

Toshiba Bipolar Integrated Circuit Silicon Monolithic

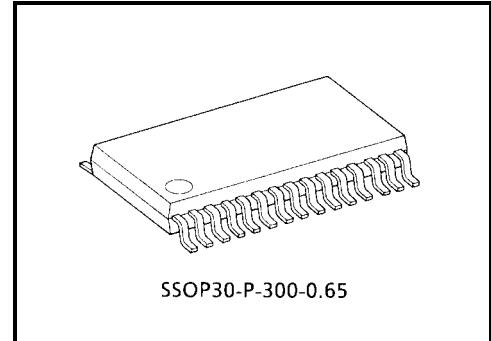
# TA2160FN

Low Consumption Current Stereo Headphone Amplifier (1.5/3 V use)

The TA2160FN is low consumption current stereo headphone amplifier IC for headphone stereo. It is suitable for 1.5 V or 3 V headphone stereo.

## Features

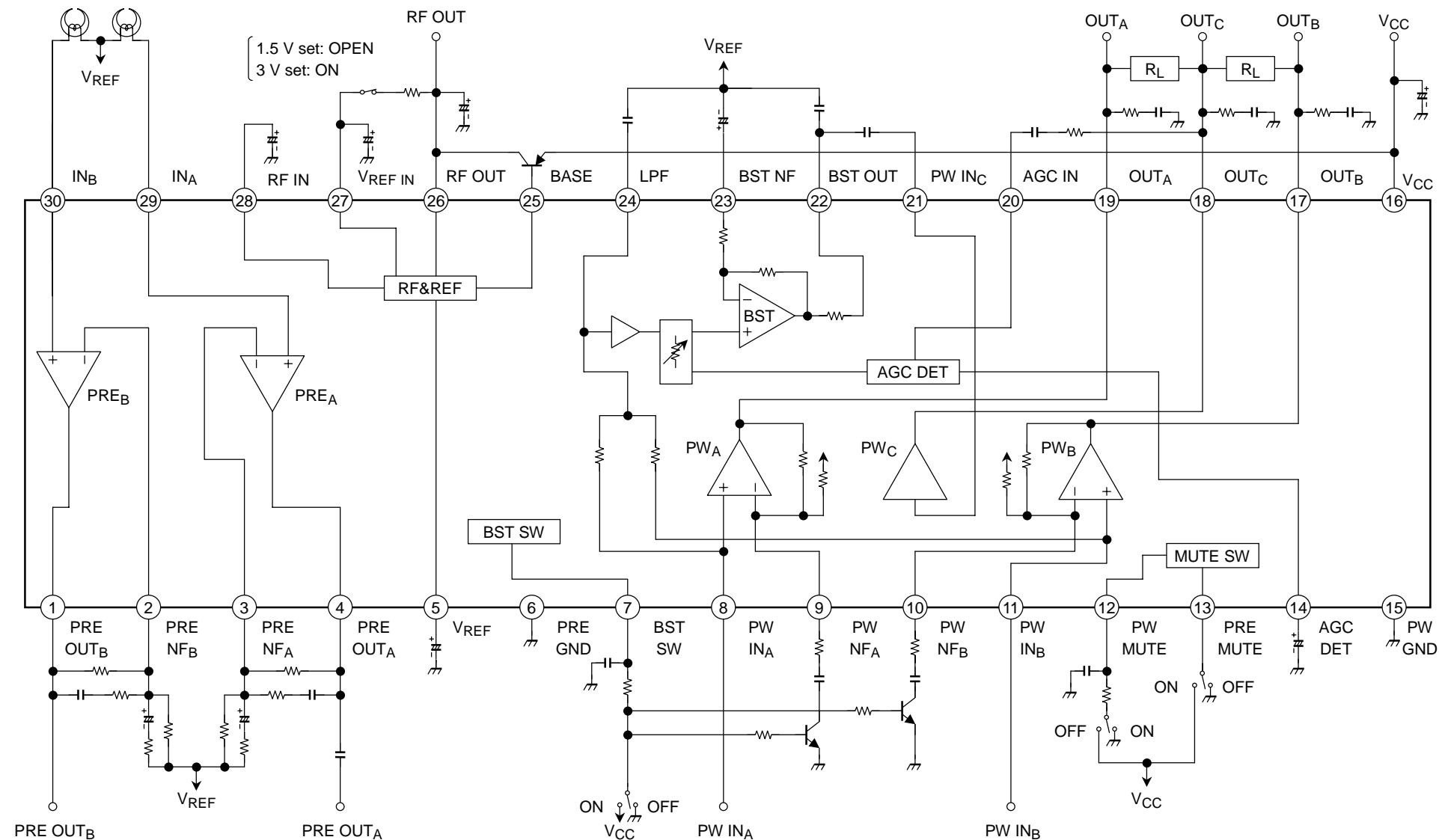
- Low consumption current  
Current value ( $f = 1 \text{ kHz}$ ,  $R_L = 32 \Omega$ ,  $T_a = 25^\circ\text{C}$ , typ.)
  - $V_{CC} = 1.3 \text{ V}$   
 $IC_{CQ} = 1.6 \text{ mA}$  (No signal)  
 $IC_{C} = 4.6 \text{ mA}$  ( $0.1 \text{ mW} \times 2 \text{ ch}$ )  
 $IC_{C} = 8.6 \text{ mA}$  ( $0.5 \text{ mW} \times 2 \text{ ch}$ )
  - $V_{CC} = 3 \text{ V}$   
 $IC_{CQ} = 3.0 \text{ mA}$  (No signal)  
 $IC_{C} = 4.8 \text{ mA}$  ( $0.1 \text{ mW} \times 2 \text{ ch}$ )  
 $IC_{C} = 8.8 \text{ mA}$  ( $0.5 \text{ mW} \times 2 \text{ ch}$ )
- Built-in ripple filter
- Preamplifier stage
  - Built-in input capacitor for reducing buzz noise
  - Input coupling condenser-less
  - Built-in preamplifier mute
- Power amplifier stage
  - Built-in bass boost function with AGC
  - Built-in treble boost function
  - Built-in input capacitor for reducing buzz noise
  - $G_V = 25\text{dB}$  (typ.)
  - Built-in power amplifier mute
- Operating supply voltage range ( $T_a = 25^\circ\text{C}$ )  
 $V_{CC(\text{opr})} = 0.95 \text{ to } 4.5 \text{ V}$



