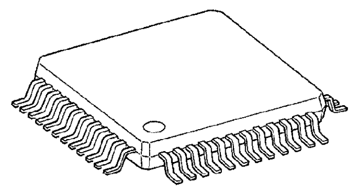
TENTATIVE TOSHIBA BIPOLAR INTEGRATED CIRCUIT SILICON MONOLITHIC

TA2123AF

1.5 V STEREO HEADPHONE AMPLIFIER

The TA2123AF is the system amplifier IC which is developed for playback stereo headphone equipments.
It is built in dual auto-reverse preamplifiers, dual power amplifiers with bass / treble boost function, AMS (Automatic Music Sensor) function, beep function, AGC for power amplifier etc.



LQFP48-P-0707-0.50

Weight : 0.17 g (Typ.)

FEATURES

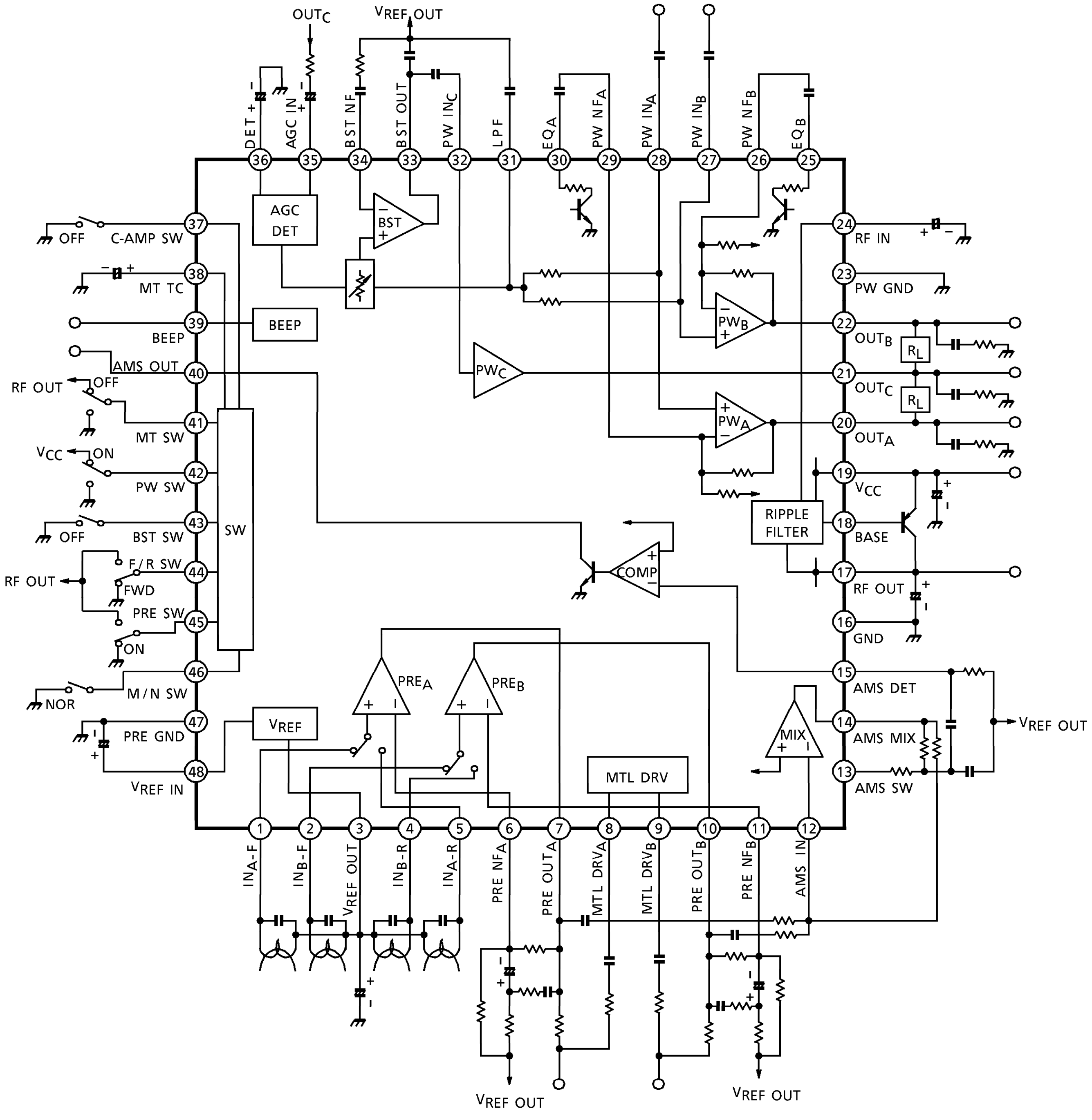
- Low supply current
  (V_{CC} = 1.3 V, f = 1 kHz, R_L = 32 Ω, Ta = 25°C, Typ.)

	No Signal	0.1 mW × 2	0.5m W × 2
Output Coupling Type	1.5 mA	3.0 mA	5.0 mA
OCL Type	2.2 mA	4.9 mA	8.6 mA

- Power amplifier stage
  - In case of output coupling type, the supply current decreases. (built-in center amplifier switch)
  - Built-in Bass Boost function
  - Built-in Treble Boost function
  - Built-in Power Amplifier Muting function
  - Built-in input terminal for Beep Signal
  - Built-in input capacitor for reducing buzz noise
  - G_V = 24 dB (Typ.)
  - Built-in AGC circuit (in case of boost mode, this circuit operates.)

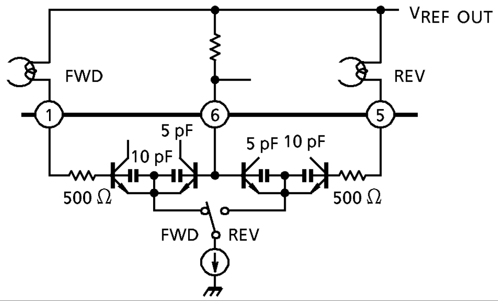
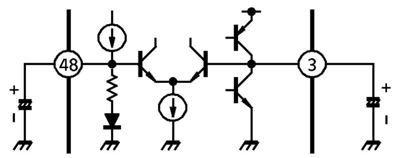
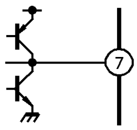
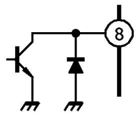
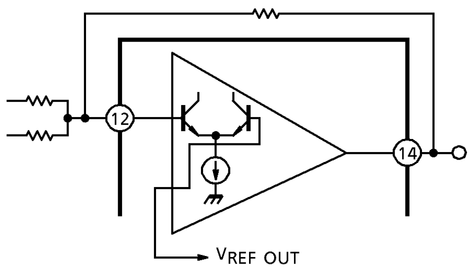
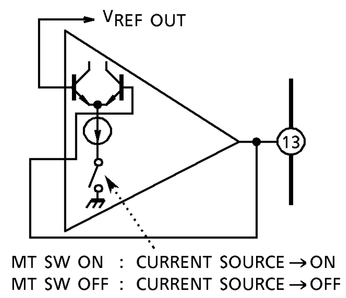
- Preamplifier stage
    - Auto-reverse compatible
    - Built-in input capacitor for reducing buzz noise
    - Input coupling condensor-less
    - Built-in Metal mode Drivers
    - Preamplifier Muting function
- Built-in Ripple filter circuit
- Built-in AMS (automatic music sensor) function (mixer amplifier and level comparator)
- Built-in Power Switch
- Operating supply voltage range (Ta = 25°C)
  $V_{CC\ (opr)}$ = 0.95~2.2 V

