequency (64fs).

- SDATA: It is Data input signal.
  It is amplitude data. The data length is different according to the resolution of the input digital audio data.
  It corresponds to 16/ 20/ 24 bit.

●I^2S data format

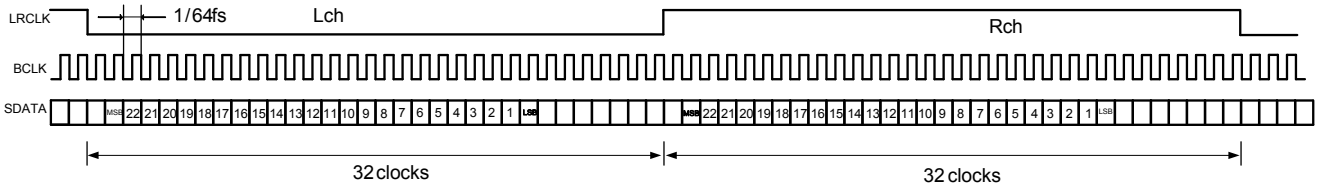


Fig.31 I^2S Data Format 64fs, 24 bit Data

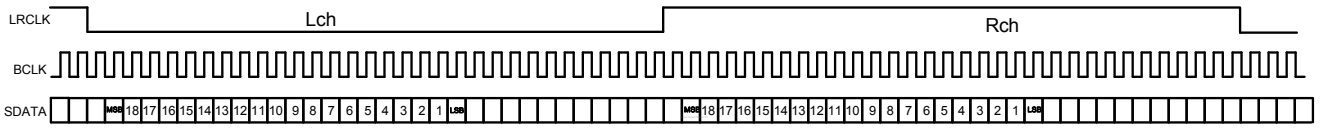


Fig.32 I^2S Data Format 64fs, 20 bit Data

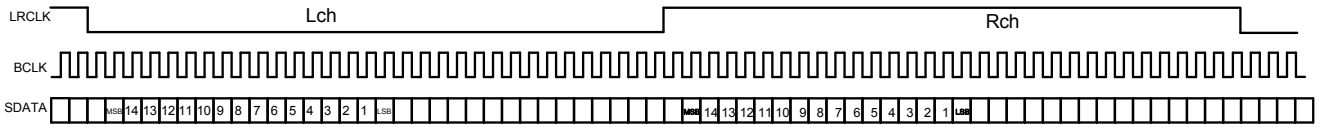


Fig.33 I^2S Data Format 64fs, 16 bit Data

The Low section of LRCLK becomes Lch, the High section of LRCLK becomes Rch.
After changing LRCLK, second bit becomes MSB.

●Audio Interface format and timing

Recommended timing and operating conditions (MCLK, BCLK, LRCLK, SDATA)

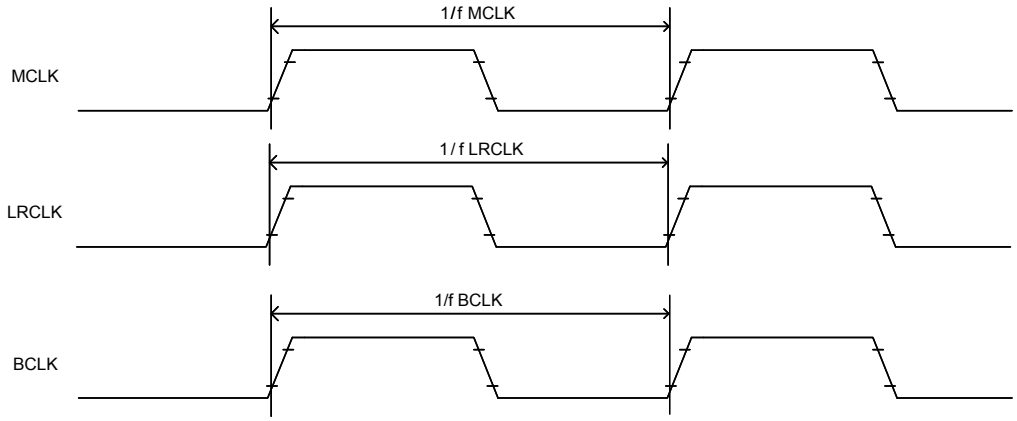


Fig.34 Clock timing

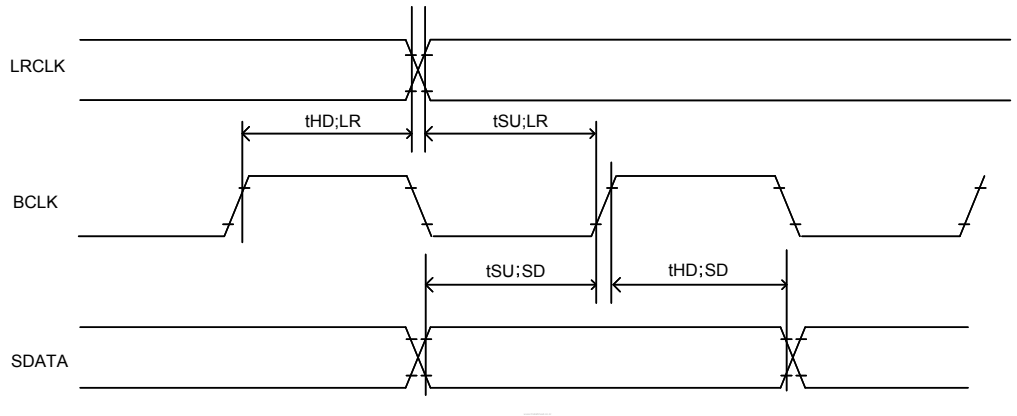


Fig.35 Audio Interface timing (1)

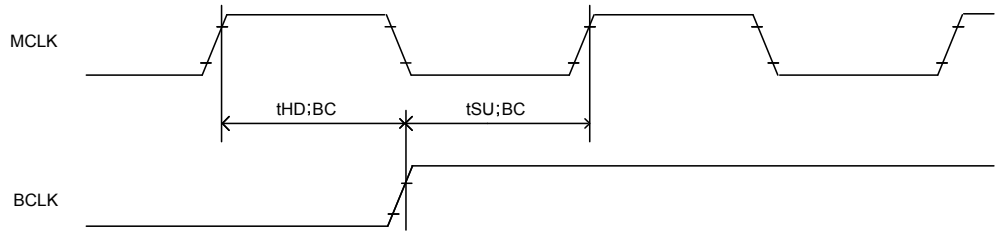
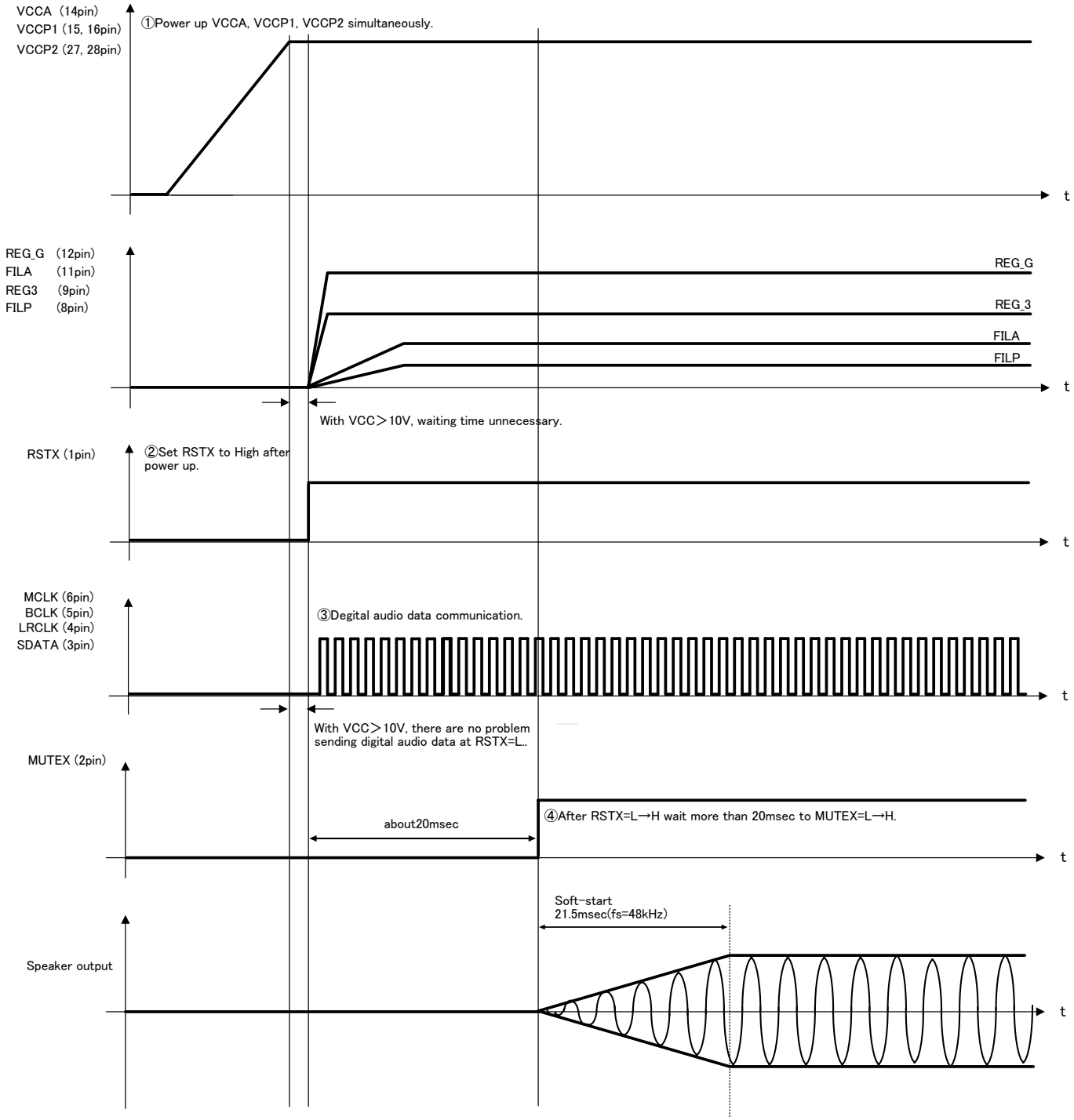


Fig.36 Audio Interface timing (2)