SSOP30-P-300-0.65

Weight: 0.17 g (typ.)

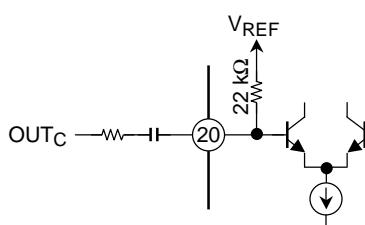
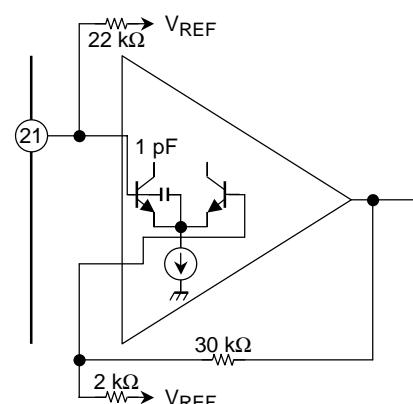
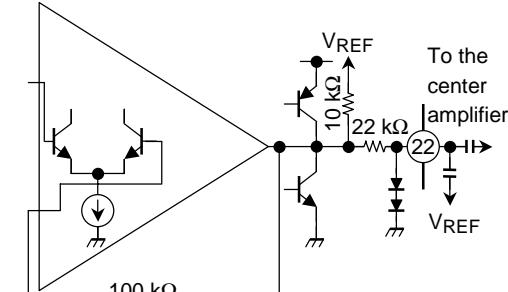
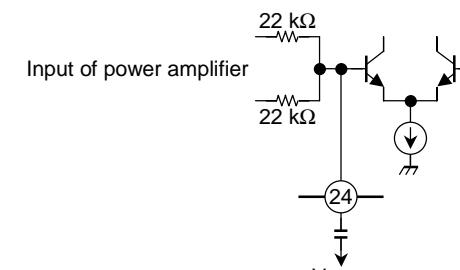
## Block Diagram



**Terminal Explanation (terminal voltage: typical terminal voltage at no signal with test circuit,  $V_{CC} = 1.3$  V,  $T_a = 25^\circ\text{C}$ )**

Terminal		Function	Internal Circuit	Terminal Voltage (V)
No.	Name			
1	PRE OUT <sub>B</sub>	Input of preamplifier		0.44
4	PRE OUT <sub>A</sub>			
17	OUT <sub>B</sub>	Output of power amplifier		0.56
18	OUT <sub>C</sub>			
19	OUT <sub>A</sub>			
2	PRE NF <sub>B</sub>	NF of preamplifier		0.7
3	PRE NFA			
29	IN <sub>A</sub>	Input of preamplifier		0.73
30	IN <sub>B</sub>			
5	V <sub>REF</sub>	Reference circuit		0.73
27	V <sub>REF</sub> IN	Input of reference circuit		
6	PRE GND	—	—	0
7	BST SW	Boost on/off switch (BST on: H level or open BST off: L level) Refer to application note 3 (2) This switch is the control terminal of the bass boost function. When it is synchronized with treble boost function, the external connection with the PW NF terminal is required. Refer to application circuit.		—
12	PW MUTE	Muting switch of power amplifier (PW MUTE OFF: H level or open PW MUTE ON: L level) Refer to application note 3 (2)		

Terminal		Function	Internal Circuit	Terminal Voltage (V)
No.	Name			
8	PW IN <sub>A</sub>	Input of power amplifier (This terminal also has function of ADD amplifier input.)		0.73
11	PW IN <sub>B</sub>			
9	PW NF <sub>A</sub>	NF of power amplifier		0.72
10	PW NF <sub>B</sub>			
13	PRE MUTE	Muting switch of preamplifier  PRE MUTE ON: H level PRE MUTE OFF: L level  Refer to application note 3 (2)		—
14	AGC DET	Smoothing terminal of boost AGC circuit		—
15	PW GND	Power GND for power drive stage	—	0
16	V <sub>CC</sub>	—	—	1.3
25	BASE	Base biasing terminal of transistor for ripple filter		0.6
26	RF OUT	Output of ripple filter  Ripple filter circuit supplies internal circuit except power drive stage with power source		
28	RF IN	Ripple filter terminal		

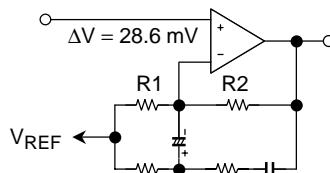
Terminal		Function	Internal Circuit	Terminal Voltage (V)
No.	Name			
20	AGC IN	Input of boost AGC circuit The input level to the boost amplifier is controlled by the input level of this terminal. Input impedance: 22 k $\Omega$ (typ.)		—
21	PW INC	Input of center amplifier		0.73
22	BST OUT	Output of boost amplifier		0.73
23	BST NF	NF of boost amplifier		0.73
24	LPF	Low pass filter terminal of bass boost	Input of power amplifier 	0.73

## Application Note

### 1. Preamplifier Stage

Output DC voltage of preamplifier

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



**Figure 1 Output DC Voltage of Preamplifier**

$$V_{O(PRE)} = V_{REF} - \Delta V \times (R_2/R_1 + 1)$$

- $V_{REF} = 0.73$  V (typ.)

