ALS headphone driver

BA3570F / BA3570FS

The BA3570F and BA3570FS are stereo headphone amplifiers with ALS (Auto Loudness System) which have been designed for use as headphone drivers in audio equipment.

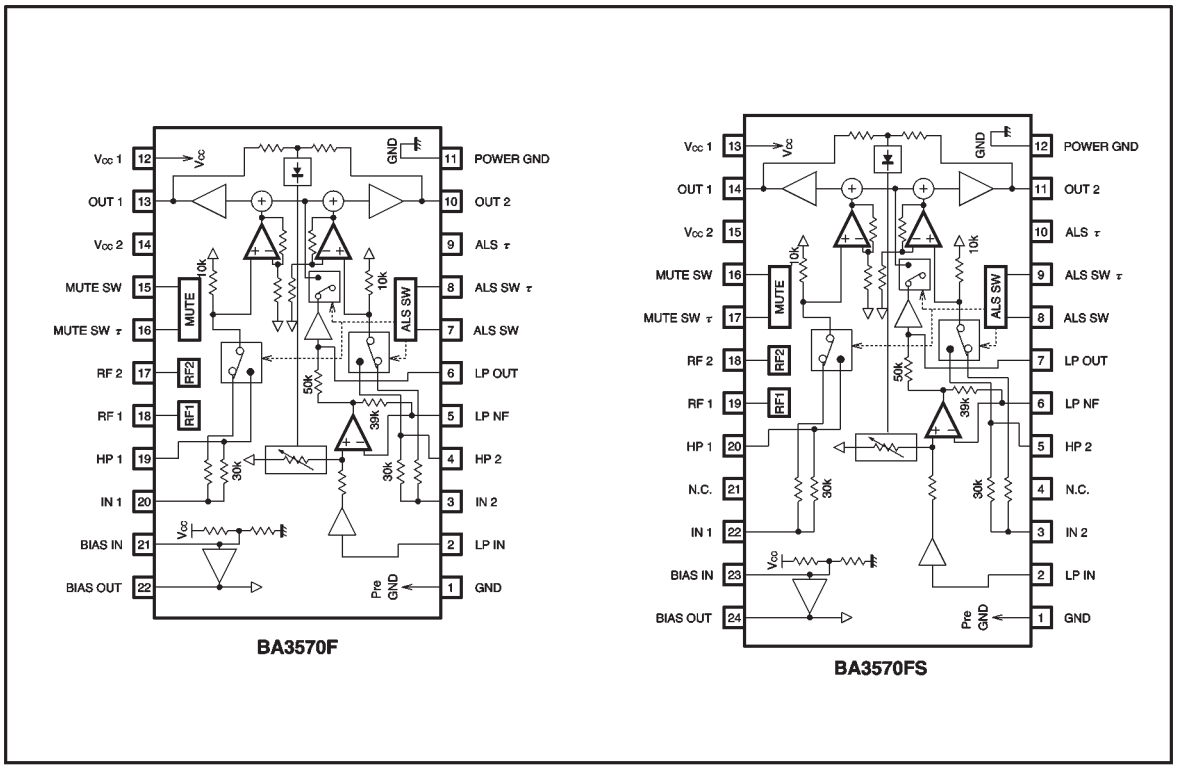
●Applications

Stereo headphones

●Features

1) The use of ALS (Auto Loudness System) makes it possible to obtain a dynamic sound regardless of the volume level.
2) Built-in power mute circuit.
3) Built-in bypass circuit.

●Block diagram



●Pin descriptions (pin numbers are for 22-pin BA3570F)

Pin No.	Pin name	Function
1	GND	Pre-ground
2	LP IN	Positive input of bass amp
3	IN2	Input 2
4	HP2	Treble input 2
5	LP NF	Negative input of bass amp
6	LP OUT	Bass amp output
7	ALS SW	ALS ON/OFF switch pin
8	ALS SW τ	Pin for setting value for ALS ON/OFF
9	ALS τ	Pin for setting value for ALS
10	OUT2	Output 2
11	POWER GND	Substrate ground
12	$V_{CC}1$	Power supply 1
13	OUT1	Output 1
14	$V_{CC}2$	Power supply 2
15	MUTE SW	Mute ON/OFF switch pin
16	MUTE SW τ	Pin for setting value for mute ON/OFF
17	RF2	Ripple filter 2
18	RF1	Ripple filter 1
19	HP1	Treble input 1
20	IN1	Input 1
21	BIAS IN	Bias amp input
22	BIAS OUT	Bias amp output