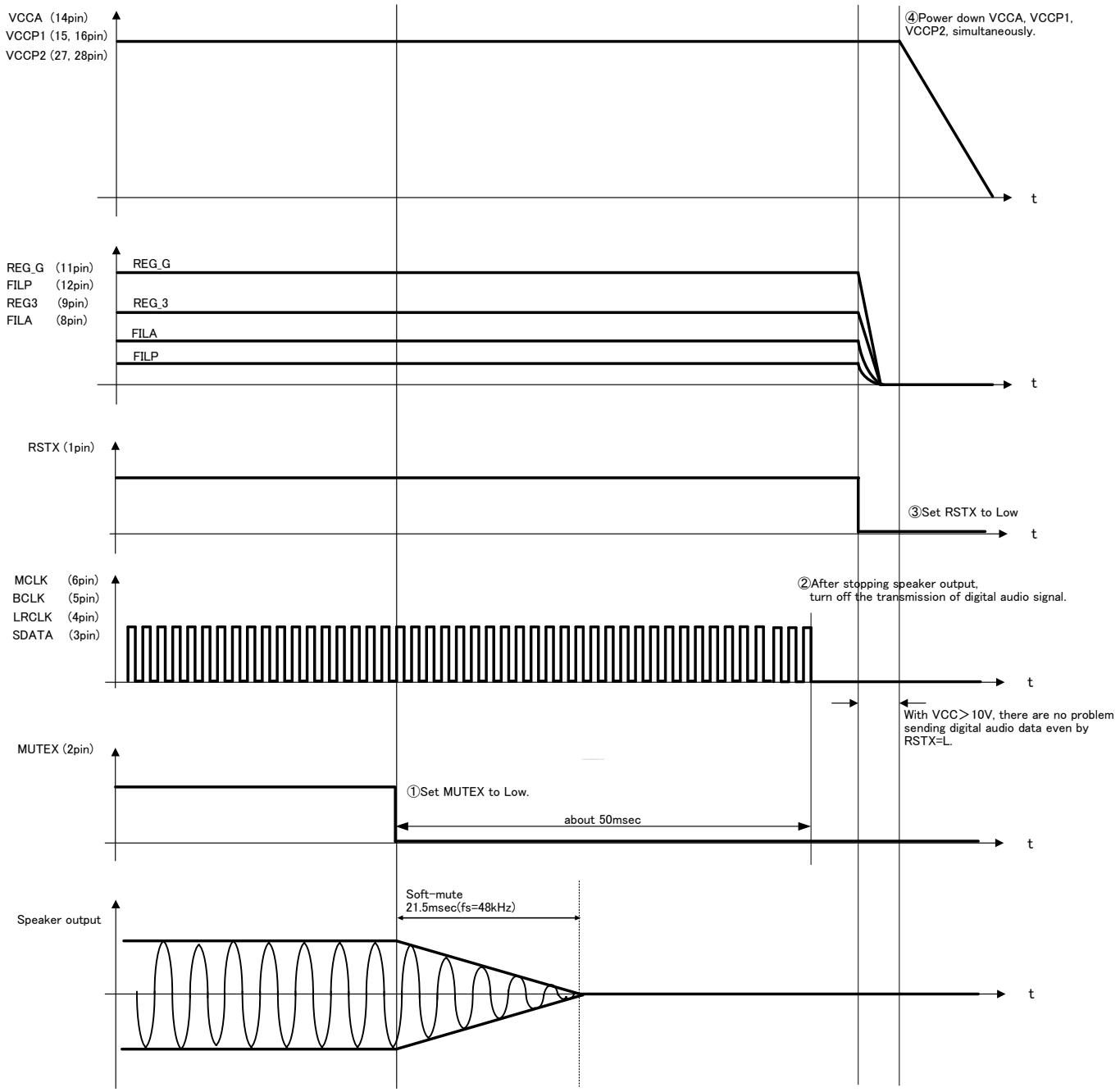
Parameter		Symbol	Limit		Unit
			Min.	Max.	
1	MCLK frequency	fMCLK	8.192	12.288	MHz
2	LRCLK frequency	fLRCLK	32	48	kHz
3	BCLK frequency	fBCLK	2.048	3.072	MHz
4	Setup time, LRCLK※1	tSU;LR	20	−	ns
5	Hold time, LRCLK※1	tHD;LR	20	−	ns
6	Setup time, SDATA	tSU;SD	20	−	ns
7	Hold time, SDATA	tHD;SD	20	−	ns
8	Setup time, BCLK※2	tSU;BC	3	−	ns
9	Hold time, BCLK※2	tHD;BC	7	−	ns

※1 This regulation is to keep rising edge of LRCK and rising edge of BCLK from overlapping.
※2 This regulation is to keep rising edge of MCLK and rising edge of BCLK from overlapping.

●Power supply start-up sequence



●Power supply shut-down sequence



●About the protection function

Protection function	Detecting & Releasing condition		PWM Output	ERROR Output
Output short protection	Detecting condition	Detecting current = 10A (TYP.)	HiZ_Low (Latch)	L (Latch)
DC voltage protection in the speaker	Detecting condition	PWM output Duty=0% or 100% 43msec(fs=48kHz) above fixed	HiZ_Low (Latch)	L (Latch)
High temperature protection	Detecting condition	Chip temperature to be above 150℃ (TYP.)	HiZ_Low	H
	Releasing condition	Chip temperature to be below 120℃ (TYP.)	Normal operation	
Under voltage protection	Detecting condition	Power supply voltage to be below 8V (TYP.)	HiZ_Low	H
	Releasing condition	Power supply voltage to be above 9V (TYP.)	Normal operation	
Over voltage Protection	Detecting condition	Power supply voltage to be above 21.5V(TYP.)	HiZ_Low	H
	Releasing condition	Power supply voltage to be below 20.5V(TYP.)	Normal operation	
Clock stop protection	Detecting condition	No change to MCLK more than 1μsec (TYP.) or no change to BCLK more than 1μsec (TYP.) or no change to LRCLK more than 21μsec (at fs=48kHz.).	HiZ_Low	H
	Releasing condition	Normal input to MCLK, BCLK and LRCLK.	Normal operation	

＊ The ERROR pin is Nch open-drain output.

＊ Once an IC is latched, the circuit is not released automatically even after an abnormal status is removed.
The following procedures ① or ② is available for recovery.
①After turning MUTEX terminal to Low(holding time to Low = 10msec(Min.)) turn back to High again.
②Restore power supply after dropping to power supply voltage Vcc＜3V(10msec (Min.) holding) which internal power on reset circuit activates.

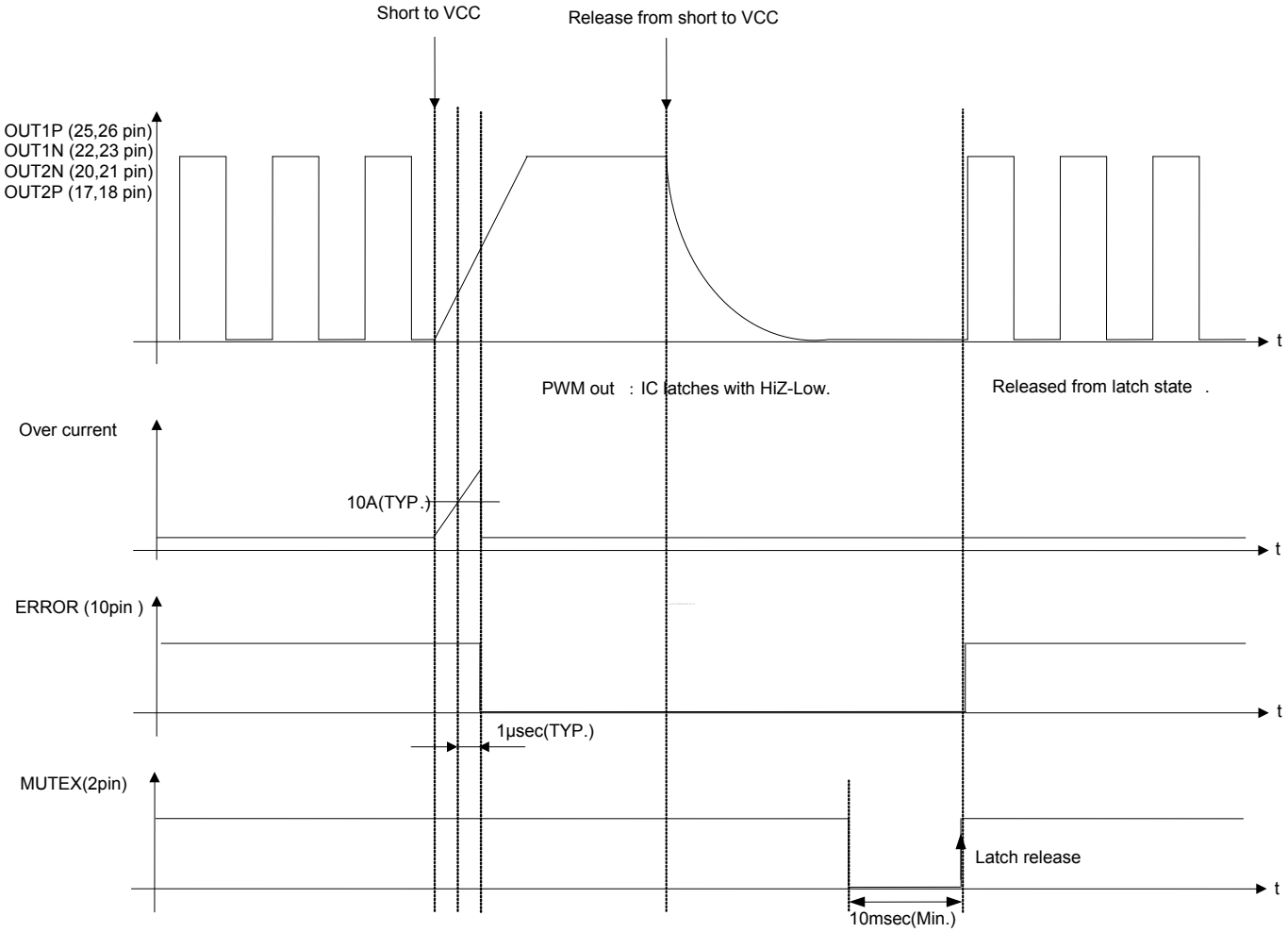
1) Output short protection(Short to the power supply)

This IC has the PWM output short protection circuit that stops the PWM output when the PWM output is short-circuited to the power supply due to abnormality.

Detecting condition - It will detect when MUTEX pin is set High and the current that flows in the PWM output pin becomes 10A(TYP.) or more. The PWM output instantaneously enters the state of HiZ-Low if detected, and IC does the latch.

Releasing method - ①After turning MUTEX terminal to Low(holding time to Low = 10msec(Min.)) turn back to High again.

②Restore power supply after dropping to power supply voltage Vcc＜3V(10msec (Min.) holding) which internal power on reset circuit activates.