$V_{REF}$  is changed when resistance is connected between RF OUT terminal and  $V_{REF}$  IN terminal (Refer to application note 3 (1)).

- $\Delta V$  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.

$$\begin{aligned} V_{O(PRE)} &= 0.73 \text{ V} - 28.6 \text{ mV} (200 \text{ k}\Omega/22 \text{ k}\Omega + 1) \\ &= 0.44 \text{ V} \end{aligned}$$

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

### 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.

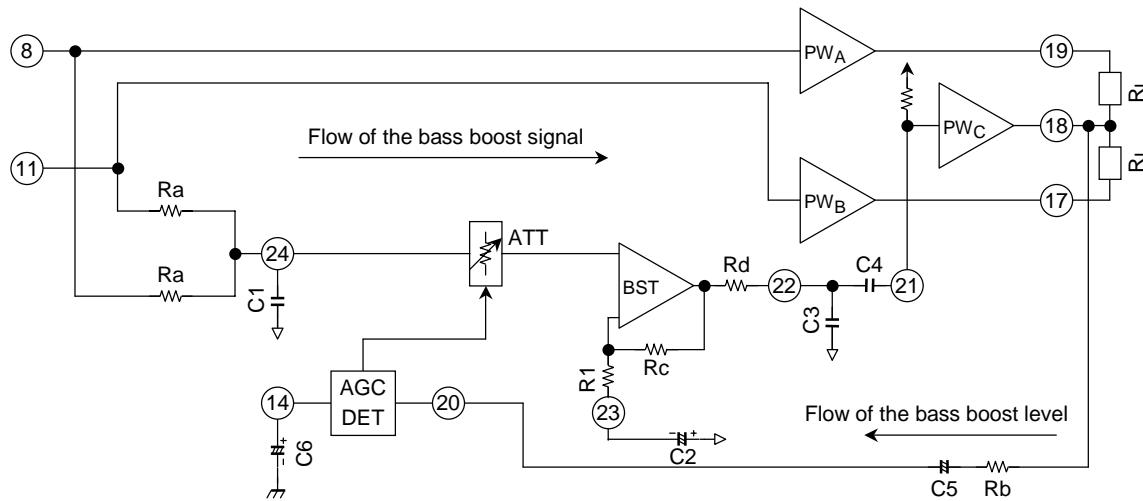
#### (2) Bass boost function

##### (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 (Figure 2)

- 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.



**Figure 2 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 Figure 2. And it is smoothed and detected by DET circuit (pin 14). 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 Figure 3.

LPF (internal resistors 2R1 and external capacitor C1)

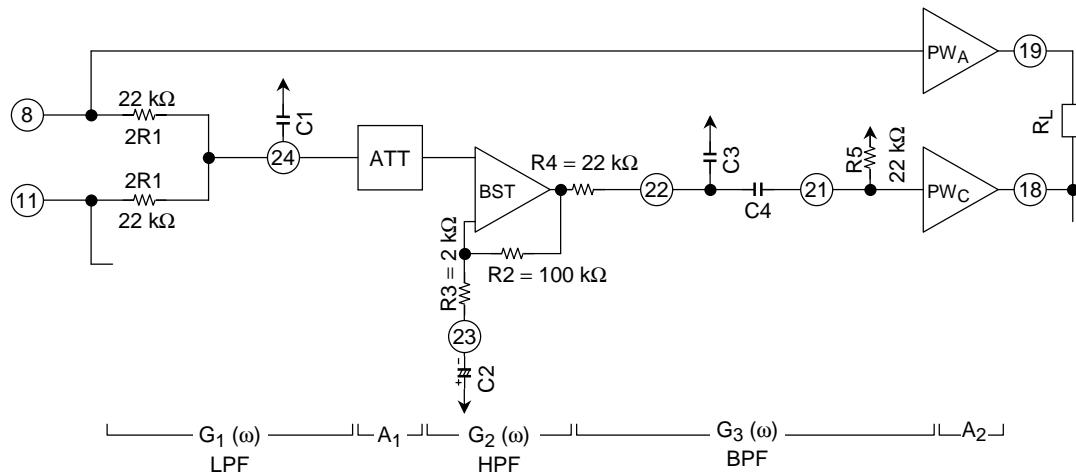
→ ATT (variable impedance circuit)

→ 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.



**Figure 3 Block Diagram of Bass Boost**

The transfer function of bass boost is as follows from Figure 3.