●Absolute maximum ratings (Ta = 25°C)

Parameter		Symbol	Limits	Unit
Applied voltage		V_{CC}	9.0	V
Power dissipation	BA3570F	Pd	550*	mW
	BA3570FS		800*	
Operating temperature		Topr	−25～+75	℃
Storage temperature		Tstg	−55～+125	℃

* Reduced by 5.5mW(BA3570F) and 8.0mW (BA3570FS) for each increase in Ta of 1℃ over 25℃.
When mounted on a 70×70×1.6 mm glass epoxy board.

●Recommended operating conditions (Ta = 25°C)

Parmeter	Symbol	Range	Unit
Power supply voltage	V_{CC}	2.0～7.2	V

●Electrical characteristics (unless otherwise noted, Ta = 25°C, V_{CC} = 3.0V, R_L = 16Ω, f = 1kHz, and the measurement circuit is as shown in Fig. 1)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Quiescent current	I_Q	—	9	18	mA	V_{IN}=0V_{rms}
Voltage gain	G_V	13.5	15	16.5	dB	
Rated output power	P_{OUT}	20	30	—	mW	THD=10%
Total harmonic distortion	THD	—	0.15	1.0	%	V_O=−16dBm
Channel balance	CB	−1.5	0	1.5	dB	V_O=−16dBm
Output noise voltage ratio 1	V_{NO}1	—	−92	−88	dBm	IHF−A, ALS=OFF
Output noise voltage ratio 2	V_{NO}2	—	−88	−84	dBm	IHF−A, ALS=ON
Input resistance	R_{IN}	10.8	13.5	16.2	kΩ	3, 22pin
Ripple rejection ratio 1	RR1	29.5	41	—	dB	f_{RR}=100Hz, V_{RR}=−30dBm, ALS=ON
Ripple rejection ratio 2	RR2	32	44	—	dB	f_{RR}=100Hz, V_{RR}=−30dBm, ALS=OFF
Boost 1	BB1	11	14	17	dB	f=100Hz, V_{IN}=−42dBm
Boost 2	BB2	6.5	9.5	12.5	dB	f=100Hz, V_{IN}=−32dBm
Boost 3	BB3	−3	0	3	dB	f=100Hz, V_{IN}=−22dBm
Channel separation	CS	52	62	—	dB	ALS=OFF, f=1kHz
Signal leak	SL	—	−67	−62	dBm	R_g=0, V_{IN} =0dBm 3, 22pin
Mute level	ML	—	−85	−79	dBm	16pin=V_{CC}, V_{IN}=−20dBm 3, 22pin