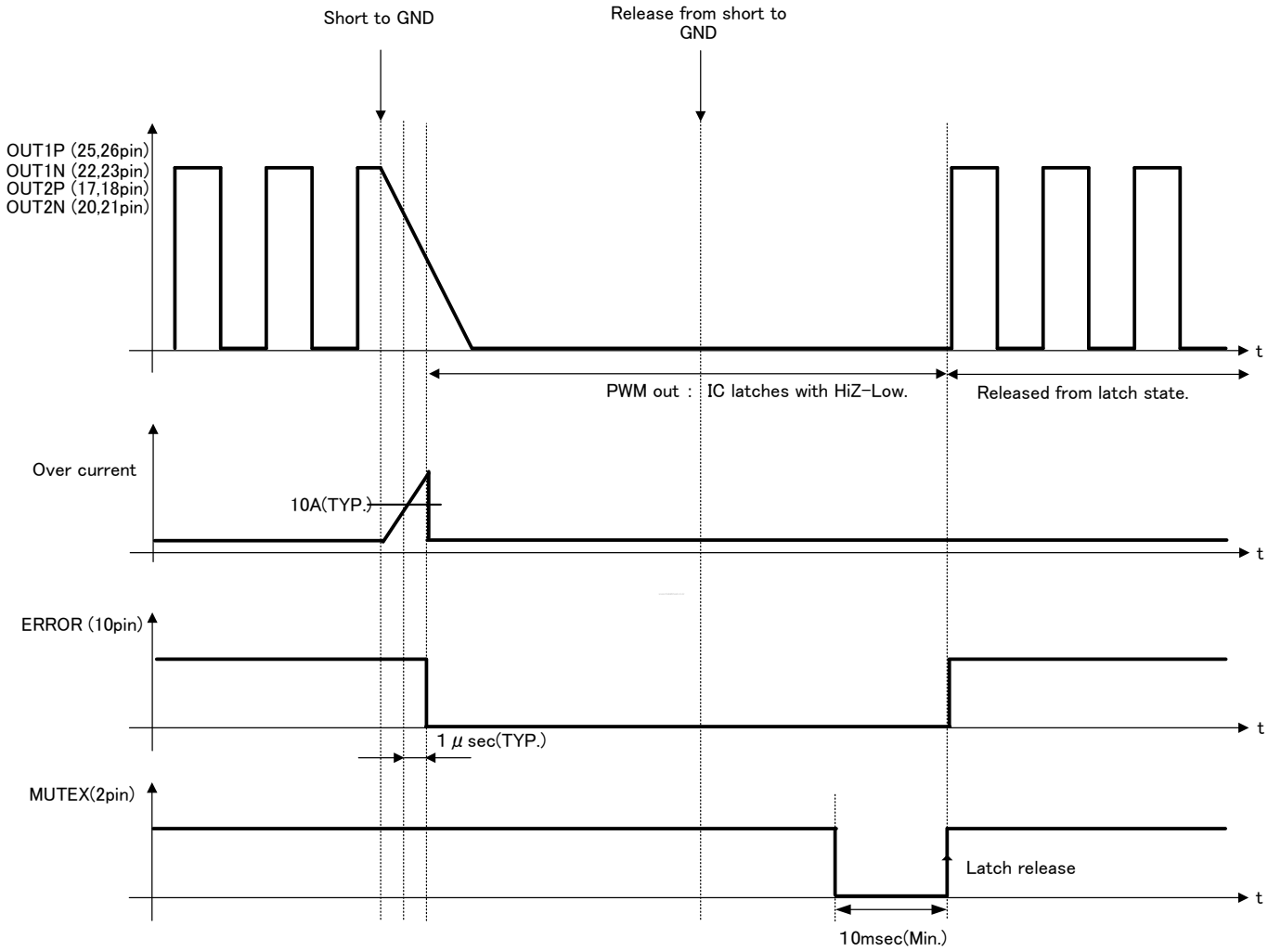
2) Output short protection(Short to GND)

This IC has the PWM output short protection circuit that stops the PWM output when the PWM output is short-circuited to GND due to abnormality.

Detecting condition - It will detect when MUTEX pin is set High and the current that flows in the PWM output terminal becomes 10A(TYP.) or more. The PWM output instantaneously enters the state of HiZ-Low if detected, and IC does the latch.

Releasing method – ①After turning MUTEX terminal to Low(holding time to Low = 10msec(Min.)) turn back to High again.

②Restore power supply after dropping to power supply voltage Vcc＜3V(10msec (Min.) holding) which internal power on reset circuit activates.



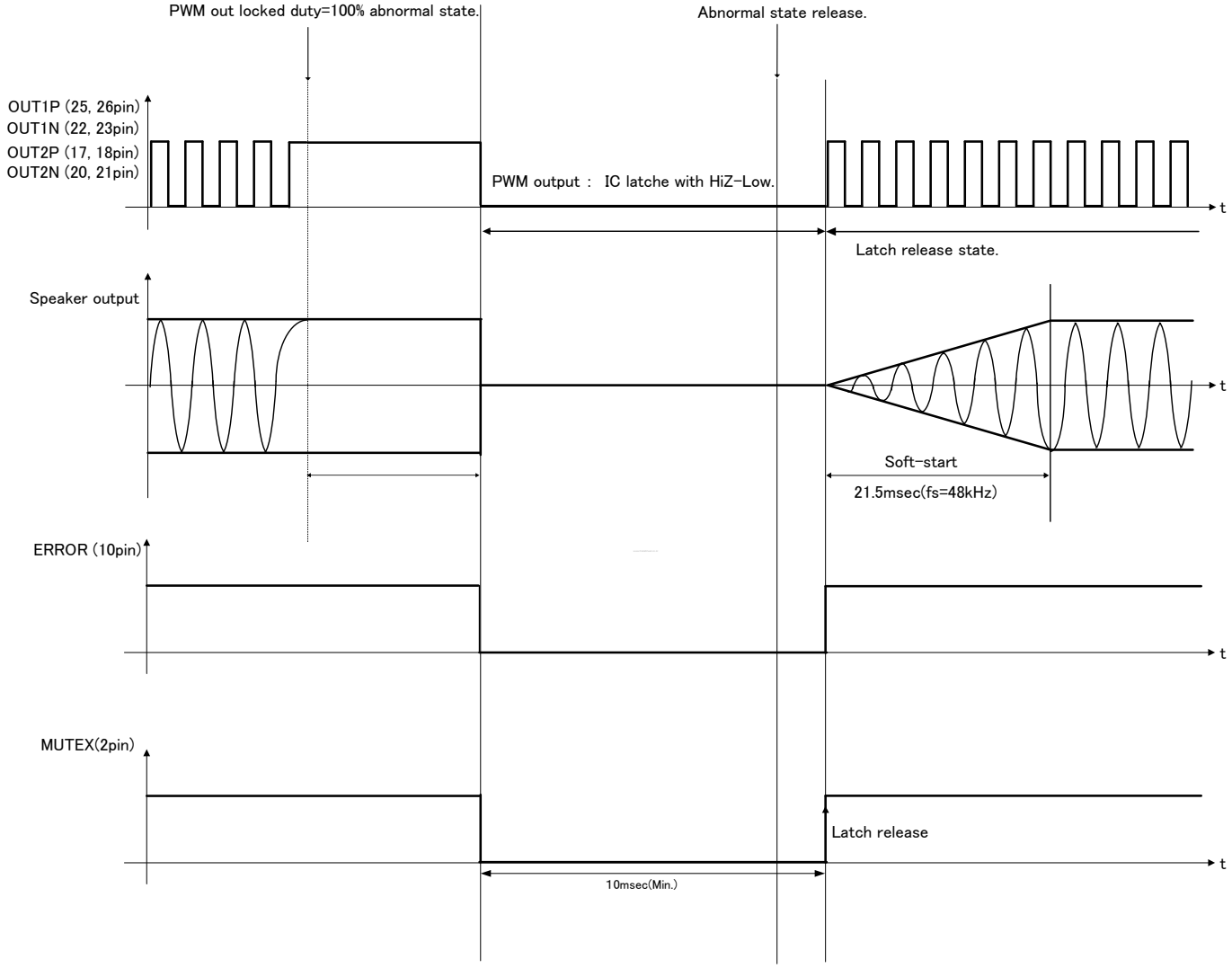
3) DC voltage protection in the speaker

When the DC voltage in the speaker is impressed due to abnormality, this IC has the protection circuit where the speaker is defended from destruction.

Detecting condition - It will detect when MUTEX pin is set High or Low and PWM output Duty=0% or 100% , 43msec(fs=48kHz) or above. Once detected, The PWM output instantaneously enters the state of HiZ-Low, and IC does the latch.

Releasing method – ①After turning MUTEX terminal to Low(holding time to Low = 10msec(Min.)) turn back to High again.

②Restore power supply after dropping to power supply voltage Vcc＜3V(10msec (Min.) holding) which internal power on reset circuit activates.

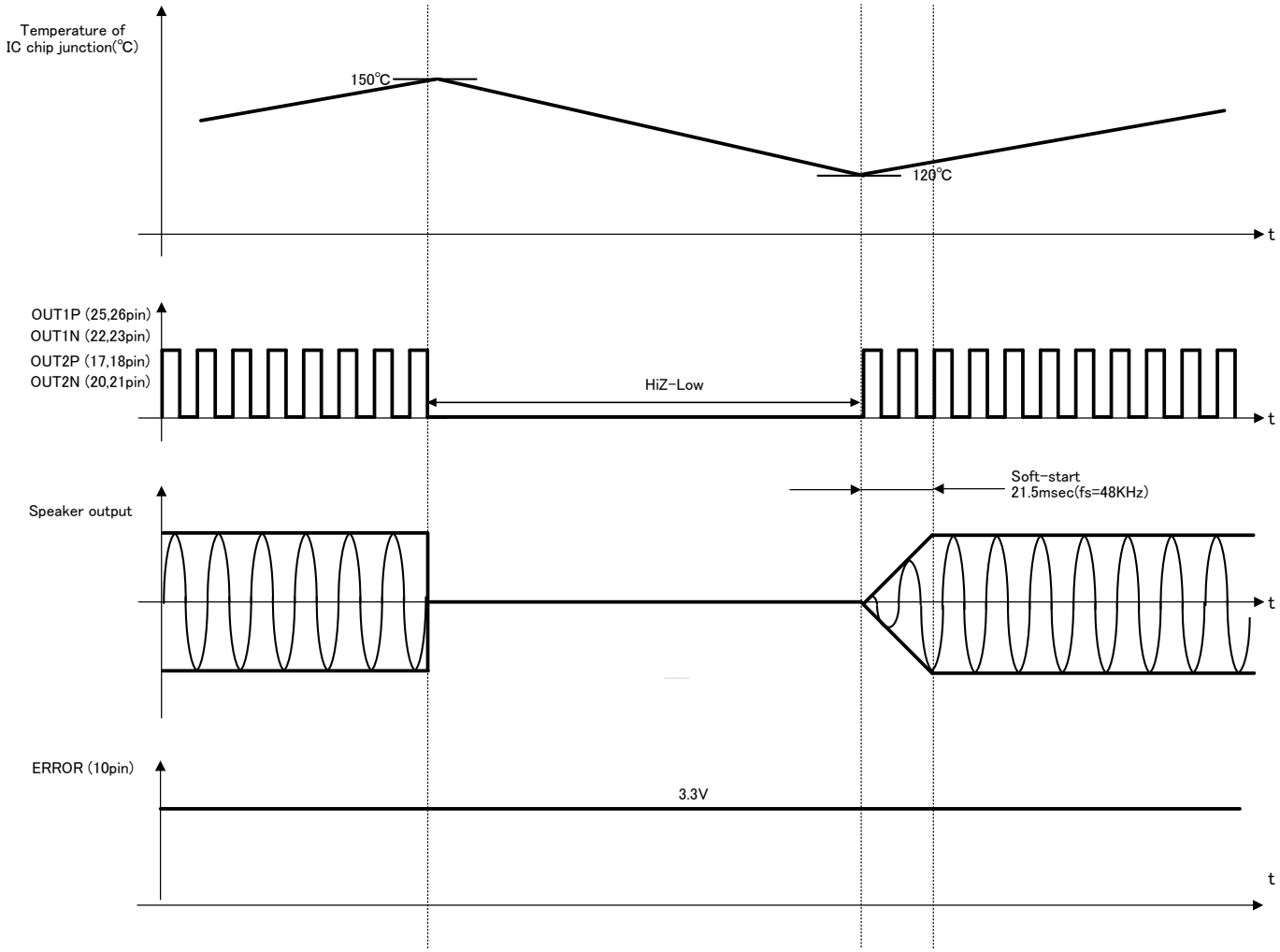


4) High temperature protection

This IC has the high temperature protection circuit that prevents thermal reckless driving under an abnormal state for the temperature of the chip to exceed Tjmax=150℃.