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

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

i Transfer function of LPF

$$G_1(\omega) = 1/(1 + j\omega C_1 \cdot R_1)$$

$$f_L = 1/2\pi C_1 \cdot R_1$$

ii Transfer function of BPF

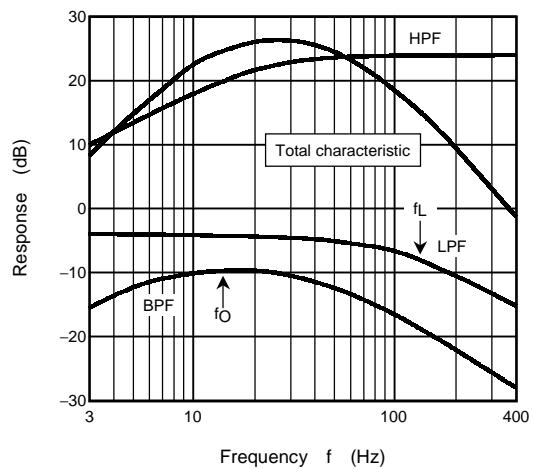
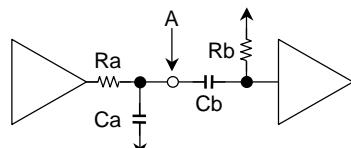
$$G_3(\omega) = j\omega C_4 \cdot R_5 / [1 + j\omega (R_4 \cdot C_3 + R_5 \cdot C_3 + C_4 \cdot R_4) - \omega^2 R_4 \cdot C_3 \cdot R_5 \cdot C_4]$$

$$f_O = 1/2\pi \sqrt{R_4 \cdot C_3 \cdot R_5 \cdot C_4}$$

iii HPF gain and cut off frequency

$$G_2(\omega) = 1 + R_2 / (R_3 + 1/j\omega C_2)$$

$$f_{HC} = 1/(2\pi R_3 \cdot C_2)$$



**Figure 4 BPF**

**Graph 1 Characteristic of Bass Boost**

iv f<sub>O</sub> and f<sub>L</sub>

The f<sub>L</sub> and f<sub>O</sub> should be set up out of the audio frequency range. In case that the f<sub>O</sub> and f<sub>L</sub> is inside of audio frequency range and AGC circuit operates, the voltage gain decrease.

## v HPF

The f<sub>HC</sub> should be made 1/2 or less frequency as compared with the f<sub>L</sub> and f<sub>O</sub>. The phase difference is large near the f<sub>HC</sub>, so that the bass boost level runs short. And the HPF gain of middle or high frequency range should be set to 10dB or more.

## (3) Treble boost function

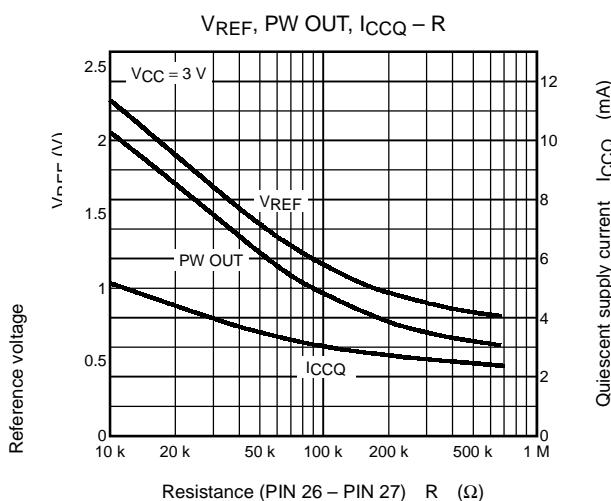
This function is realized by using the PW NF terminal. For details, please refer to application note.

**3. Total**

## (1) Changeover of power amplifier output DC voltage at 3 V set.

The output DC voltage of the power amplifier is raised by the resistance connected between the RF OUT terminal and the VREF IN terminal.

In case of 3 V set, the dynamic range spreads.



**Figure 5 Adjustment of output DC voltage**

## (2) Switch

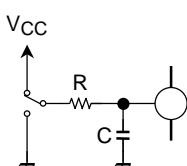
## (a) Switch terminal

The current flows through each terminal, in case that these terminals are connected with H level independently, even though the IC off mode.

It is necessary to connect an external pull-down resistor with each terminal in case that IC is turned on due to external noise etc. The sensitivity of each switch is set up highly.