●Measurement circuit

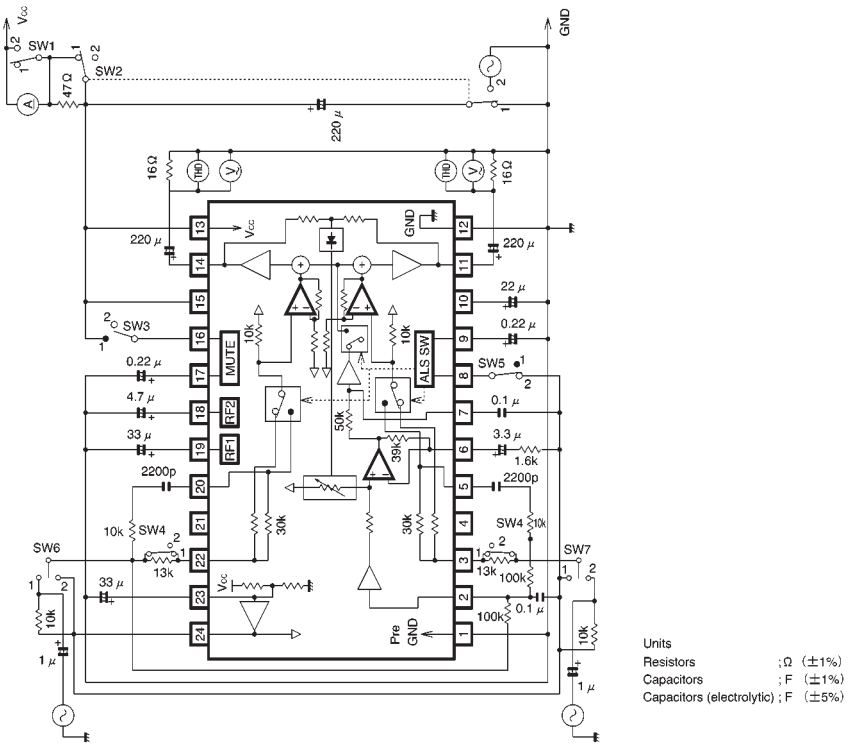


Fig.1

●Explanation of ALS operation and attached components (pin numbers are for 22-pin BA3570F)

(1) ALS ON

When ALS is on, the signal circuit (including external connections) is as shown in Fig. 2.

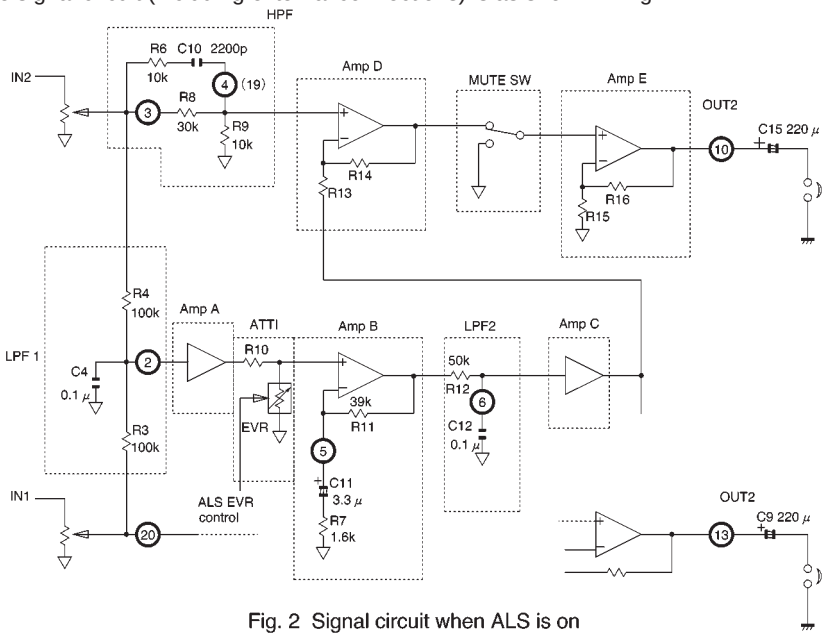


Fig. 2 Signal circuit when ALS is on

1) Bass signal transmission and gain vs. frequency

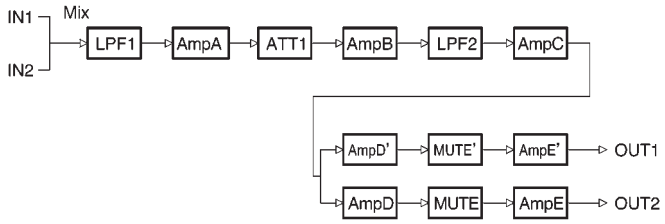


Fig.3

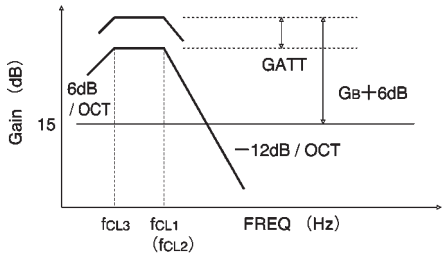


Fig. 4 Total frequency characteristics of bass signals

2) Treble signal transmission and gain vs. frequency

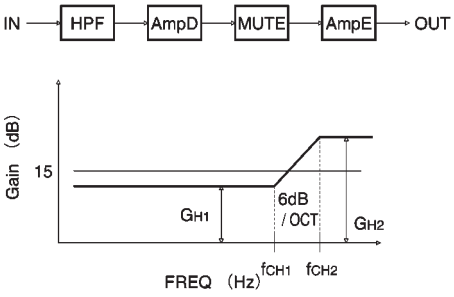


Fig. 5 Total frequency characteristics of treble signals

The gain and cutoff frequency of each block is as follows:

LPF1 cutoff frequency : $f_{CL1} = \frac{1}{2\pi \cdot (R3//R4) \cdot C4}$ (Hz)

Amp A gain : $G_{V(A)} = 0$ (dB)

ATT attenuation : $G_{V(ATT)} = 20\log \frac{EVR}{R_{10}+EVR}$ (dB)

Amp B gain : $G_{V(B)} = 20\log \frac{R_7+R_{11}}{R_7}$ (dB)

Amp B cutoff frequency : $f_{CL3} = \frac{1}{2\pi \cdot R_7 \cdot C_{11}}$ (Hz)

LPF2 cutoff frequency : $f_{CL2} = \frac{1}{2\pi \cdot R_{12} \cdot C_{12}}$ (Hz)

Amp C gain : $G_{V(C)} = 0$ (dB)

Amp D gain : $G_{V(D)} = 20\log \frac{R_{14}}{R_{13}}$ (dB)

Mute switch gain : $G_{V(MUTE)} = 0$ (dB)

Amp E gain : $G_{V(E)} = 20\log \frac{R_{15}+R_{16}}{R_{15}}$ (dB) ←15dB

In this case, $R_3 = R_4 = 2 \cdot R_{12}$ (= 100kΩ) and $C_4 = C_{12}$ (= 0.1μF), therefore $f_{CL1} = f_{CL2}$ (= 32Hz), and the frequency characteristic is bass boost (−12 dB/OCT) as shown in Fig. 4. Also, $R_{14} = 2 \cdot R_{13}$, therefore $G_{V(D)} = 6$ (dB) and the EVR MAX total gain G_{LMAX} when signals are input from both channels is

$$G_{LMAX} = G_{V(A)}+G_{V(B)}+G_{V(C)}+G_{V(D)} +G_{V(MUTE)}+G_{V(E)} = G_{V(B)}+6+15 \text{ (dB)}$$

The gain and cutoff frequency of each block is as follows:

HPF cutoff frequency 1 : $f_{CH1} = \frac{1}{2\pi \cdot (R_6+R_8) \cdot C_{10}}$ (Hz)

HPF cutoff frequency 2 : $f_{CH2} = \frac{R_8+R_9}{2\pi \cdot (R_6R_8+R_8R_{10}+R_6R_{10}) \cdot C_{10}}$ (Hz)

Amp D gain : $G_{V(D)} = 20\log \frac{R_{13}}{R_{13}+R_{14}}$ (dB)

Furthermore, as $R_{14} = 2R_{13}$,
$G_{V(D)} = +9.5$ (dB)
The total gain G_{H1} for the frequency band $f < f_{CH1}$ is

$$G_{H1} = 20\log\frac{R_9}{R_8+R_9} +9.5+15 \quad \text{(dB)}$$

and the total gain G_{H2} for the frequency band $f_{CH2} < f$ is

$$G_{H2} = 20\log\frac{R_9}{R_6 // R_8+R_9} +9.5+15 \quad \text{(dB)}$$

3) Combined frequency characteristics
As shown in Fig. 6, the ALS characteristics can be obtained from the bass characteristics (Fig. 4) and the treble characteristics (Fig. 6).

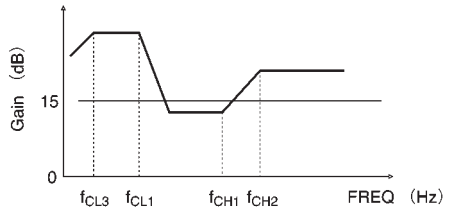


Fig. 6 ALS frequency characteristics

(2) ALS OFF
The signal circuit when ALS is off is shown in Fig. 7.