Detecting condition - It will detect when MUTEX pin is set High and the temperature of the chip becomes 150℃(TYP.) or more. Speaker output turn MUTE immediately, when High temperature protection is detected.

Releasing condition - It will release when MUTEX pin is set High and the temperature of the chip becomes 120℃ (TYP.) or less. The speaker output is outputted through a soft-start when released.

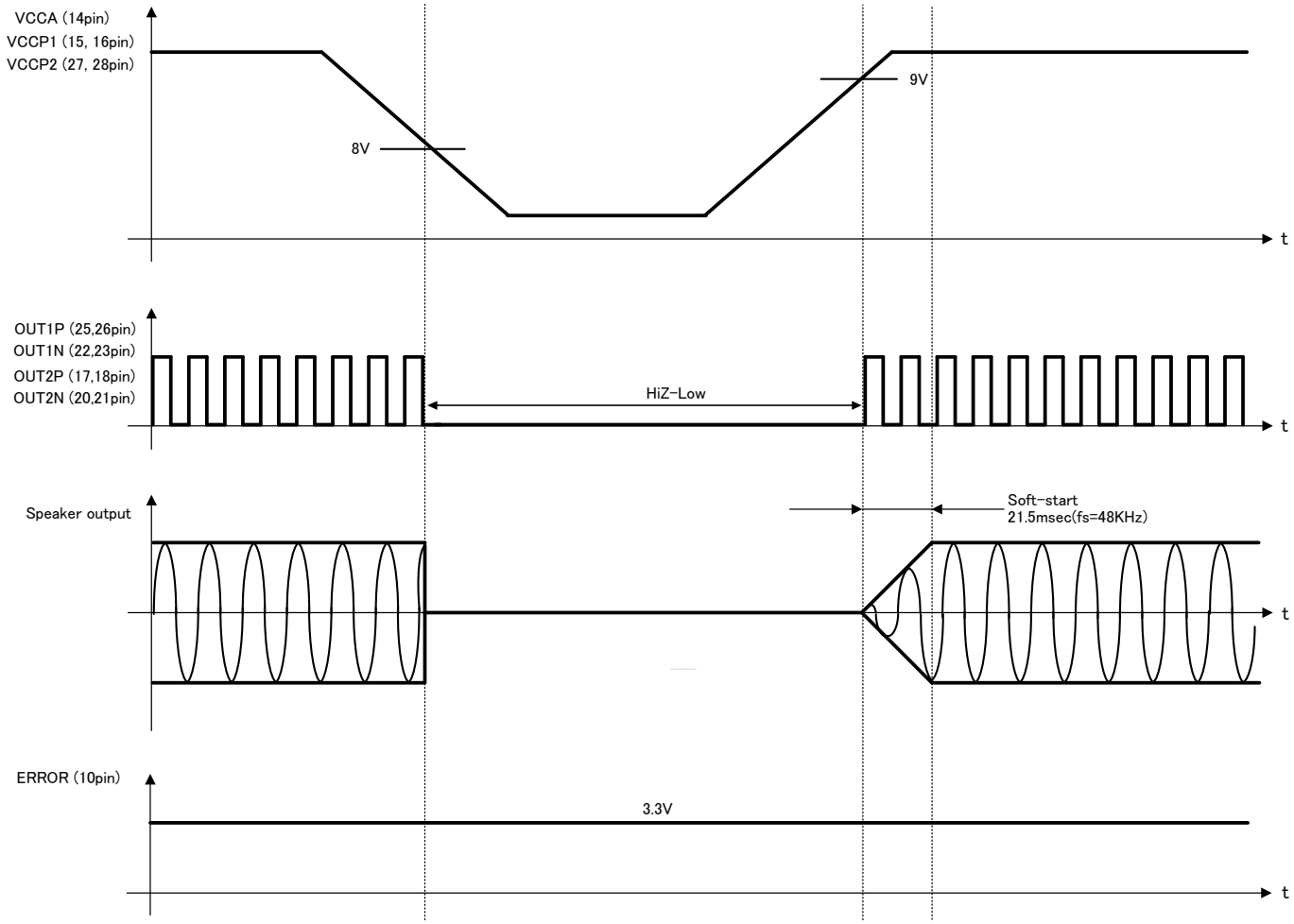


5) Under voltage protection

This IC has the under voltage protection circuit that make speaker output mute once detecting extreme drop of the power supply voltage.

Detecting condition – It will detect when MUTEX pin is set High and the power supply voltage becomes lower than 8V.Speaker output turn MUTE immediately, when Under voltage protection is detected.

Releasing condition – It will release when MUTEX pin is set High and the power supply voltage becomes more than 9V. The speaker output is outputted through a soft-start when released.

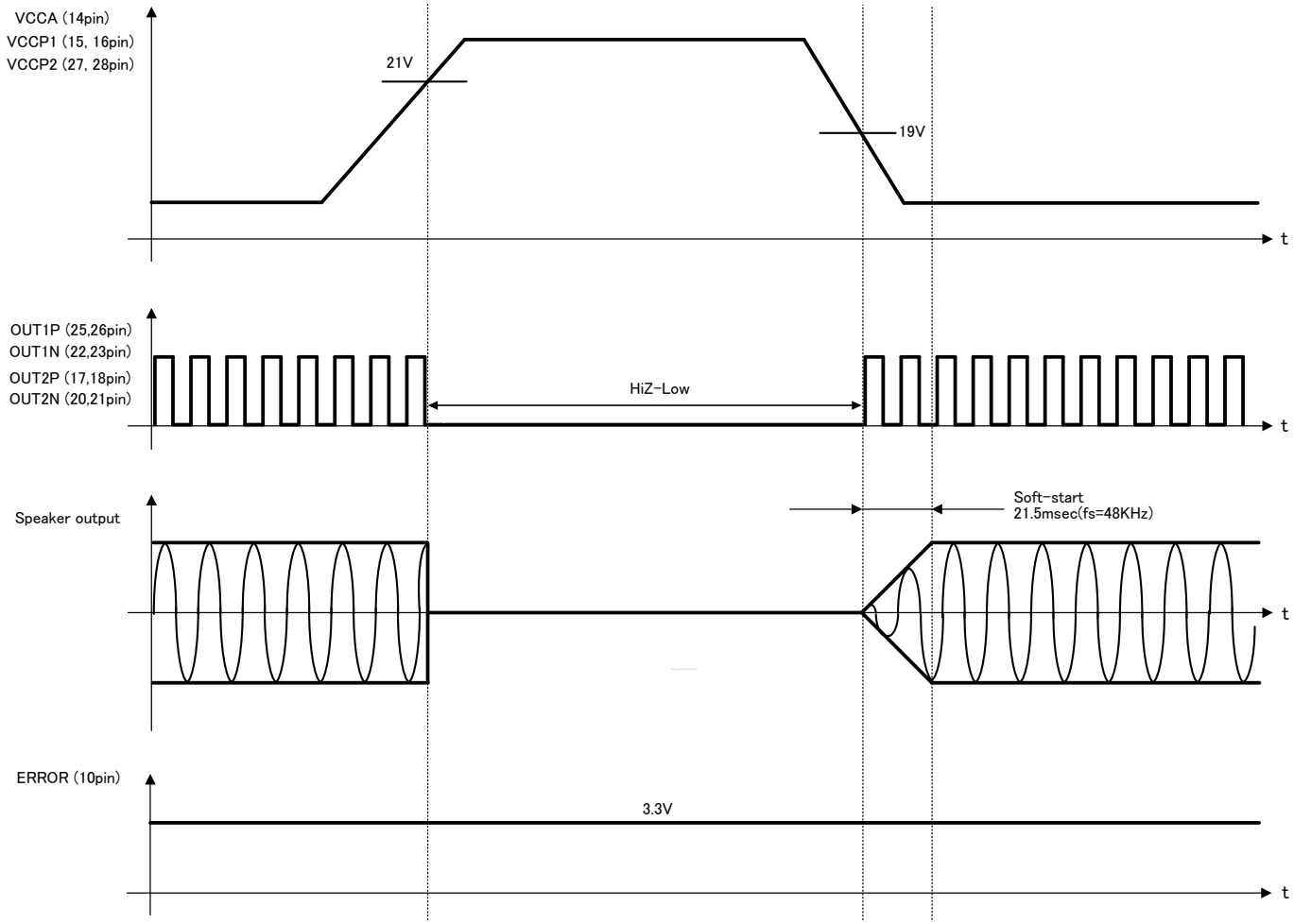


6) Over voltage protection

This IC has the under voltage protection circuit that make speaker output mute once detecting extreme drop of the power supply voltage.

Detecting condition – It will detect when MUTEX pin is set High and the power supply voltage becomes more than 21.5V.Speaker output turn MUTE immediately, when over voltage protection is detected.

Releasing condition – It will release when MUTEX pin is set High and the power supply voltage becomes lower than 20.5V. The speaker output is outputted through a soft-start when released.