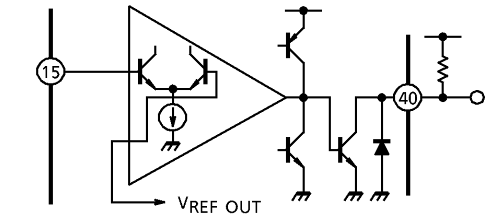
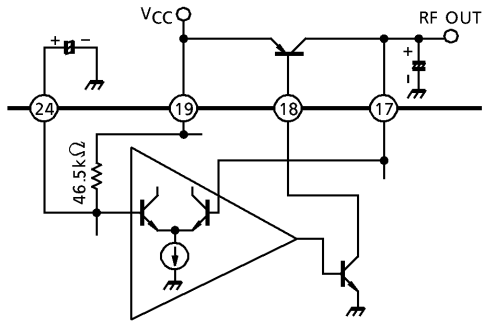
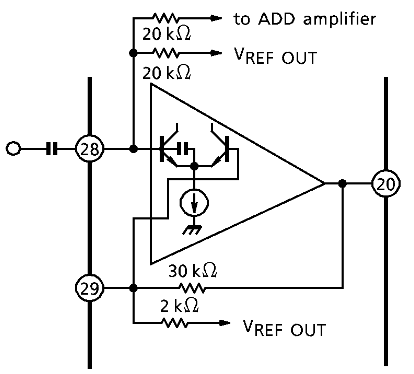
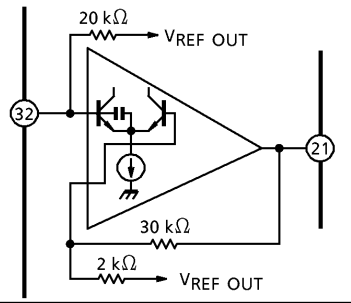
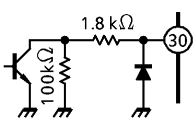
BLOCK DIAGRAM

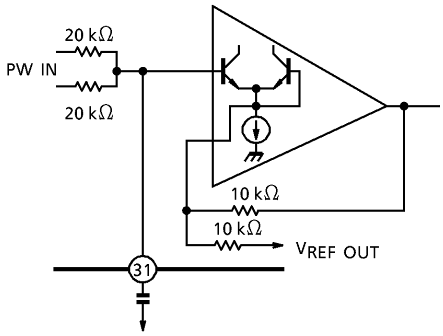
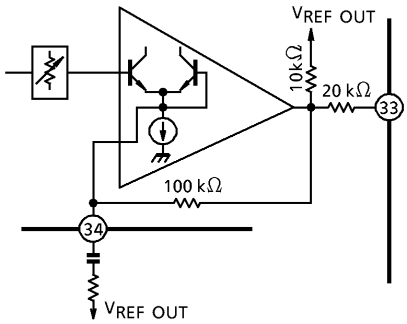
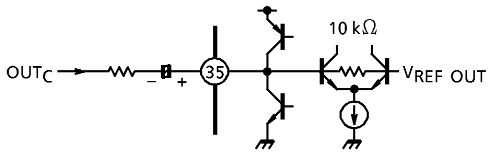
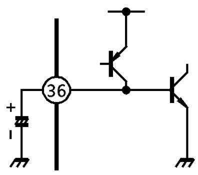
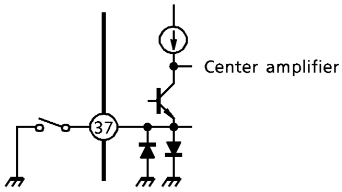
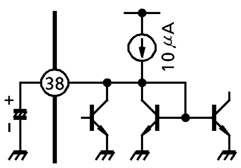


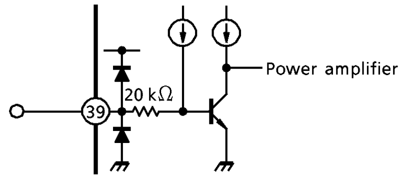
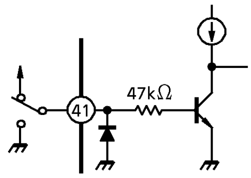
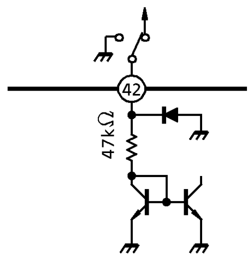
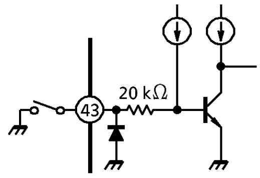
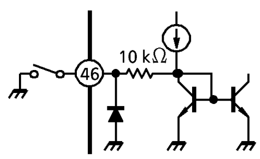
TERMINAL EXPLANATION

(Terminal voltage : Typical terminal voltage at no signal with test circuit, V_{CC} = 1.3 V, Ta = 25°C)

TERMINAL No.	TERMINAL NAME	FUNCTION	INTERNAL CIRCUIT	TERMINAL VOLTAGE (V)
1	$IN_{A\text{-}F}$	Input of preamplifier F / R SW (pin 44) ("L" level : Pin 1 / 2 "H" level : Pin 4 / 5) Refer to application note 3 (2)		0.73
2	$IN_{B\text{-}F}$			
4	$IN_{B\text{-}R}$			
5	$IN_{A\text{-}R}$			
6	$PRE\ NF_A$	NF of preamplifier		0.7
11	$PRE\ NF_B$			
3	$V_{REF\ OUT}$	Output of reference circuit		0.73
48	$V_{REF\ IN}$	Input of reference circuit		
7	$PRE\ OUT_A$	Output of preamplifier		0.44
10	$PRE\ OUT_B$			
8	$MTL\ DRV_A$	Metal driver terminal On resistance : 90 Ω (Typ.)		—
9	$MTL\ DRV_B$			
12	AMS IN	Input of mixer amplifier for AMS signal		0.7
14	AMS MIX	Output of mixer amplifier for AMS signal		0.7
13	AMS SW	AMS sensitivity changeover switch (This switch synchronizes with the MT SW)		—