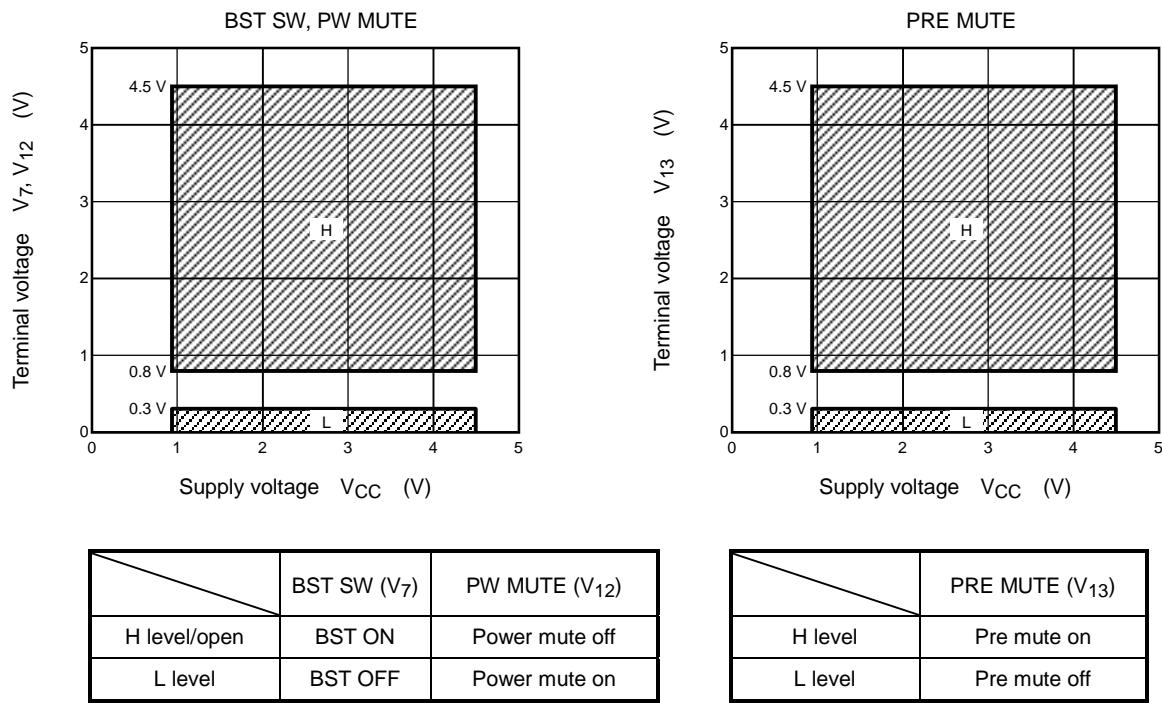
## (b) Pop noise

It is advised to connect R and C with each switch, to reduce the pop noise in switchover (see Fig.1). It is better that the constants are R = 100 kΩ, C = 1 μF. As for the constants, select the optimum one depending on each a set carefully.



**Figure 6 Pop noise**

(c) Sensitivity voltage of each switch ( $T_a = 25^\circ\text{C}$ )



(3) 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.

(4) Capacitor

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

- Oscillation preventing capacitors for power amplifier output
- Capacitor between VREF and GND
- Capacitor between VCC and GND
- Capacitor between RF OUT and GND

### Maximum Ratings ( $T_a = 25^\circ\text{C}$ )

Characteristics	Symbol	Rating	Unit
Supply voltage	$V_{CC}$	4.5	V
Output current	$I_O$ (peak)	100	mA
Power dissipation	$P_D$ (Note)	550	mW
Operating temperature	$T_{opr}$	-25~75	°C
Storage temperature	$T_{stg}$	-55~150	°C

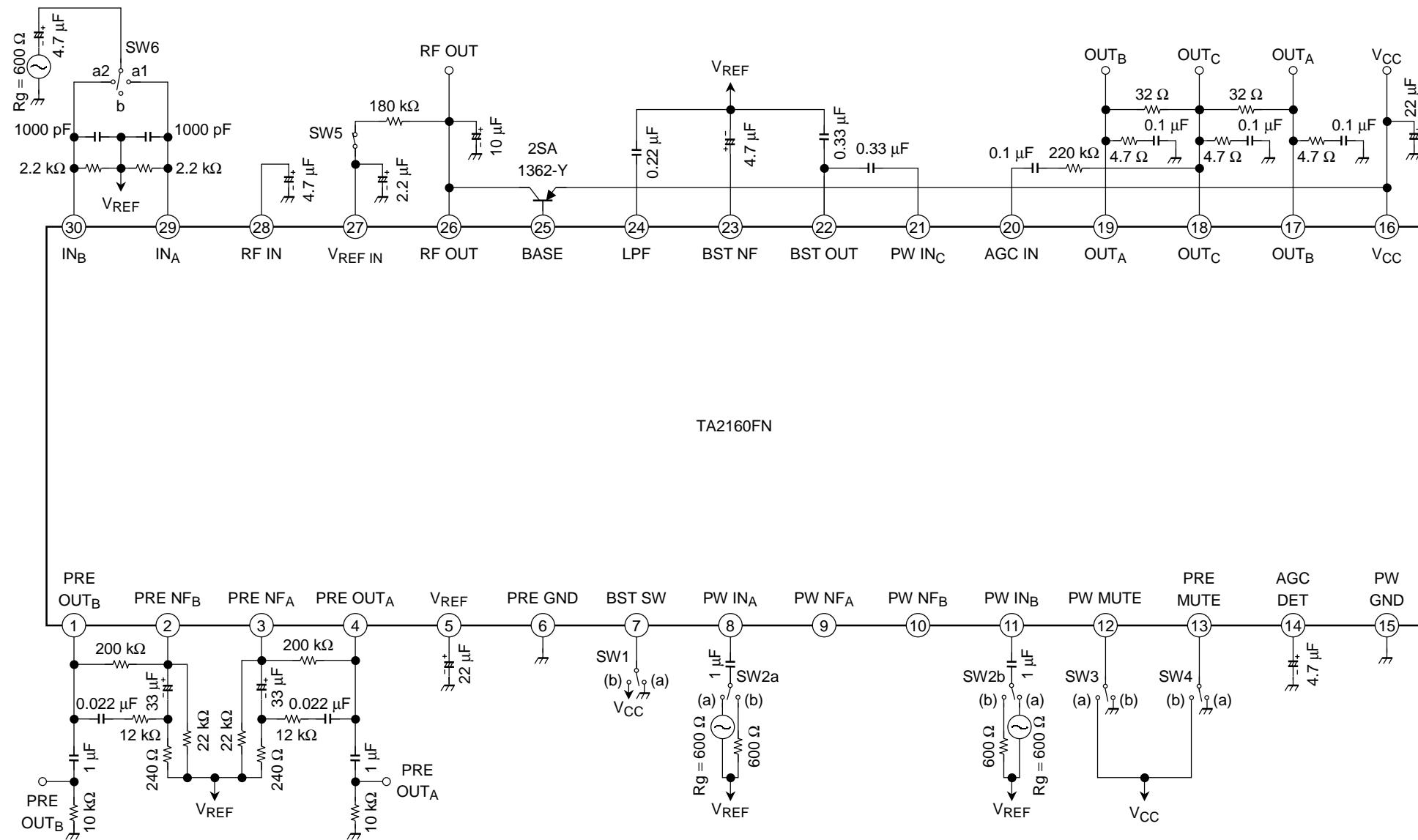
Note: Derated above  $T_a = 25^\circ\text{C}$  in proportion of 4.4 mW/°C.