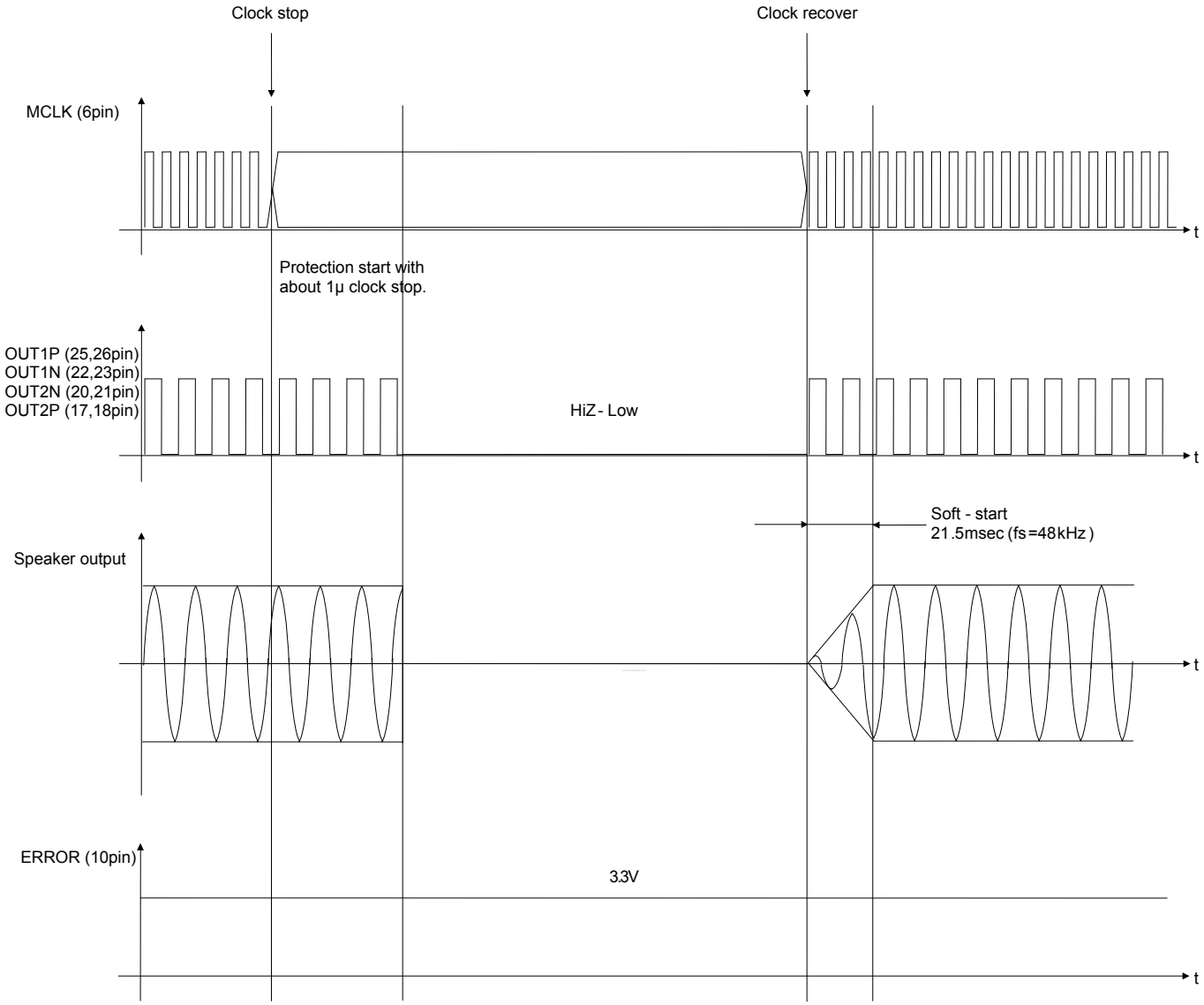


7-1) Clock stop protection(MCLK)

This IC has the clock stop protection circuit that make the speaker output mute when the MCLK signal of the digital audio input stops.

Detecting condition - It will detect when MUTEX pin is set High and the MCLK signal stops for about 1µsec or more. 21.5V. Speaker output turn MUTE immediately, clock stop protection is detected.

Releasing condition - It will release when MUTEX pin is set High and the MCLK signal returns to the normal clock operation. The speaker output is outputted through a soft-start when released.

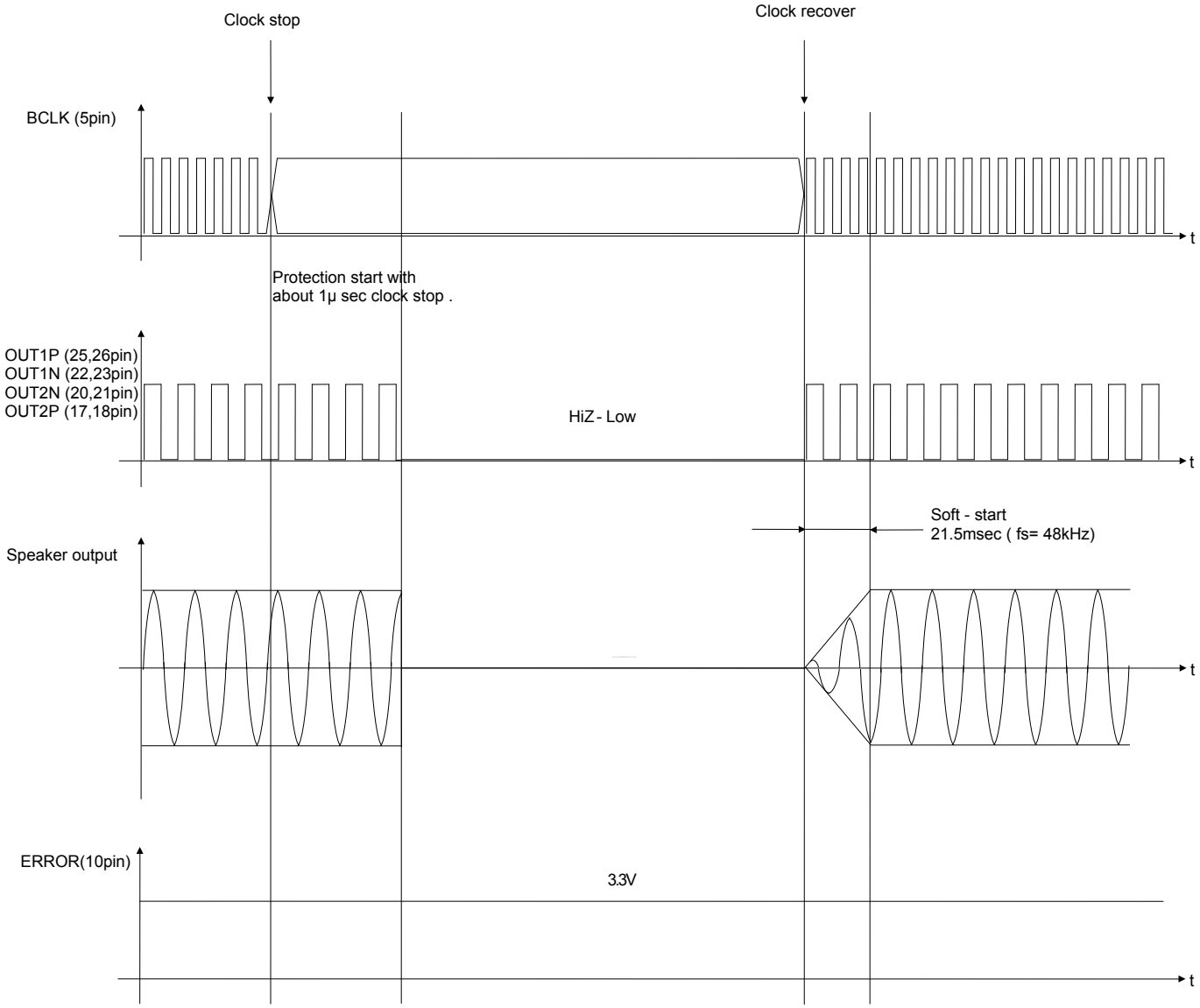


7-2) Clock stop protection(BCLK)

This IC has the clock stop protection circuit that make the speaker output mute when the BCLK signal of the digital audio input stops.

Detecting condition - It will detect when MUTEX pin is set High and the BCLK signal stops for about 1μsec or more. 21.5V.Speaker output turn MUTE immediately, when clock stop protection is detected.

Releasing condition - It will release when MUTEX pin is set High and the BCLK signal returns to the normal clock operation. The speaker output is outputted through a soft-start when released.

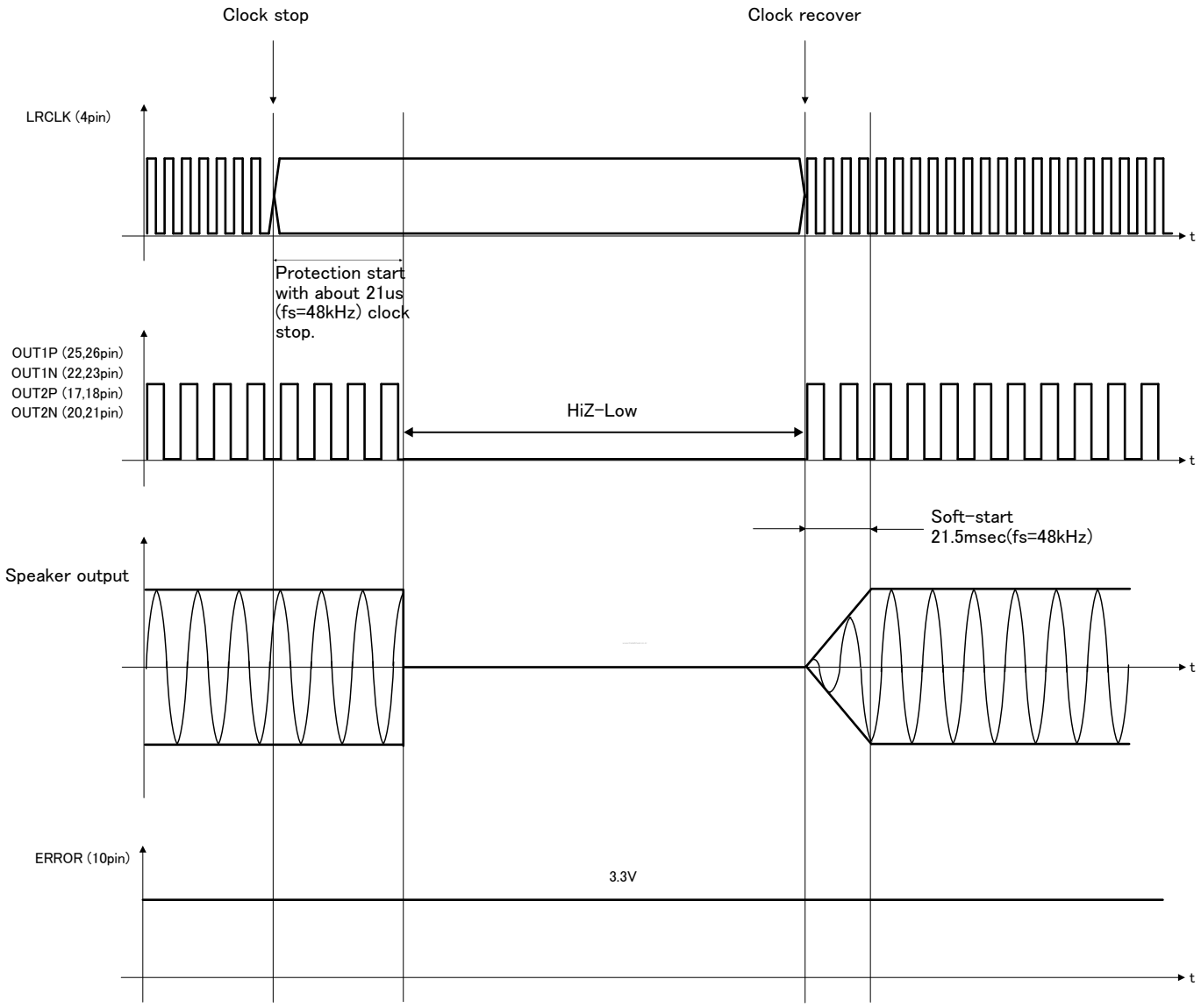


7-3) Clock stop protection (LRCLK)