TERMINAL No.	TERMINAL NAME	FUNCTION	INTERNAL CIRCUIT	TERMINAL VOLTAGE (V)
15	AMS DET	Input of AMS comparator circuit		0.73
40	AMS OUT	Output of AMS comparator circuit (High level : Rectangular pulse Low level : "H")		—
16	GND	—	—	0
17	RF OUT	Output of ripple filter ● Ripple filter circuit supplies internal circuit except power drive stage with power source		1.22
18	BASE	Base biasing terminal of transistor for ripple filter		0.5
19	V_{CC}	—		1.3
24	RF IN	Ripple filter terminal		1.23
20	OUT_A	Output of power amplifier		0.56
22	OUT_B			
26	PW NF_B	NF of power amplifier		0.73
29	PW NF_A			
27	PW IN_B	Input of power amplifier (This terminal also has function of an ADD amplifier Input.)		0.73
28	PW IN_A			
21	OUT_C	Output of center amplifier		0.56
32	PW IN_C	Input of center amplifier		0.73
23	PW GND	Power GND for power drive stage	—	0
25	EQ_B	Equalizer circuit (This circuit synchronizes with the BST SW) ● Input impedance : 1.9 kΩ (Typ.)		—
30	EQ_A			

TERMINAL No.	TERMINAL NAME	FUNCTION	INTERNAL CIRCUIT	TERMINAL VOLTAGE (V)
31	LPF	Low pass filter terminal of bass boost		0.73
33	BST OUT	Output of boost amplifier		0.73
34	BST NF	NF of boost amplifier		0.73
35	AGC IN	Input of boost AGC circuit ● The input level to the boost amplifier is controlled by the input level of this terminal. ● Input impedance : 10 kΩ (Typ.)		0.73
36	DET	Smoothing terminal of boost AGC circuit		—
37	C-AMP SW	Center amplifier on / off switch ● Output type of power amplifier OCL type : OPEN (C-AMP ON) Output coupling type: GND (C-AMP OFF)		—
38	MT TC	Smoothing terminal of MT SW In order to reduce a pop noise at power amplifier on / off switching		0.7

TERMINAL No.	TERMINAL NAME	FUNCTION	INTERNAL CIRCUIT	TERMINAL VOLTAGE (V)
39	BEEP	Input of beep signal ● This terminal receives beep signal of a microcomputer etc. ● This terminal should be set as high impedance or "H" when not using this function		0.7
41	MT SW	Muting switch of power amplifier (Power amp. on : "H" level Power amp. off : "L" level) Refer to application note 3 (2)		—
44	F / R SW	Forward / Reverse switch (Forward : "L" level Reverse : "H" level) Refer to application note 3 (2)		—
45	PRE SW	Muting switch of preamplifier (Preamp. on : "L" level Preamp. off : "H" level) Refer to application note 3 (2)		—
42	PW SW	Power on / off switch (IC on : "H" level IC off : "L" level) Refer to application note 3 (2)		—
43	BST SW	Boost on / off switch (BST on : OPEN / "H" level BST off : "L" level) Refer to application note 3 (2)		—
46	M / N SW	Metal / Normal mode switch (Metal mode : OPEN / "H" level Normal mode : "L" level) Refer to application note 3 (2)		—
47	PRE GND	Power GND for power drive stage	—	0

APPLICATION NOTE

1. PREAMPLIFIER STAGE

(1) Output DC voltage of preamplifier

Output DC voltage of preamplifier is determined by external resistors R1 and R2 as shown in Fig.1.

$$V_{O\,(PRE)} = V_{REF\ OUT} - \Delta V \times (R2 / R1 + 1)$$

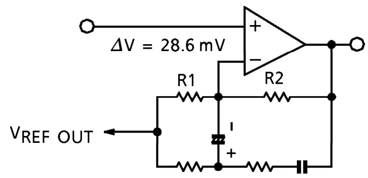


Fig.1 Output DC voltage of preamplifier

- $V_{REF\ OUT}$ = 0.73 V (Typ.)
- ΔV is an offset voltage which is designed to 28.6 mV.

It is as follows in case that the DC voltage is calculated by the constant of a test circuit.

$$V_{O\,(PRE)} = 0.73\ \mathrm{V} - 28.6\ \mathrm{mV}\ (200\ \mathrm{k}\Omega / 22\ \mathrm{k}\Omega + 1) = 0.44\ \mathrm{V}$$

Output DC voltage of preamplifier should be fixed about $V_{CC}/2$, because preamplifier get a enough dynamic range.

(2) AMS (Automatic Music Sensor) function

A block diagram is shown in Fig.2. This function can AMS (Automatic Music Sensor) and BS (Blank skip).

- The comparator input level is higher than comparator sensitivity.
  → Rectangle wave is outputted.
- The comparator input level is lower than comparator sensitivity.
  → High level is outputted.

The sensitivity changeover is determined by AMS switch (The comparator sensitivity doesn't change.).

- Automatic Music Sensor Mode

  The AMS SW is also turned on when the MT SW is turned on. And the comparator input level is determined by external resistors (R4~R6) and capacitors (C3, C4) from mixer amplifier output level.
  The transfer function is as follows.

$$V_O / V_i = R3 / [R1 \cdot R2 / (R1 + R2)] \times \{j\omega C4 \cdot R5 \cdot R6 / [R4 \cdot R5 + j\omega (C3 \cdot R4 \cdot R5 + C4 \cdot R4 \cdot R5 + C4 \cdot R4 \cdot R6 + C4 \cdot R5 \cdot R6) - \omega^2 C3 \cdot C4 \cdot R4 \cdot R5 \cdot R6]\}$$

- Blank Skip Mode

  The AMS SW is also turned of when the MT SW is turned off. And the comparator input level is determined by external resistors (R4, R6) and capacitors (C3, C4) from mixer amplifier output level.