**Electrical Characteristics**(unless otherwise specified,  $V_{CC} = 1.3$  V,  $T_a = 25^\circ\text{C}$ ,  $f = 1$  kHz, SW1: a, SW3: a, SW4: a, SW5: OPEN)Preamplifier stage:  $R_g = 2.2$  k $\Omega$ ,  $R_L = 10$  k $\Omega$ , SW6: aPower amplifier stage:  $R_g = 600$   $\Omega$ ,  $R_L = 32$   $\Omega$ , SW2: a)

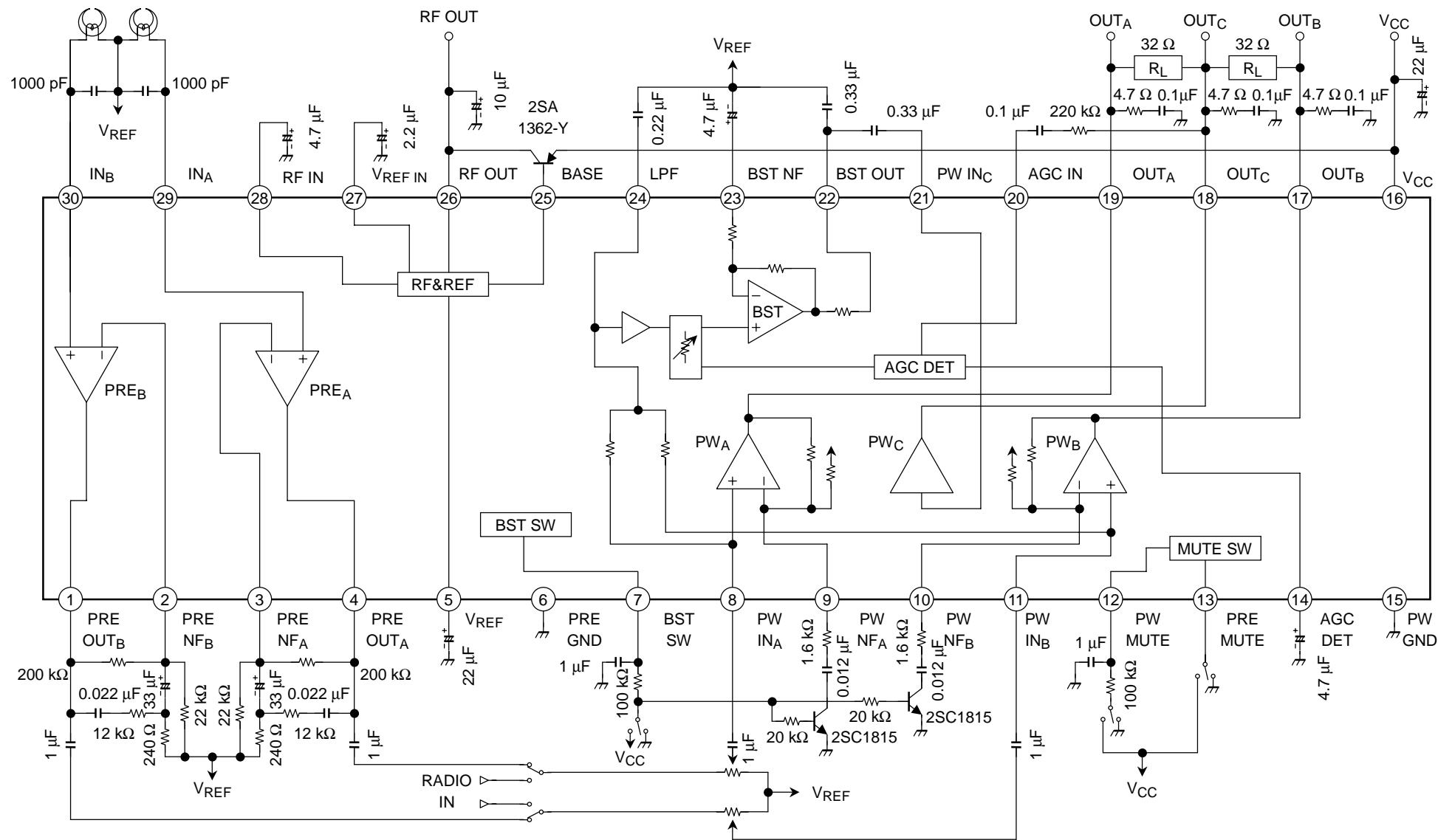
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit	
Quiescent supply current	$I_{CCQ1}$	—	PRE + PW	—	1.6	3.0	mA	
	$I_{CCQ2}$	—	PRE: OFF, SW4: b	—	1.3	2.4		
	$I_{CCQ3}$	—	$V_{CC} = 3$ V, PRE + PW, SW5: ON	—	3.0	5.5		
	$I_{CCQ4}$	—	$V_{CC} = 3$ V, PRE: OFF, SW4: b, SW5: ON	—	2.7	5.0		
Power supply current during drive	$I_{CC1}$	—	PRE + PW, 0.1 mW/32 $\Omega \times 2$ ch	—	4.6	—	mA	
	$I_{CC2}$	—	$V_{CC} = 3$ V, PRE + PW, 0.1 mW/32 $\Omega \times 2$ ch, SW5: ON	—	4.8	—		
Preamp. stage	Open loop voltage gain	$G_{VO}$	—	$V_O = -22$ dBV, NF resistor (240 $\Omega$ ): short	65	80	—	dB
	Closed loop voltage gain	$G_{VC}$	—	$V_O = -22$ dBV	—	35	—	dB
	Maximum output voltage	$V_{om1}$	—	THD = 1%	160	250	—	mVrms
	Total harmonic distortion	THD1	—	$V_{CC} = 1$ V, $V_O = -22$ dBV	—	0.1	0.3	%
	Equivalent input noise voltage	$V_{ni}$	—	$R_g = 2.2$ k $\Omega$ , DIN/AUDIO NAB ( $G_V = 35$ dB, $f = 1$ kHz), SW6: b	—	1.5	2.7	$\mu$ Vrms
	Cross talk	CT1	—	$V_O = -22$ dBV	—	60	—	dB