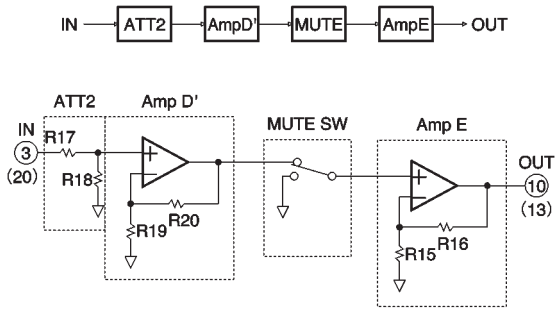


Fig. 7 Signal circuit when ALS is off

The gain and cutoff frequency of each block is as follows:

ATT2 attenuation: $G_{V(ATT2)} = 20\log \frac{R_{18}}{R_{17}+R_{18}}$ (dB)

Amp D' gain: $G_{V(D)} = 20\log \frac{R_{19}+R_{20}}{R_{19}}$ (dB)

As $R_{17} = R_{18}$ and $R_{19} = R_{20}$, the total gain $G_{V(OFF)}$ when ALS is off is

$$G_{V\,(OFF)} = \underset{-6}{G_{V\,(ATT2)}} + \underset{+6}{G_{V\,(D)}} + \underset{0}{G_{V\,(MUTE)}} + \underset{15}{G_{V\,(E)}} = 15 \quad \text{(dB)}$$

and it is flat as shown in Fig. 8.

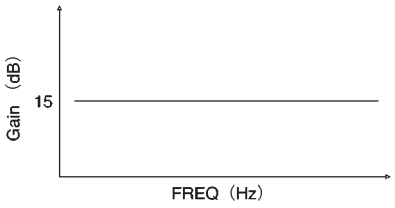


Fig. 8 Total frequency characteristics when ALS is off

●Explanation of ALS operation and attached components

(1) ALS system control circuit

The ALS system control circuit is shown in Fig. 9.

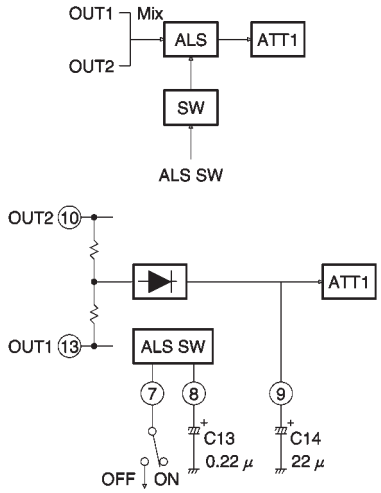


Fig. 9 ALS system control circuits

• ALS mode switching table

ALS mode	Pin ⑦ voltage
ALS ON	OPEN
ALS OFF	BIAS OUT

• ALS SW τ external connection value: C13

By increasing the capacitance of C13, the switching sound made when ALS is turned on or off can be reduced, however, the switching time will increase. Set the value appropriately for the application.

• ALSτ external connection value: C14

The ALC attack and recovery time for ALS is determined by C14 connected to the τ pin (Pin 9).

●Mute amplifier (pin numbers are for 22-pin BA3570F)

The output muting can be switched on or off.

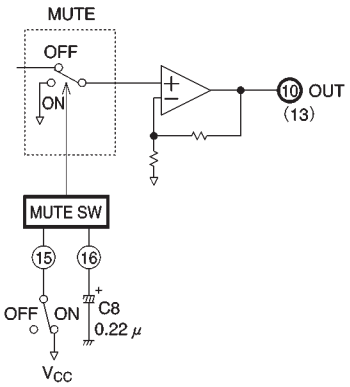


Fig. 10 Mute circuit

●Mute switching table

MUTE	Pin ⑮ voltage
ON	V_{CC}
OFF	OPEN

●MUTE SWτ external connection value: C8

By increasing the capacitance of C8, the switching sound made when the mute is turned on or off can be reduced, however, the switching time will increase. Set the value appropriately for the application.