  The transfer function is as follows.

$$V_O / V_i = R3 / [R1 \cdot R2 / (R1 + R2)] \times \{j\omega C4 \cdot R6 / [1 + j\omega (C3 \cdot R4 + C4 \cdot R4 + C4 \cdot R6) - \omega^2 C3 \cdot C4 \cdot R4 \cdot R6]\}$$

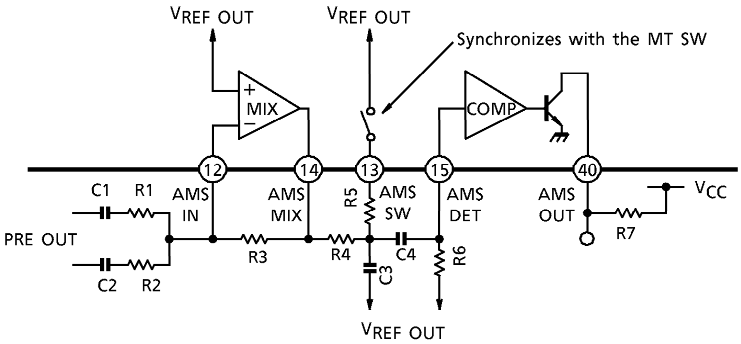


Fig.2 AMS system

2. POWER AMPLIFIER STAGE

(1) Input of power amplifier

Each input signal should be applied through a capacitor. In case that DC current or DC voltage is applied to each amplifier, the internal circuit has unbalance and the each amplifier doesn't operate normally.
It is advised that input signal refer to V_{REF} voltage, in order to reduce a pop noise or low frequency leak.

(2) Output application

This IC can chose the output coupling type and OCL type. The C-AMP SW should be connected to GND in case that the output coupling type is chosen. The supply current decreases when not using the bass boost function.

(3) Bass boost function

(a) System

This IC has the bass boost function in power amplifier stage. After this system adds the low frequency ingredient of side amplifier, it is applied into the center amplifier. And the bass boost level is controlled by the variable impedance circuit (Fig.3)

- Flow of the bass boost signal
  Variable impedance circuit → Boost amplifier → Center amplifier
- Flow of the bass boost level
  Output of center amplifier → AGC DET (Level detection) →
  Variable impedance circuit operation

The system of treble boost function is realized by frequency characteristic adjustment of the side amplifier.

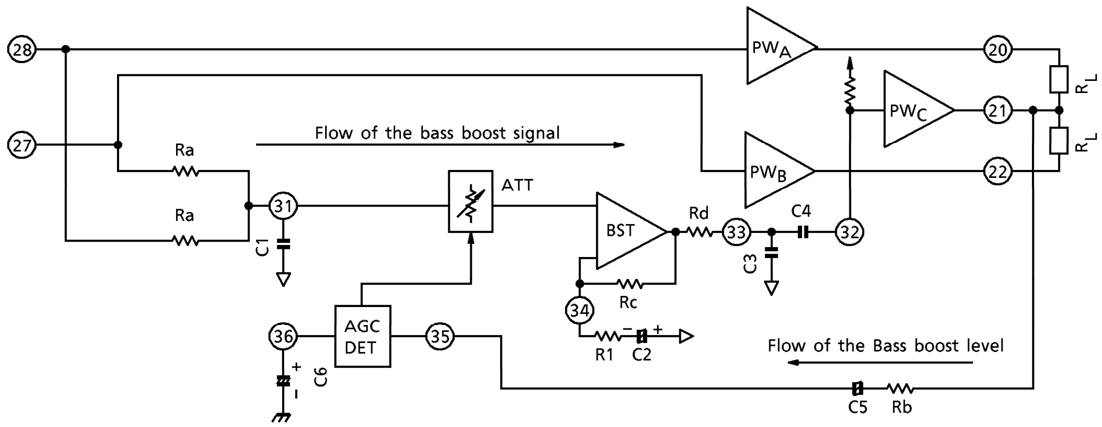


Fig.3 Bass boost system

(b) AGC circuit

The AGC circuit of bass boost function is realized by the variable impedance circuit. The AGC DET circuit detects the low frequency level of center amplifier. When this level becomes high, the variable impedance circuit operates, and this circuit attenuates the input level of center amplifier.
The AGC DET circuit is the current input, so that the output voltage of ADD amplifier is changed into the current ingredient by resistor Rb and capacitor C5 which are shown in Fig.3. And it is smoothed and detected by DET circuit (pin 36). And the direct current should not be applied to the AGC IN circuit, because, as for the circuit, the sensitivity setup is high.
Moreover, the AGC signal level is decreased in case that the resistor R5 is connected with the capacitor C5 in series. And the AGC point can be changed. But the center amplifier is clipped in the low frequency in case that the resistor R5 is larger.

(c) Bass boost

The signal flow of bass boost function is as follows, refer to Fig.4.

LPF (internal resistors 2R1 and external capacitor C1)

→ATT (variable impedance circuit)

→HPF (BST amplifier)

→BPF (LPF : internal resistor R4 and external capacitor C3, HPF : external capacitor C4 and internal resistor R5)

→Center amplifier

The center amplifier signal becomes the reverse phase, because the phase of audio frequency range is reversed with two LPFs.

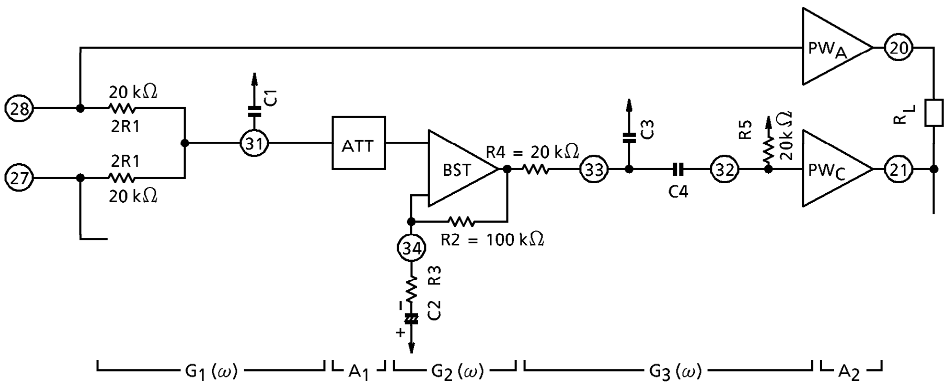


Fig.4 Block diagram of bass boost

The transfer function of bass boost is as follows from Fig.4.

$$G(\omega) = G_1(\omega) \cdot A_1 \cdot G_2(\omega) \cdot G_3(\omega) \cdot A_2$$

The bass boost effect is changed by external resistor or external capacitor. The transfer function and cut off frequency are as follows.