	Ripple Rejection ratio	RR1	—	$f_r = 100$ Hz, $V_r = -32$ dBV BPF = 100 Hz	—	70	—	dB
	Preamplifier muting attenuation	ATT1	—	$V_O = -22$ dBV, SW4: a $\rightarrow$ b	—	84	—	dB
Power amp. stage	Voltage gain	$G_{V1}$	—	$V_O = -22$ dBV	23	25	27	dB
	Channel balance	CB	—	$V_O = -22$ dBV	—1.5	0	+1.5	dB
	Output power	$P_{o1}$	—	$V_{CC} = 1.5$ V, THD = 10%	3	6	—	mW
		$P_{o2}$	—	$V_{CC} = 3$ V, THD = 10%, SW5: ON	8	12	—	
	Total harmonic distortion	THD2	—	$P_o = 1$ mW	—	0.1	0.5	%
	Output noise voltage	$V_{no}$	—	$R_g = 600$ $\Omega$ , DIN/AUDIO, SW2: b	—	30	60	$\mu$ Vrms
	Cross talk	CT2	—	$V_O = -22$ dBV	34	43	—	dB
	Ripple rejection ratio	RR2	—	$V_{CC} = 1$ V, $f_r = 100$ Hz, $V_r = -32$ dBV, BPF = 100 Hz	—	80	—	dB
Boost stage	Power amplifier muting attenuation	ATT2	—	$V_O = -22$ dBV, SW3: a $\rightarrow$ b	—	80	—	dB
	Voltage gain	$G_{V2}$	—	$f = 40$ Hz, $V_{in} = -64$ dBV, SW1: b, MONI: C-AMP - GND	45	48.5	52	dB
	Voltage gain	$G_{V3}$	—	$f = 40$ Hz, $V_{in} = -47$ dBV, SW1: b, MONI: C-AMP - GND	31	34.5	38	dB
	Maximum output voltage	$V_{om2}$	—	$f = 40$ Hz, THD = 1%, SW1: b, MONI: C-AMP - GND	—	270	—	mVrms
	Muting attenuation	ATT3	—	$f = 40$ Hz, $V_O = -32$ dBV, SW1: b $\rightarrow$ a	—	58	—	dB
Ripple filter output voltage		$V_{RF OUT}$	—	$V_{CC} = 1$ V, $I_{RF} = 20$ mA	0.9	0.93	—	V