●Application example

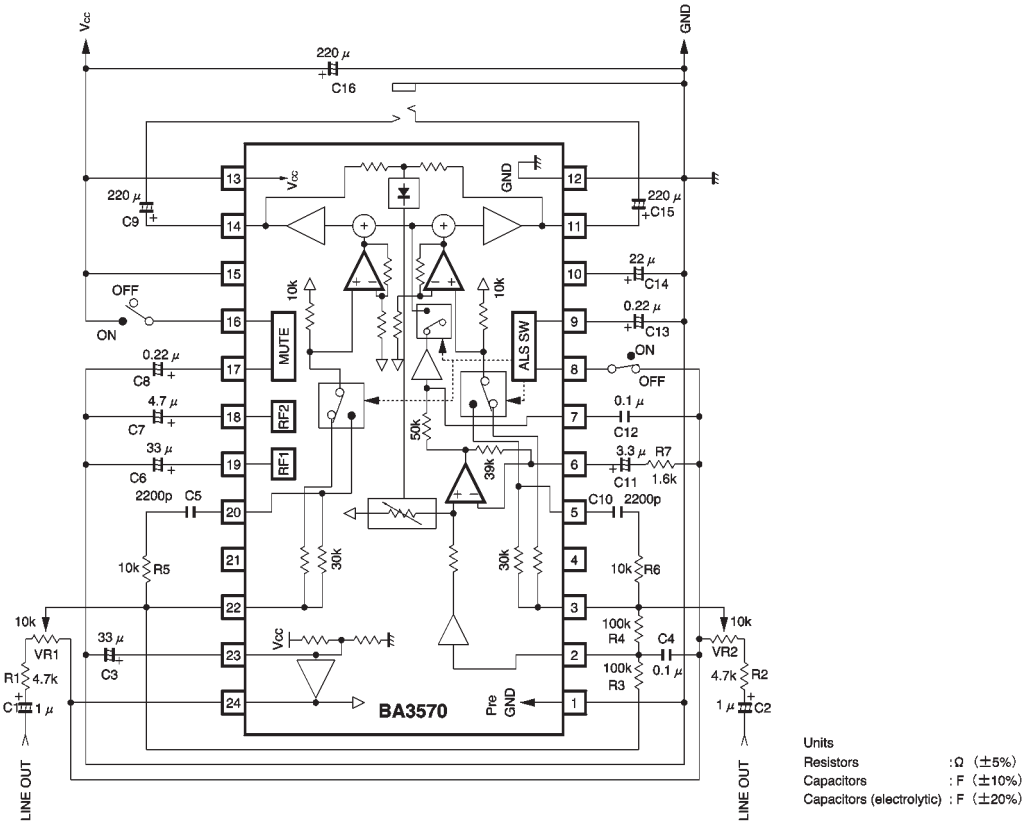


Fig. 11

●Electrical characteristic curves

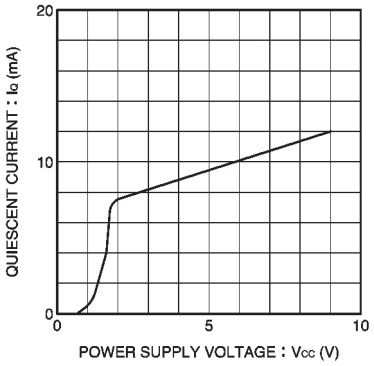


Fig.12 Quiescent current vs. power supply voltage

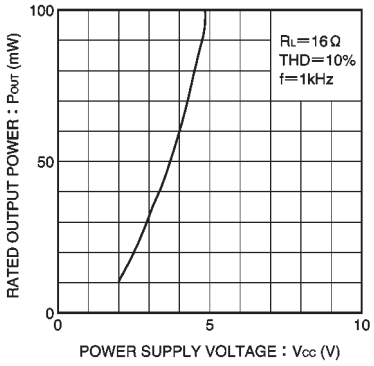


Fig.13 Rated output vs. power supply voltage

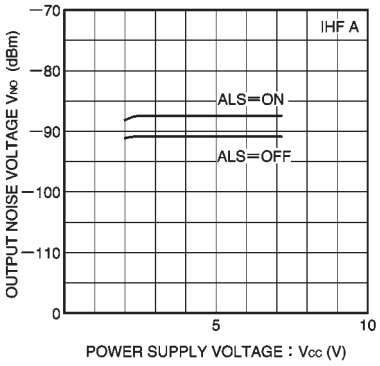


Fig.14 Output noise voltage vs. power supply voltage

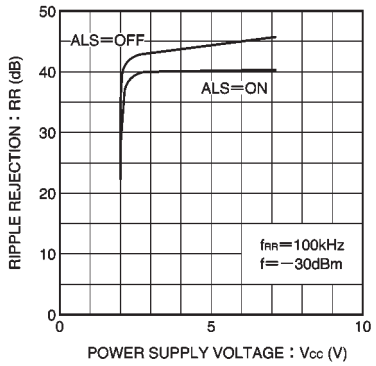


Fig.15 Ripple rejection vs. power supply voltage

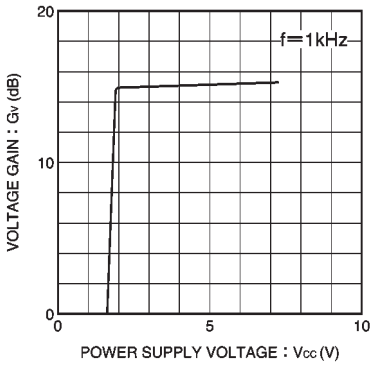


Fig.16 Supply voltage gain vs. power supply voltage

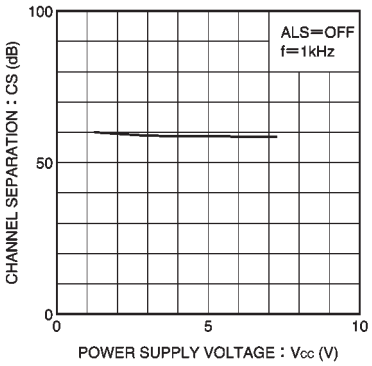