① Transfer function of LPF

$$G_1(\omega) = 1/(1 + j\omega C1 \cdot R1)$$
$$f_L = 1/2\pi C1 \cdot R1$$

② Transfer function of BPF

$$G_3(\omega) = j\omega C4 \cdot R5/[1 + j\omega(R4 \cdot C3 + R5 \cdot C3 + C4 \cdot R4) - \omega^2 R4 \cdot C3 \cdot R5 \cdot C4]$$
$$f_O = 1/2\pi\sqrt{R4 \cdot C3 \cdot R5 \cdot C4}$$

③ HPF gain and cut off frequency

$$G_2(\omega) = 1 + R2/(R3 + 1/j\omega C2)$$
$$f_{HC} = 1/(2\pi R3 \cdot C2)$$

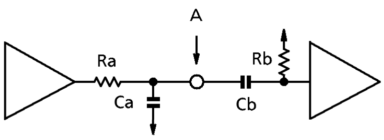
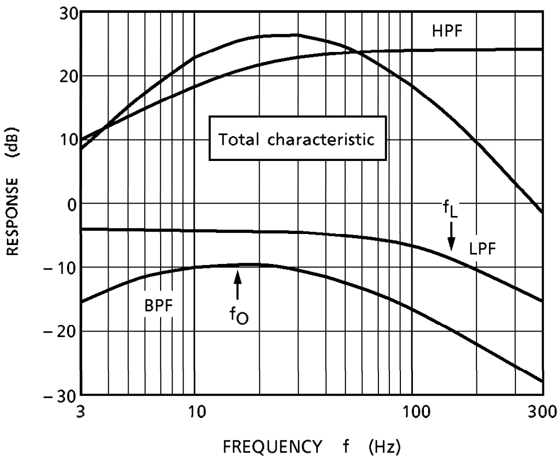


Fig.5 BPF



Graph. 1 Characteristic of bass boost

④ f_O and f_L

The f_L and f_O should be set up out of the audio frequency range. In case that the f_O and f_L is inside of audio frequency range and AGC circuit operates, the voltage gain decrease.

⑤ HPF

The f_{HC} should be made 1/2 or less frequency as compared with the f_L or f_O. The phase difference is large near the f_{HC}, so that the bass boost level runs short. And the HPF gain of middle or high frequency range should be set to 10 dB or more.

(4) Treble boost

The EQ terminal is synchronizes with the BST SW, and the input impedance is changed.

BST OFF : 100 kΩ (Typ.)

BST ON : 1.9 kΩ (Typ.)

The voltage gain increase 6 dB (Typ.) at high frequency range in case that the capacitor CX is connected between the EQ terminal and the PW NF terminal.

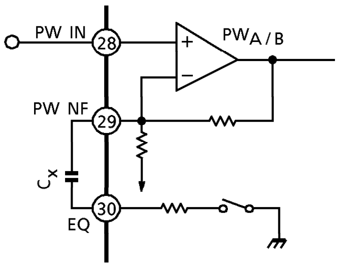


Fig.6 Treble boost

(5) Cross talk of output coupling type

In case of output coupling mode, the cross talk is determined by resistor R_L and capacitor C which are connected with power amplifier output as shown in Fig.7.
The formula is shown below.

$G(\omega) = 1/2\,[1 + j\omega C\,(R_L/2)]$

$CT = 20\ell og\,|G_V| = 20\ell og\,[1/2\,[\sqrt{1 + (\omega/\omega_0)^2}]],\ \omega_0 = 1/C\,(R_L/2)$

At f = 1 kHz, C1 = 220 μF, R_L = 32 Ω, The cross talk becomes about 33 dB.

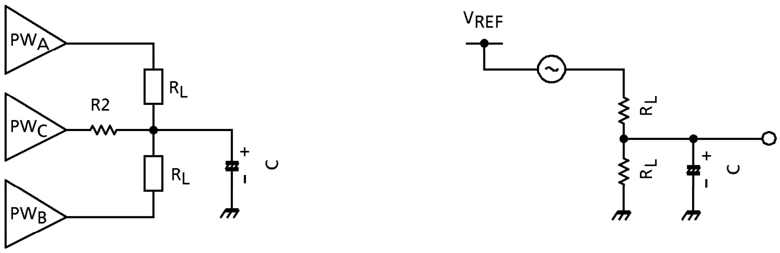


Fig.7 Cross talk of output coupling type

3. Total

(1) Ripple filter

It is necessary to connect a low saturation transistor (2SA1362 etc.) for ripple filter, because this IC doesn't have transistor for ripple filter. Care should be taken to stabilize the ripple filter circuit, because the ripple filter circuit supplies internal circuit except power drive stage with power source.

(2) Switch terminal

(a) PW SW

It is necessary to connect an external pull-down resistor with terminal PW SW, in case that this IC is turned on due to external noise etc. (The PW SW sensitivity is designed highly.)

(b) MT SW, BST SW, F / R SW, PRE SW, M / N SW

The current flows through terminals of MT SW, BST SW, PRE SW and M / N SW, in case that these terminals are connected with V_{CC} line independently, even though the PW SW is off-mode. It is necessary to connect an external pull-down resistor with each terminals in case that IC is turned on due to external noise etc. These switches are designed highly.)

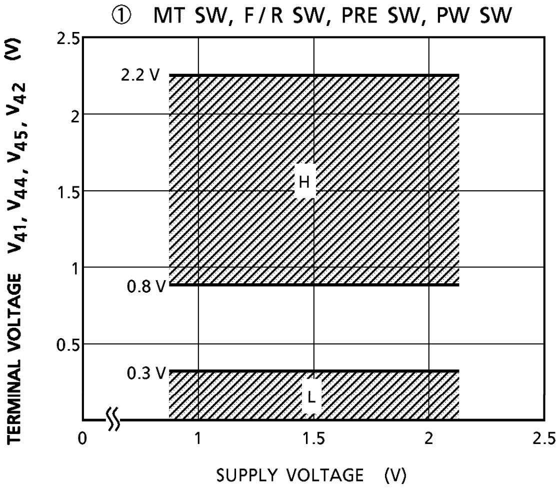
- The pop noise at turning on / off MT SW can be reduced by the external capacitor of the MT TC terminal.