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Ripple filter ripple rejection ration	RR3	—	$V_{CC} = 1 \text{ V}$ , $I_{RF} = 20 \text{ mA}$ $f_r = 100 \text{ Hz}$ , $V_r = -32 \text{ dBV}$ $BPF = 100 \text{ Hz}$	35	42	—	dB
Preamplifier on voltage	$V_{13}$	—	$V_{CC} = 0.95 \text{ V}$	0	—	0.3	V
Preamplifier off current	$I_{13}$	—		5	—	—	$\mu\text{A}$
Power amplifier on current	$I_{12}$	—		5	—	—	$\mu\text{A}$
Power amplifier off voltage	$V_{12}$	—		0	—	0.3	V
Boost switch on current	$I_7$	—		5	—	—	$\mu\text{A}$
Boost switch off voltage	$V_7$	—		0	—	0.3	V

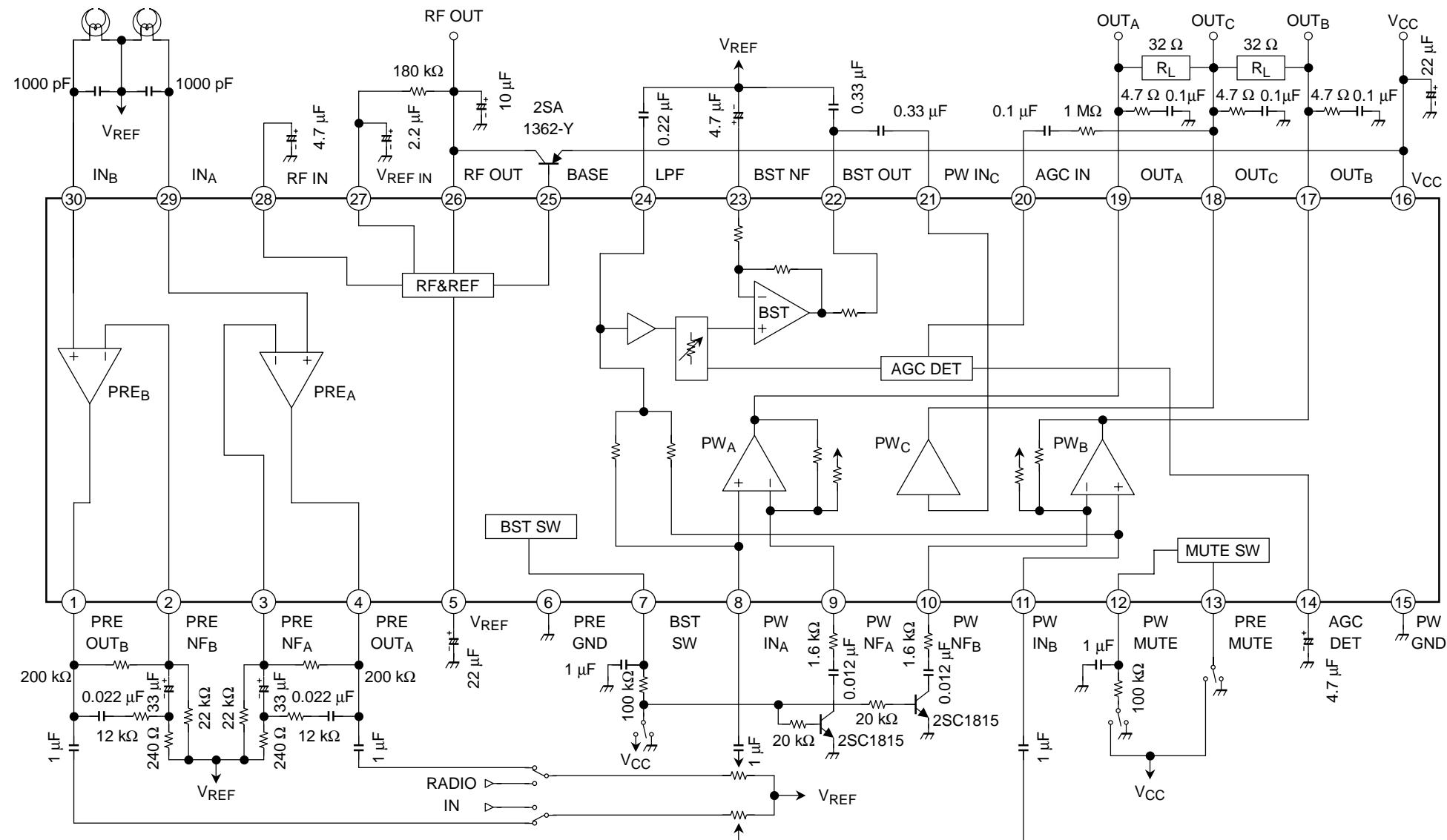
## Test Circuit



## Application Note 1 (1.5 V set)



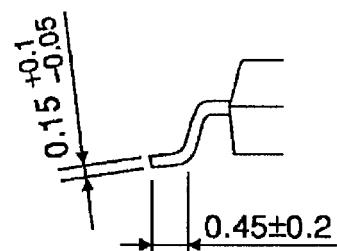
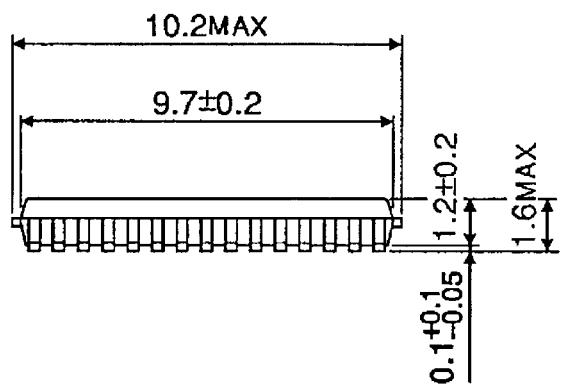
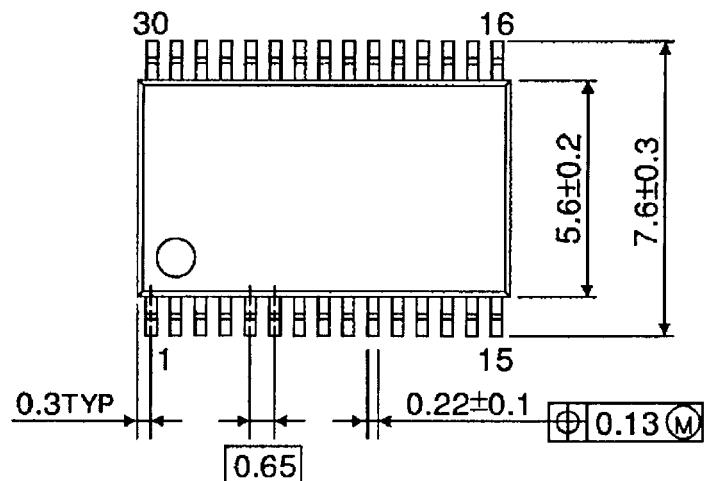
## Application Note 2 (3 V Set)



## Package Dimensions

SSOP30-P-300-0.65

Unit : mm



Weight: 0.17 g (typ.)

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