Fig.17 Channel separation vs. power supply voltage

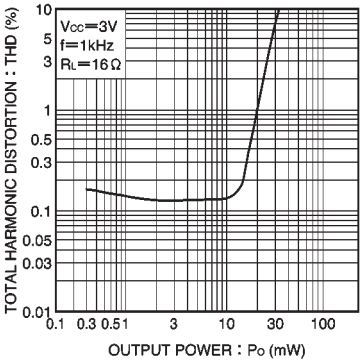


Fig.18 Total harmonic distortion vs. output power

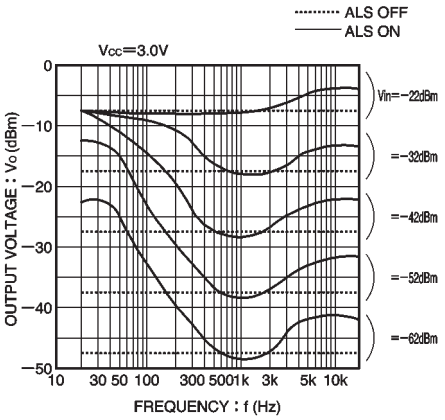


Fig.19 Output voltage vs. frequency

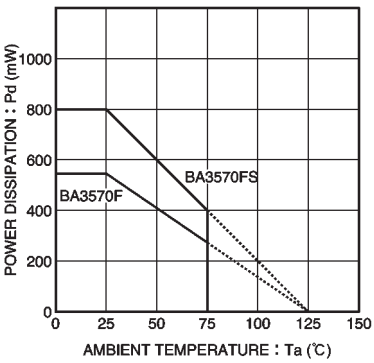


Fig.20 Thermal derating curve

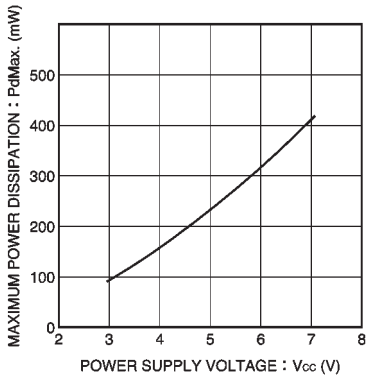
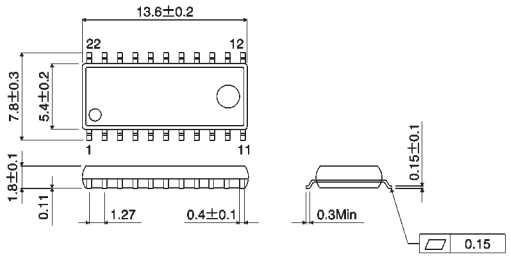


Fig.21 Maximum power dissipation

●External dimensions (Units: mm)

BA3570F



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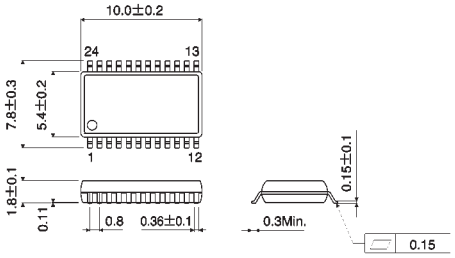

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