(c) C-AMP SW

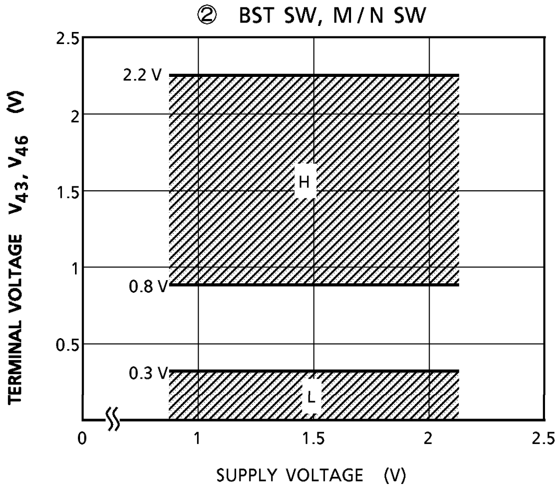
The C-AMP SW terminal should not be connected with high voltage of V_{CC} etc., because internal circuit is broken.

(d) Sensitivity voltage of each switch (Ta = 25°C)

① MT SW, F / R SW, PRE SW, PW SW



② BST SW, M / N SW



	MT SW (V_{41})	F / R SW (V_{44})	PRE SW (V_{45})	PW SW (V_{42})
'H'	Muting OFF	REV mode	Preamp. OFF	IC ON
'L'	Muting ON	FWD mode	Preamp. ON	IC OFF

	BST SW (V_{43})	M / N SW (V_{46})
'H', OPEN	BST ON	Metal mode
'L'	BST OFF	Normal mode

(3) Capacitor

Small temperature coefficient and excellent frequency characteristic is needed by capacitor below.

- Oscillation preventing capacitors for power amplifier output
- Capacitor between V_{REF} and GND
- Capacitor between V_{CC} and GND
- Capacitor between RF OUT and GND

MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V_{CC}	4.5	V
Output Current (PW AMP.)	$I_{O\ (peak)}$	100	mA
Power Dissipation	P_D (Note)	750	mW
Operating Temperature	T_{opr}	−25 ~ 75	°C
Storage Temperature	T_{stg}	−55 ~ 150	°C

Note : Derated above Ta = 25°C in proportion of 6 mW / °C

ELECTRICAL CHARACTERISTICS

Unless otherwise specified : V_{CC} = 1.3 V, Ta = 25°C, f = 1 kHz, SW1 : b, SW2 : b, SW3 : a, SW4 : OPEN
SW5 : a, SW6 : a, SW7 : ON, SW8 : a / b, SW9 : b, SW10 : ON

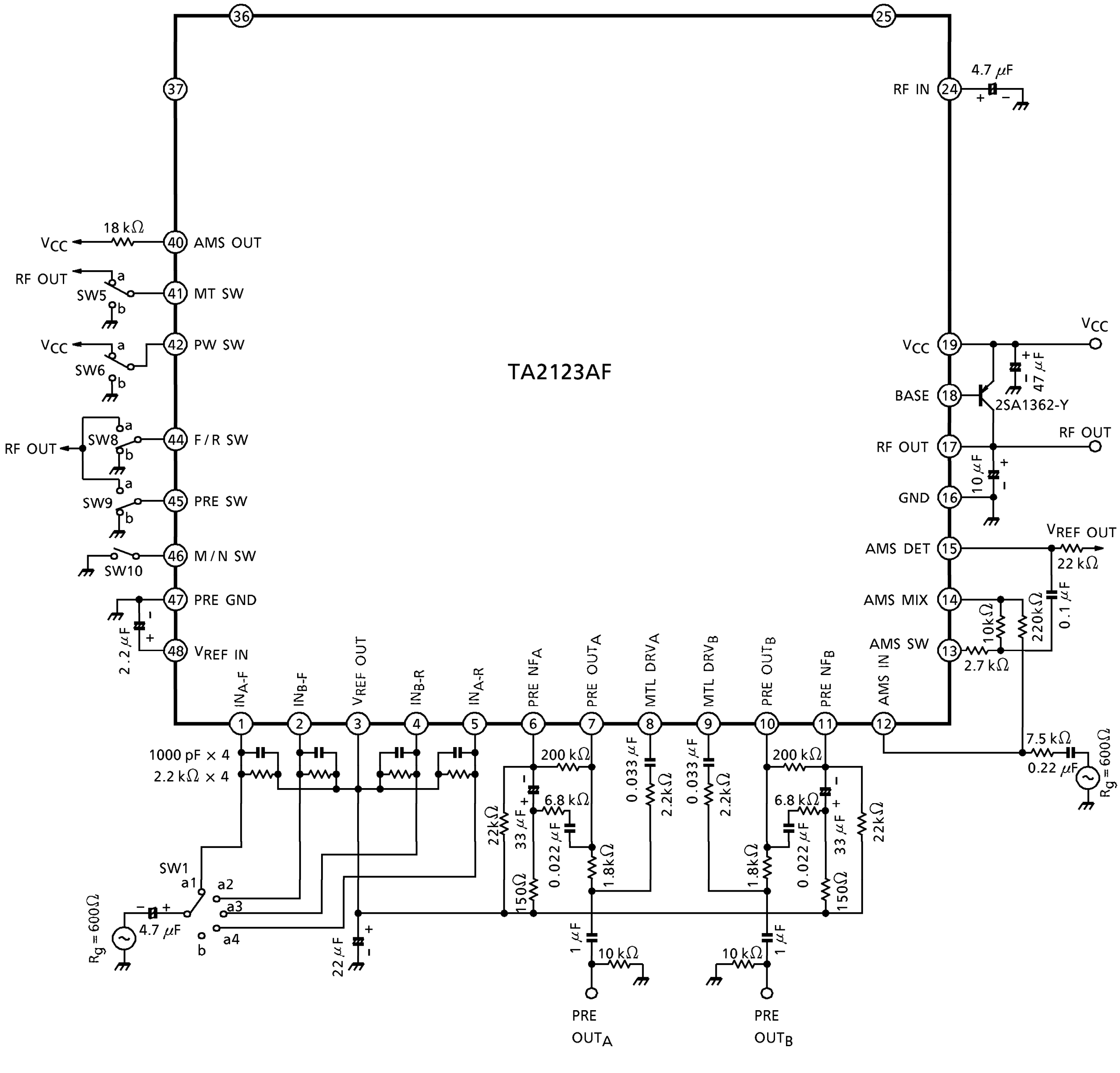
Preamplifier : Normal mode, Rg = 2.2 kΩ, R_L = 10 kΩ, SW1 : a