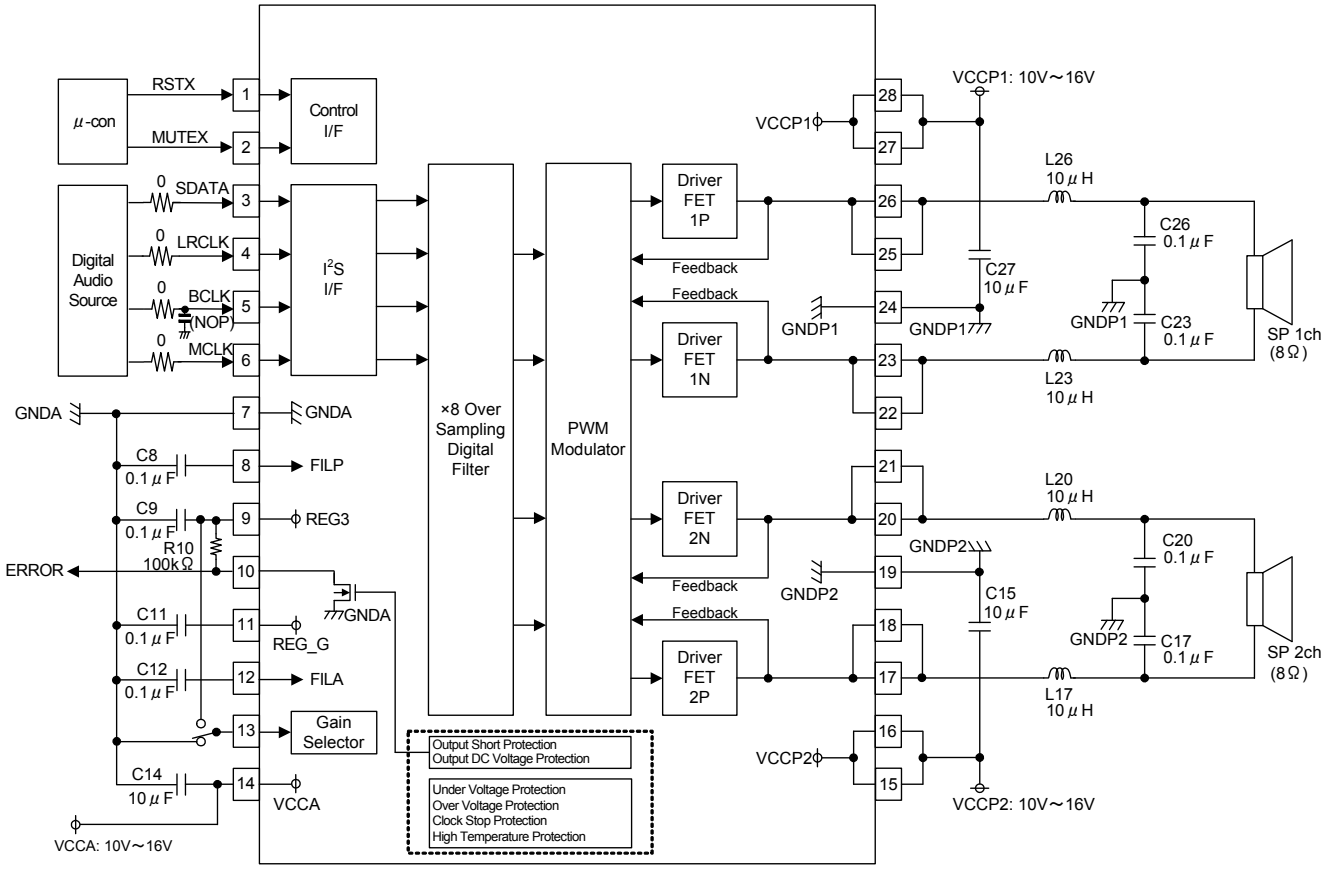
This IC has the clock stop protection circuit that make the speaker output mute when the LRCLK signal of the digital audio input stops.

Detecting condition - It will detect when MUTEX pin is set High and the LRCLK signal stops for about 21µsec (at fs=48kHz) or more. Speaker output turn MUTE immediately, when clock stop protection is detected.

Releasing condition - It will release when MUTEX pin is set High and the LRCLK signal returns to the normal clock operation. The speaker output is outputted through a soft-start when released.



●**Application Circuit Example** (Stereo BTL Output, RL=8Ω, VCC=10V～16V, Po=～15W)

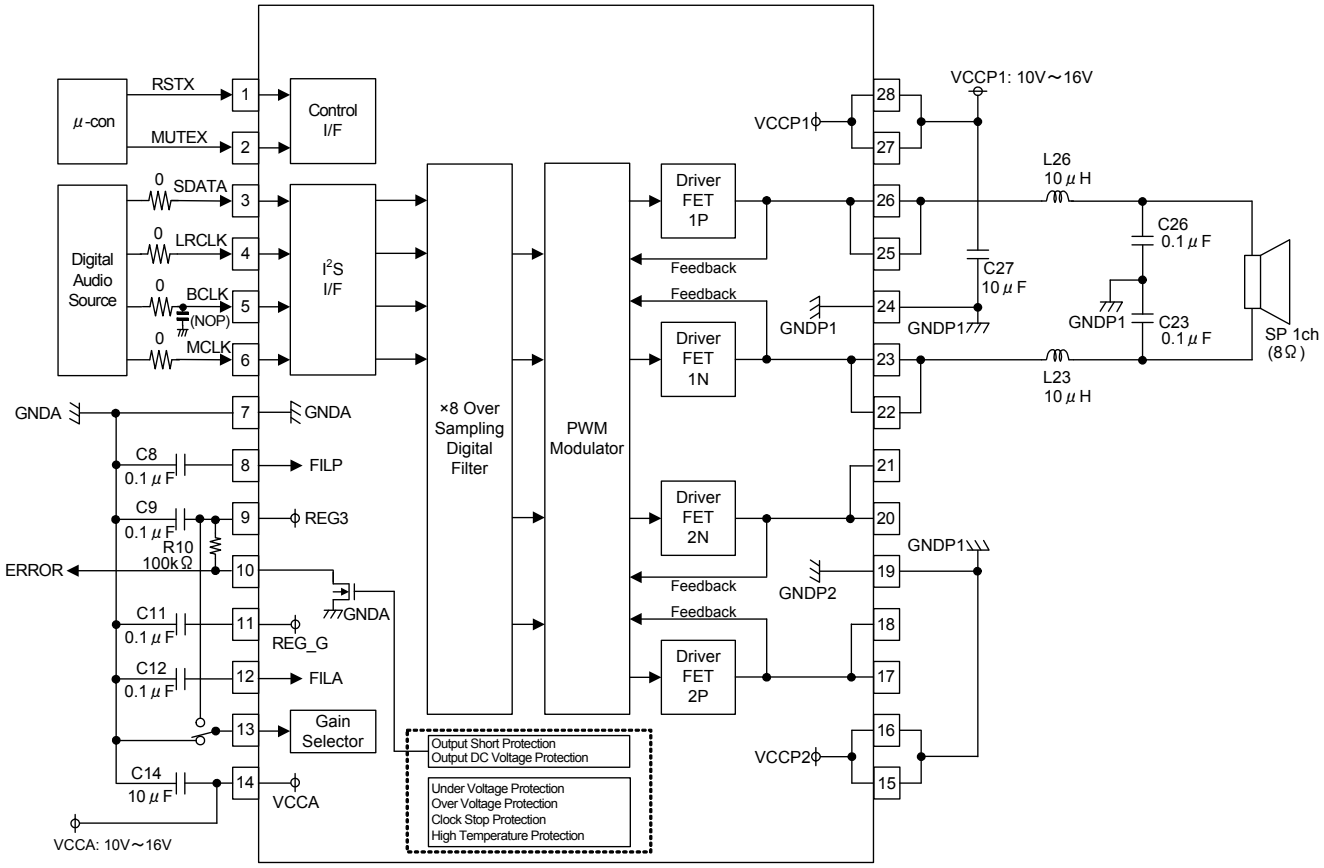


●**BOM list** (Stereo BTL Output, RL=8Ω, VCC=10V～16V, Po=～15W)

Parts	Parts No.	Value	Company	Product No.	Rated Voltage	Tolerance	Size
IC	U1	—	ROHM	BD5451EFV	—	—	9.7mm×6.4mm
Inductor	L17, L20, L23, L26	10μH	TOKO	B1047DS-100M=3P	-	(±20%)	7.6mm×7.6mm
Resistor	R10	100kΩ	ROHM	MCR03EZPJ104	1/10W	J(±1%)	1.6mm×0.8mm
Capacitor	C14, C15, C27	10μF	MURATA	GRM31CB11E106KA75L	25V	B(±10%)	3.2mm×1.6mm
	C8, C9, C11, C12	0.1μF		GRM188B11A104KA92D	10V	B(±10%)	1.6mm×0.8mm
	C17, C20, C23, C26	0.1μF		GRM188B11E104KA01D	25V	B(±10%)	1.6mm×0.8mm

As return of current regenerated by back EMF of output coil happens, take steps such as putting capacitor between power supply and GND as a electric pathway for the regenerated current. Be sure that there is no problem with each property such as emptied capacity at lower temperature regarding electrolytic capacitor to decide capacity value. If the connected power supply does not have sufficient current absorption capacity, regenerative current will cause the voltage on the power supply line to rise, which combined with the product and its peripheral circuitry may exceed the absolute maximum ratings. It is recommended to implement a physical safety measure such as the insertion of a voltage clamp diode between the power supply and GND pins.

●**Application Circuit Example** (Monaural BTL Output, RL=8Ω, VCC=10V～16V, Po=～15W)