Power amplifier : Rg = 600 Ω, R_L = 32 Ω, SW2 : a

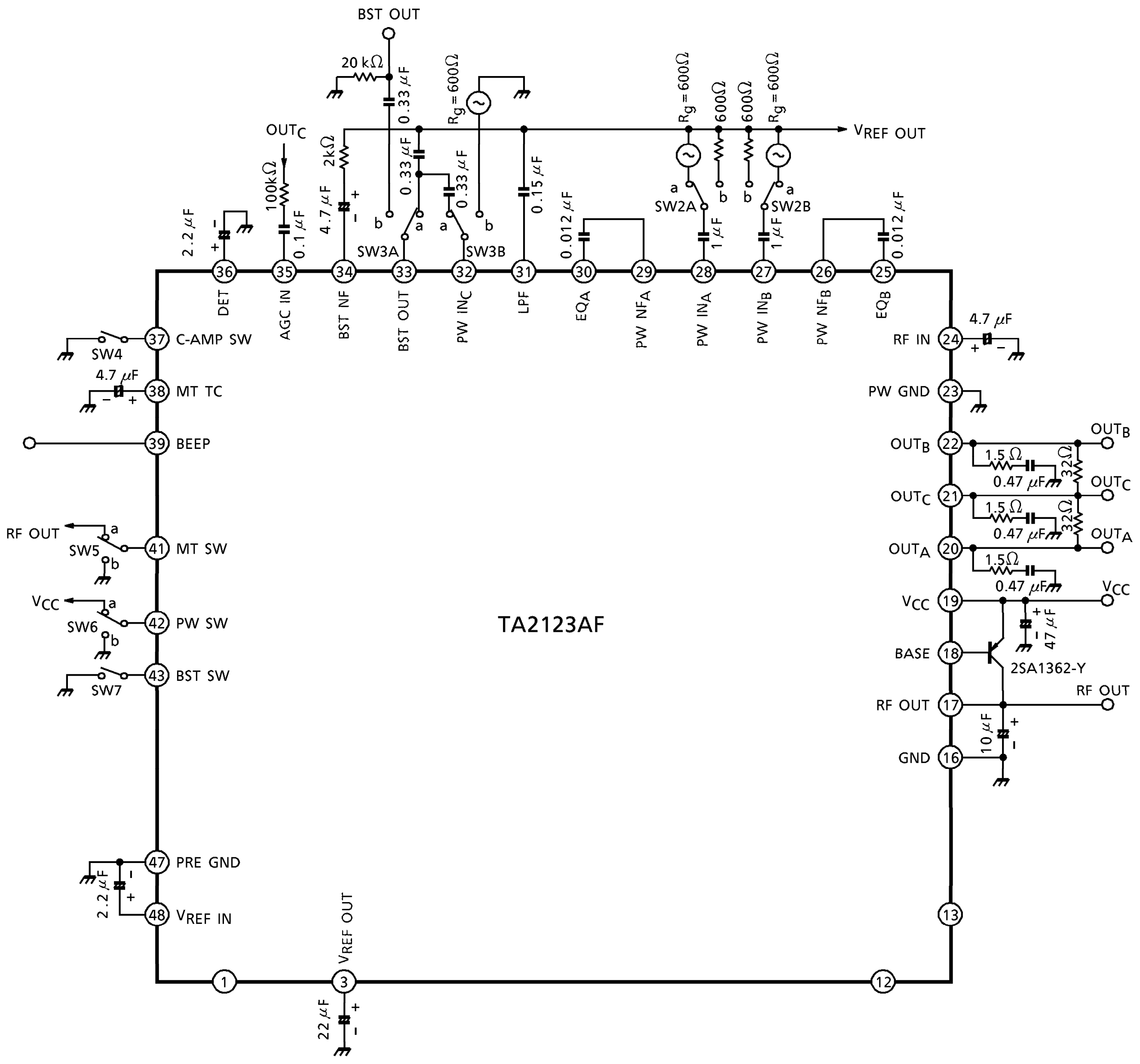
CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Quiescent Supply Current 1		I_{CCQ1}	—	OCL mode, PRE + PW	—	2.2	4.0	mA
Quiescent Supply Current 2		I_{CCQ2}	—	OCL mode, PRE : OFF SW9 : a	—	1.7	3.0	
Quiescent Supply Current 3		I_{CCQ3}	—	Coupling mode PRE + PW, SW4 : ON	—	1.5	2.7	
Quiescent Supply Current 4		I_{CCQ4}	—	Coupling mode PRE : OFF, SW4 : ON SW9 : a	—	1.0	1.8	
Preamp. stage	Open Loop Voltage Gain	G_{VO}	—	V_o = −22 dBV NF resistor (150 Ω) : Short	65	80	—	dB
	Closed Loop Voltage Gain	G_{VC}	—	V_o = −22 dBV	—	35	—	
	Maximum Output Voltage	V_{om1}	—	THD = 1%	160	250	—	mV_{rms}
	Total Harmonic Distortion	THD1	—	V_{CC} = 1 V, V_o = −22 dBV	—	0.08	0.3	%
	Equivalent Input Noise Voltage	V_{ni}	—	Rg = 2.2 kΩ BPF : 20 Hz~20 kHz NAB (G_V = 35 dB, f = 1 kHz) SW1 : b	—	1.7	2.7	μV_{rms}
	Cross Talk (CH-A / CH-B)	CT1	—	V_o = −22 dBV	—	60	—	dB
	Cross Talk (Forward / Reverse)	CT2	—		—	62	—	
	Ripple Rejection Ratio	RR1	—	f_r = 100 Hz, V_r = −32 dBV BPF = 100 Hz	—	54	—	
	Preamplifier Muting Attenuation	ATT1	—	V_o = −22 dBV SW9 : b → a	—	84	—	
	Driver On Resistance	R1	—	I_L = 100 μA, SW10 : OPEN	—	90	—	Ω
AMS Sensitivity 1		AMS1	—	SW5 : b	− 58.3	− 56.3	− 54.3	dBV
AMS Sensitivity 2		AMS2	—	SW5 : a	− 69.7	− 67.7	− 65.7	
Forward Mode On Voltage		V_{44}	—	V_{CC} = 0.95 V	0	—	0.3	V
Reverse Mode On Current		I_{44}	—		5	—	—	μA
Preamplifier On Voltage		V_{45}	—		0	—	0.3	V
Preamplifier Off Current		I_{45}	—		5	—	—	μA
Metal Mode On Voltage		$V_{46 (M)}$	—		0.8	—	0.95	V
Normal Mode On Voltage		$V_{46 (N)}$	—		0	—	0.3	V