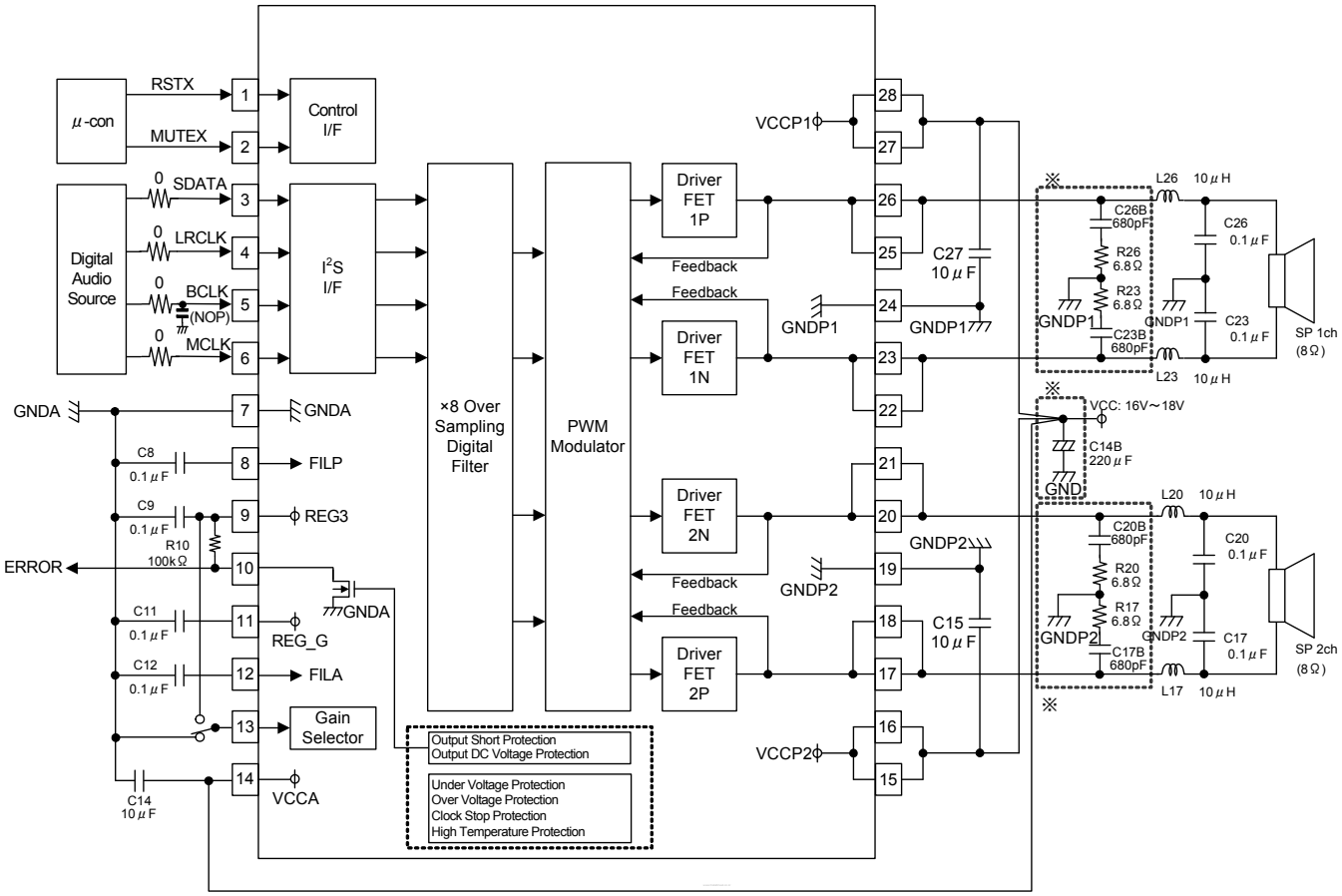
●**BOM list** (Monaural BTL Output, RL=8Ω, VCC=10V～16V, Po=～15W)

Parts	Parts No.	Value	Company	Product No.	Rated Voltage	Tolerance	Size
IC	U1	—	ROHM	BD5451EFV	—	—	9.7mm×6.4mm
Inductor	L23, L26	10μH	TOKO	B1047DS-100M=3P	-	(±20%)	7.6mm×7.6mm
Resistor	R10	100kΩ	ROHM	MCR03EZPJ104	1/10W	F(±1%)	1.6mm×0.8mm
Capacitor	C14, C27	10μF	MURATA	GRM31CB11E106KA75L	25V	B(±10%)	3.2mm×1.6mm
	C8, C9, C11, C12	0.1μF		GRM188B11A104KA92D	10V	B(±10%)	1.6mm×0.8mm
	C23, C26	0.1μF		GRM188B11E104KA01D	25V	B(±10%)	1.6mm×0.8mm

As return of current regenerated by back EMF of output coil happens, take steps such as putting capacitor between power supply and GND as a electric pathway for the regenerated current. Be sure that there is no problem with each property such as emptied capacity at lower temperature regarding electrolytic capacitor to decide capacity value. If the connected power supply does not have sufficient current absorption capacity, regenerative current will cause the voltage on the power supply line to rise, which combined with the product and its peripheral circuitry may exceed the absolute maximum ratings. It is recommended to implement a physical safety measure such as the insertion of a voltage clamp diode between the power supply and GND pins.

●**Application Circuit Example** (Stereo BTL Output, RL=8Ω, VCC=16V～18V, Po=～20W)

※To prevent going over absolute maximum rating by the leap out of power supply and the linking of PWM output wave form, please provide countermeasure shown below diagram (dot-line ※) when using at Vcc＞16V.



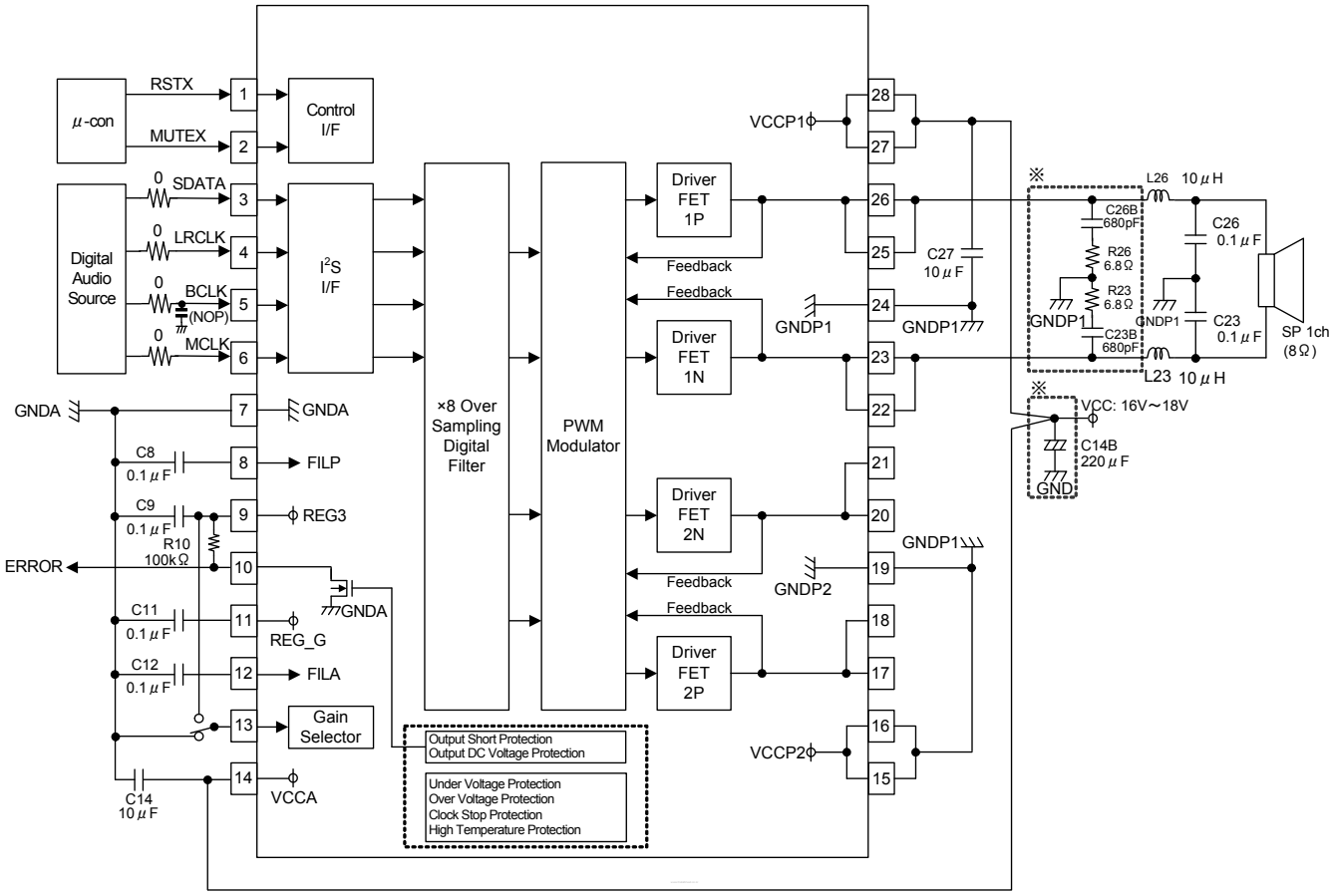
●**BOM list** (Stereo BTL Output, RL=8Ω, VCC=16V～18V, Po=～20W)

Parts	Parts No.	Value	Company	Product No.	Rated Voltage	Tolerance	Size
IC	U1	—	ROHM	BD5451EFV	—	—	9.7mm×6.4mm
Inductor	L17, L20, L23, L26	10μH	TOKO	B1047DS-100M=3P	-	(±20%)	7.6mm×7.6mm
Resistor	R10	100kΩ	ROHM	MCR03EZPJ104	1/10W	J(±5%)	1.6mm×0.8mm
	R17, R20, R23, R26	6.8Ω	ROHM	MCR03EZPFL6R80	1/10W	F(±1%)	1.6mm×0.8mm
Capacitor	C14, C15, C27	10μF	MURATA	GRM31CB11E106KA75L	25V	B(±10%)	3.2mm×1.6mm
	C8, C9, C11, C12	0.1μF		GRM188B11A104KA92D	10V	B(±10%)	1.6mm×0.8mm
	C17, C20, C23, C26	0.1μF		GRM188B11E104KA01D	25V	B(±10%)	1.6mm×0.8mm
	C17,B C20B, C23B, C26B	680pF		GRM188B11E681KA01	25V	B(±10%)	1.6mm×0.8mm
Electrolytic Capacitor	C14B	220μF	Panasonic	ECA1EMH221	25V	±20%	φ8mm×11.5mm

As return of current regenerated by back EMF of output coil happens, take steps such as putting capacitor between power supply and GND as a electric pathway for the regenerated current. Be sure that there is no problem with each property such as emptied capacity at lower temperature regarding electrolytic capacitor to decide capacity value. If the connected power supply does not have sufficient current absorption capacity, regenerative current will cause the voltage on the power supply line to rise, which combined with the product and its peripheral circuitry may exceed the absolute maximum ratings. It is recommended to implement a physical safety measure such as the insertion of a voltage clamp diode between the power supply and GND pins.

●**Application Circuit Example** (Monaural BTL Output, RL=8Ω, VCC=16V～18V, Po=～20W)

※To prevent going over absolute maximum rating by the leap out of power supply and the linking of PWM output wave form, please provide countermeasure shown below diagram (dot-line ※) when using at Vcc＞16V.



●**BOM list** (Monaural BTL Output, RL=8Ω, VCC=16V～18V, Po=～20W)

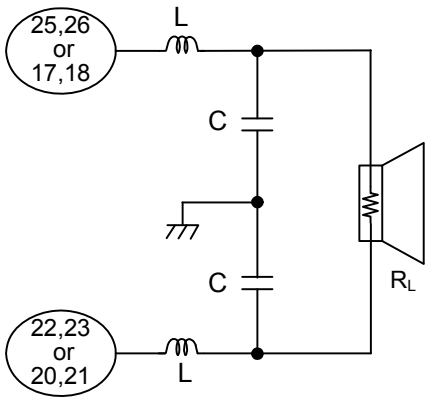
Parts	Parts No.	Value	Company	Product No.	Rated Voltage	Tolerance	Size
IC	U1	—	ROHM	BD5451EFV	—	—	9.7mm×6.4mm
Inductor	L23, L26	10μH	TOKO	B1047DS-100M=P3	-	(±20%)	7.6mm×7.6mm
Resistor	R10	100kΩ	ROHM	MCR03EZPJ104	1/10W	J(±5%)	1.6mm×0.8mm
	R23, R26	6.8Ω		MCR03EZPFL6R80	1/10W	F(±1%)	1.6mm×0.8mm
Capacitor	C14, C27	10μF	MURATA	GRM31CB31E106KA75L	25V	B(±10%)	3.2mm×1.6mm
	C8, C9, C11, C12	0.1μF		GRM188B11A104KA92D	10V	B(±10%)	1.6mm×0.8mm
	C23, C26	0.1μF		GRM188B11E104KA01D	25V	B(±10%)	1.6mm×0.8mm
	C23B, C26B	680pF		GRM188B11E681KA01	25V	B(±10%)	1.6mm×0.8mm
Electrolytic Capacitor	C14B	220μF	Panasonic	ECA1EMH221	25V	±20%	φ8mm×11.5mm

As return of current regenerated by back EMF of output coil happens, take steps such as putting capacitor between power supply and GND as a electric pathway for the regenerated current. Be sure that there is no problem with each property such as emptied capacity at lower temperature regarding electrolytic capacitor to decide capacity value.
If the connected power supply does not have sufficient current absorption capacity, regenerative current will cause the voltage on the power supply line to rise, which combined with the product and its peripheral circuitry may exceed the absolute maximum ratings. It is recommended to implement a physical safety measure such as the insertion of a voltage clamp diode between the power supply and GND pins.