	CHARACTERISTIC	SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Power amp. stage	Voltage Gain 1	G_{V1}	—	V_o = −22 dBV	—	24	—	dB
	Channel Balance	CB	—		−1.5	0	+1.5	
	Voltage Gain 2	G_{V2}	—	$V_{in (A)}$ = $V_{in (B)}$ = $-V_{in (C)}$ V_o = −22 dBV	28	30	32	
	Output Power	P_o	—	V_{CC} = 1.5 V THD (A) = THD (B) = 10%	3	6	—	mW
	Total Harmonic Distortion	THD	—	P_o = 1 mW	—	0.1	0.8	%
	Output Noise Voltage	V_{no}	—	Rg = 600 Ω, SW2 : b BPF = 20 Hz ~ 20 kHz	—	40	80	μV_{rms}
	Cross Talk	CT3	—	V_o = −22 dBV	34	43	—	dB
	Ripple Rejection Ratio	RR2	—	V_{CC} = 1 V, f_r = 100 Hz V_r = −32 dBV, BPF = 100 Hz	—	70	—	
	Power Amplifier Muting Attenuation	ATT2	—	V_o = −22 dBV SW5 : a → b	—	72	—	
	Beep Signal Input Sensitivity	SEN	—	V_o = −62 dBV, SW5 : OPEN	0.7	1.3	2.2	μA_{p-p}
Boost amp. stage	Voltage Gain 3	G_{V3}	—	f = 40 Hz, V_{in} = −64 dBV SW7 : OPEN Monitor : C-AMP. −GND	41	44	47	dB
	Voltage Gain 4	G_{V4}	—	f = 40 Hz, V_{in} = −47 dBV SW7 : OPEN Monitor : C-AMP. −GND	27.5	30.5	33.5	
	Maximum Output Voltage	V_{om2}	—	f = 40 Hz, THD = 1% SW3 : b, SW7 : OPEN	—	86	—	mV_{rms}
	Muting Attenuation	ATT3	—	f = 40 Hz, V_o = −32 dBV SW7 : OPEN → ON	—	53	—	dB
	Equalizer On Resistance	R2	—	I_L = 100 μA, SW7 : OPEN	—	1.9	—	kΩ
Ripple Filter Output Voltage		$V_{RF\ OUT}$	—	V_{CC} = 1 V, I_{RF} = 20 mA	0.89	0.92	—	V
Ripple Filter Ripple Rejection Ratio		RR3	—	V_{CC} = 1 V, I_{RF} = 20 mA BPF = 100 Hz, f_r = 100 Hz V_r = −32 dBV	35	42	—	dB
Power Amplifier On Current		I_{41}	—	V_{CC} = 0.95 V	5	—	—	μA
Power Amplifier Off Voltage		V_{41}	—		0	—	0.3	V
Power On Curent		I_{42}	—		5	—	—	μA
Power Off Voltage		V_{42}	—		0	—	0.3	V
Boost On Voltage		$V_{43 (ON)}$	—		0.8	—	0.95	V
Boost Off Voltage		$V_{43 (OFF)}$	—		0	—	0.3	V

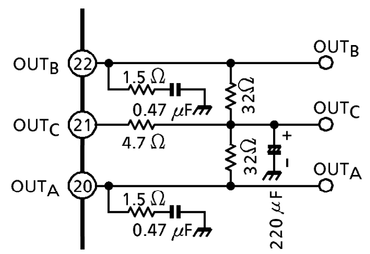
TEST CIRCUIT (PREAMPLIFIER STAGE)



TEST CIRCUIT (POWER AMPLIFIER STAGE)

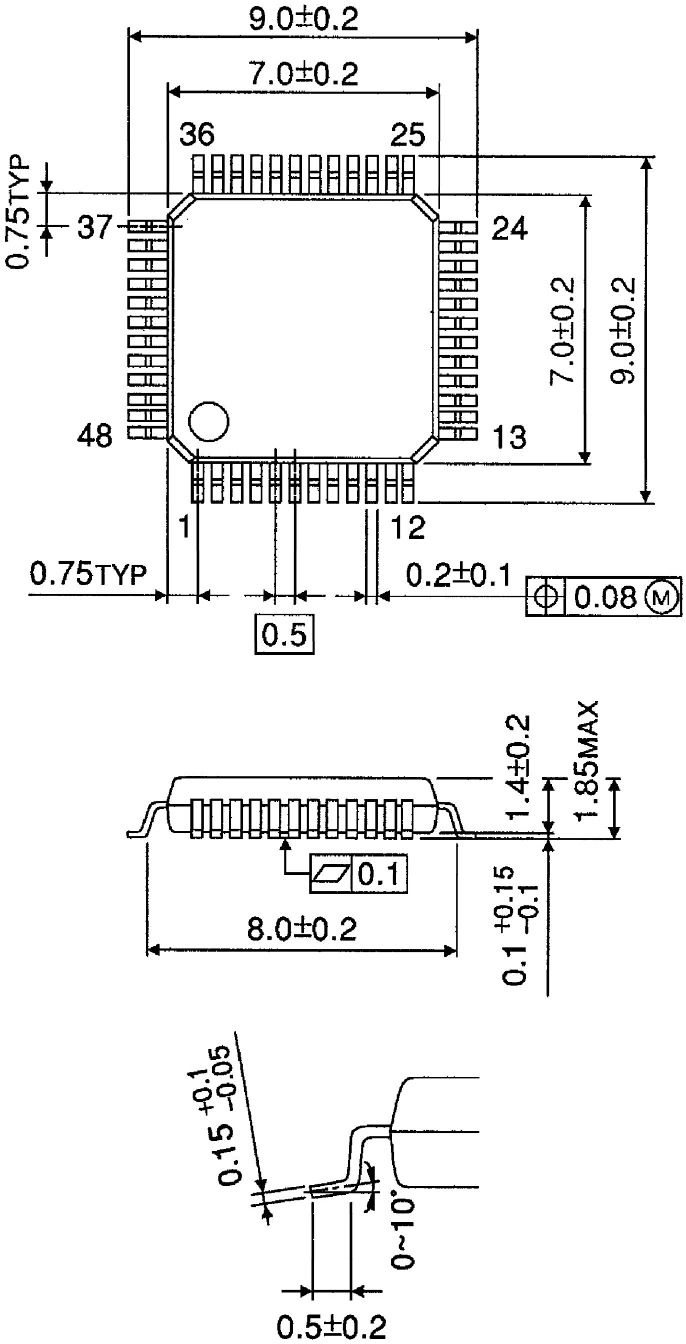


Output circut of outu coupling type



PACKAGE DIMENSIONS

LQFP48-P-0707-0.50 Unit : mm



Weight : 0.17 g (Typ.)