●Output LC Filter Circuit

An output filter is required to eliminate radio-frequency components exceeding the audio-frequency region supplied to a load (speaker). Because this IC uses sampling clock frequencies from 256kHz (fs=32kHz) to 384kHz (fs=48kHz) in the output PWM signals, the high-frequency components must be appropriately removed.

This section takes an example of an LC type LPF shown below, in which coil L and capacitor C compose a differential filter with an attenuation property of -12dB / oct. A large part of switching currents flow to capacitor C, and only a small part of the currents flow to speaker R_L. This filter reduces unwanted emission this way. In addition, coil L and capacitor Cg compose a filter against in-phase components, reducing unwanted emission further.



Following presents output LC filter constants with typical load impedances.

R_L	L	C
4Ω	10μH	0.47μF
6Ω	10μH	0.15μF
8Ω	10μH	0.1μF

Use coils with a low direct-current resistance and with a sufficient margin of allowable currents. A high direct-current resistance causes power losses. In addition, select a closed magnetic circuit type product in normal cases to prevent unwanted emission.

Use capacitors with a low equivalent series resistance, and good impedance characteristics at high frequency ranges (100kHz or higher). Also, select an item with sufficient withstand voltage because flowing massive amount of high-frequency currents is expected.

●Notes for use

1) Absolute maximum ratings
Use of the IC in excess of absolute maximum ratings such as the applied voltage or operating temperature range 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 use of the IC in a special mode where the absolute maximum ratings may be exceeded is anticipated.

2) Power supply lines
As return of current regenerated by back EMF of output coil happens, take steps such as putting capacitor between power supply and GND as a electric pathway for the regenerated current. Be sure that there is no problem with each property such as emptied capacity at lower temperature regarding electrolytic capacitor to decide capacity value. If the connected power supply does not have sufficient current absorption capacity, regenerative current will cause the voltage on the power supply line to rise, which combined with the product and its peripheral circuitry may exceed the absolute maximum ratings. It is recommended to implement a physical safety measure such as the insertion of a voltage clamp diode between the power supply and GND pins.

3) GND potential(Pin 7, 19, 24).
Any state must become the lowest voltage about GND terminal and VSS terminal.

4) Input terminal
The parasitic elements are formed in the IC because of the voltage relation. The parasitic element operating causes the wrong operation and destruction. Therefore, please be careful so as not to operate the parasitic elements by impressing to input terminals lower voltage than GND and VSS. Please do not apply the voltage to the input terminal when the power-supply voltage is not impressed.

5) Setting of heat
Use a thermal design that allows for a sufficient margin in light of the power dissipation (Pd) in actual operating conditions. This IC exposes its frame of the backside of package. Note that this part is assumed to use after providing heat dissipation treatment to improve heat dissipation efficiency. Try to occupy as wide as possible with heat dissipation pattern not only on the board surface but also the backside.
Class D speaker amplifier is high efficiency and low heat generation by comparison with conventional Analog power amplifier. However, In case it is operated continuously by maximum output power, Power dissipation (Pdiss) may exceed package dissipation. Please consider about heat design that Power dissipation (Pdiss) does not exceed Package dissipation (Pd) in average power (Poav). (Tjmax : Maximum junction temperature=150℃, Ta : Peripheral temperature[℃], θja : Thermal resistance of package[℃/W], Poav: Average power[W], η: Efficiency)

Package dissipation: $Pd\ (W) = (Tjmax - Ta)/\theta ja$

Power dissipation : $Pdiss(W) = Poav \times (1/\eta - 1)$

6) Actions in strong magnetic field
Use caution when using the IC in the presence of a strong magnetic field as doing so may cause the IC to malfunction.

7) Thermal shutdown circuit
This product is provided with a built-in thermal shutdown circuit. When the thermal shutdown circuit operates, the output transistors are placed under open status. The thermal shutdown circuit is primarily intended to shut down the IC avoiding thermal runaway under abnormal conditions with a chip temperature exceeding Tjmax = 150℃.

8) Shorts between pins and misinstallation
When mounting the IC on a board, pay adequate attention to orientation and placement discrepancies of the IC. If it is misinstalled and the power is turned on, the IC may be damaged. It also may be damaged if it is shorted by a foreign substance coming between pins of the IC or between a pin and a power supply or a pin and a GND.

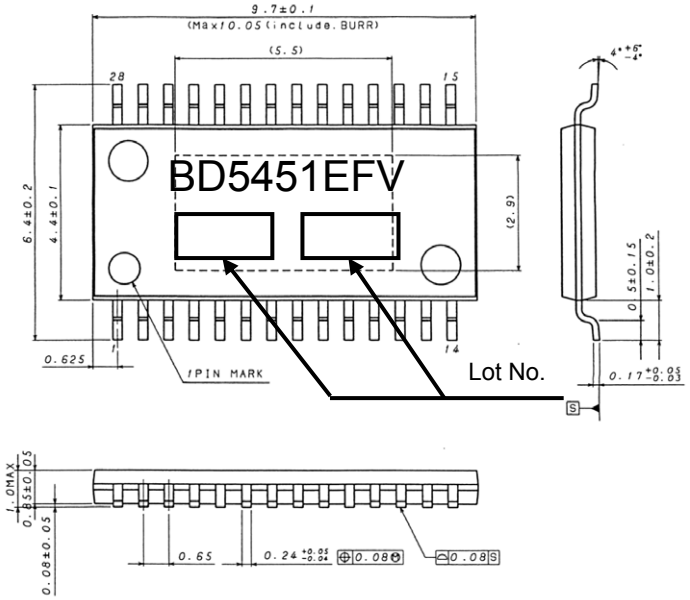
9) Power supply on/off (Pin 14, 15, 16, 27, 28)
In case power supply is started up, RSTX (Pin 1) and MUTEX (Pin 2) always should be set Low. And in case power supply is shut down, it should be set Low likewise. Then it is possible to eliminate pop noise when power supply is turned on/off. And also, all power supply terminals should start up and shut down together.

10) ERROR terminal(Pin 10)
A error flag is outputted when Output short protection and DC voltage protection in the speaker are operated. These flags are the function which the condition of this product is shown in.

11) Precautions for Spealer-setting
If the impedance characteristics of the speakers at high-frequency range while increase rapidly, the IC might not have stable-operation in the resonance frequency range of the LC-filter. Therefore, consider adding damping-circuit, etc., depending on the impedance of the speaker.

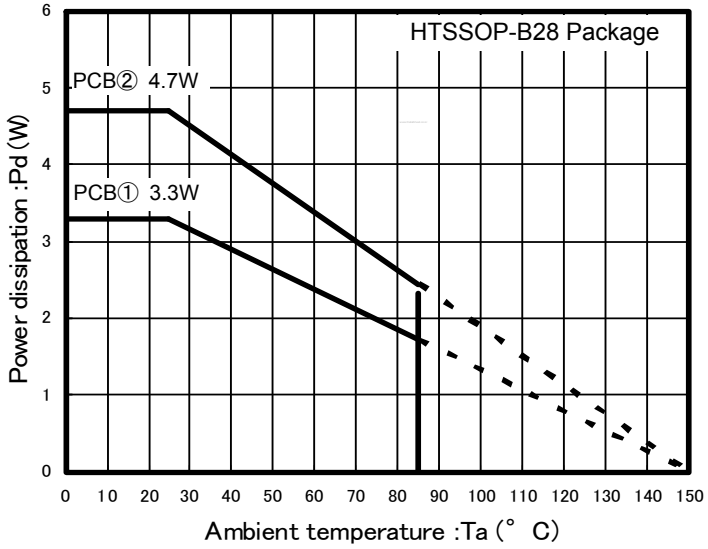
12) Notes about the phase of MCLK (Pin6) and BCLK (Pin5)
If the rising edge of MCLK (Pin6) and BCLK (Pin5) becomes simultaneous, noise or sound shutdown may occur. Please cope with it, when the rising edge of MCLK and BCLK becomes simultaneous. (Example: Insert RC filter in BCLK)

●Package outline (HTSSOP-B28)



(UNIT: mm)
PKG: HTSSOP-B28
Drawing No: EX199-5002-1

●Allowable Power Dissipation



Measuring instrument: TH-156(Shibukawa Kuwano Electrical Instruments Co., Ltd.)
Measuring conditions: Installation on ROHM's board
Board size: 70mm×70mm×1.6mm(with thermal via on board)
Material: FR4
・The board on exposed heat sink on the back of package are connected by soldering.

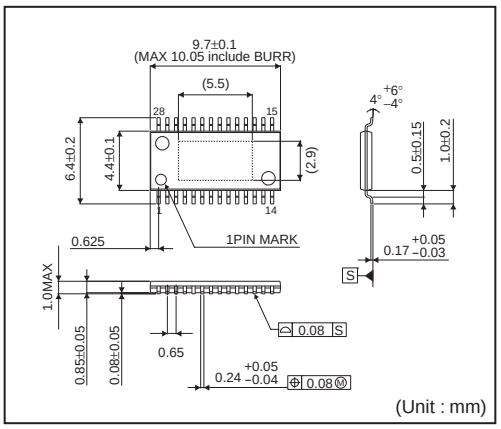
PCB①: 2-layer board(back copper foil size: 70mm×70mm), θja=37.9℃/W
PCB②: 4-layer board(back copper foil size: 70mm×70mm), θja=26.6℃/W

●Ordering part number

B	D	5	4	5	1	E	F	V	-	E	2

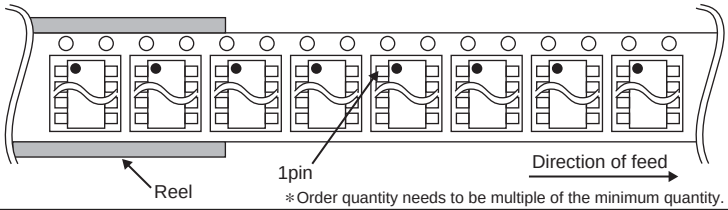
Part No. Part No. Package EFV: HTSSOP-B28 Packaging and forming specification E2: Embossed tape and reel

HTSSOP-B28



<Tape and Reel information>

Tape	Embossed carrier tape (with dry pack)
Quantity	2500pcs
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)



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

Notes

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