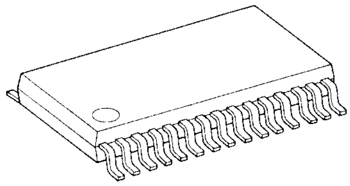
Toshiba Bipolar Integrated Circuit Silicon Monolithic

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.

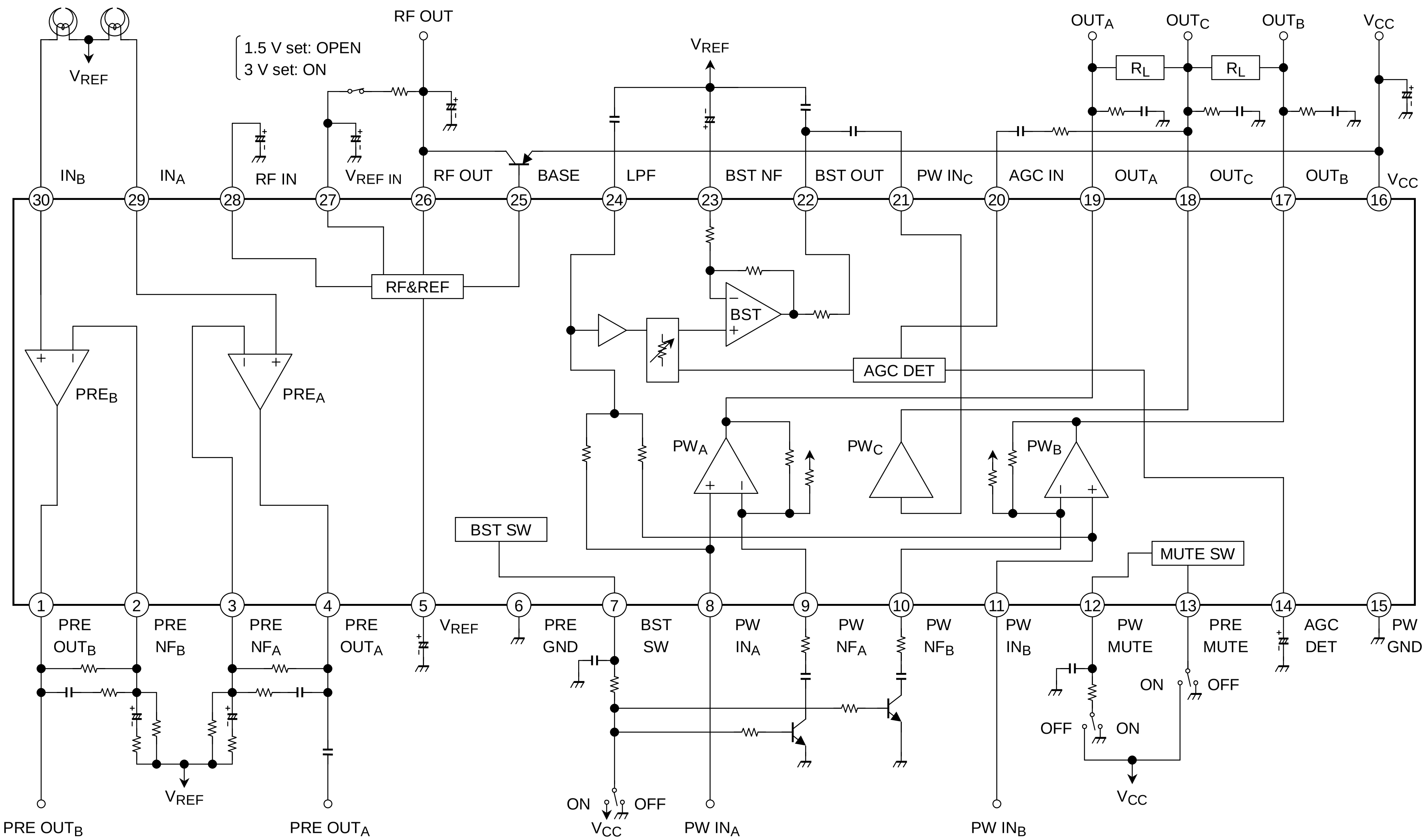


Weight: 0.17 g (typ.)

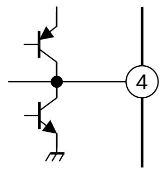
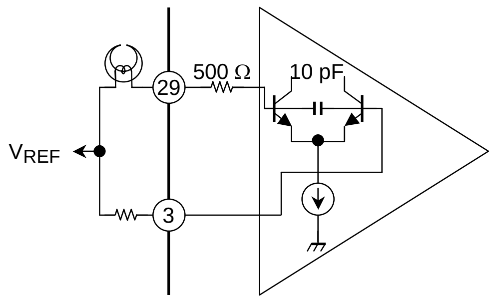
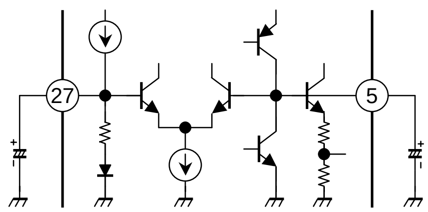
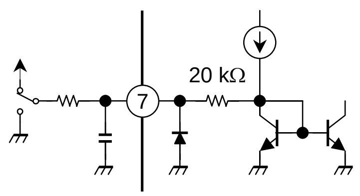
Features

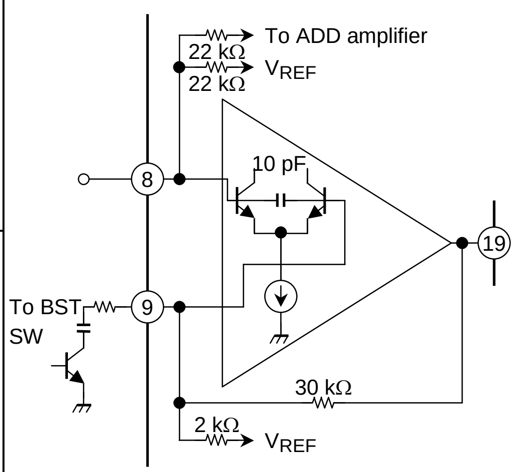
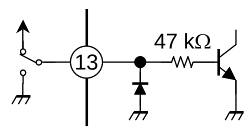
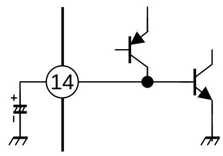
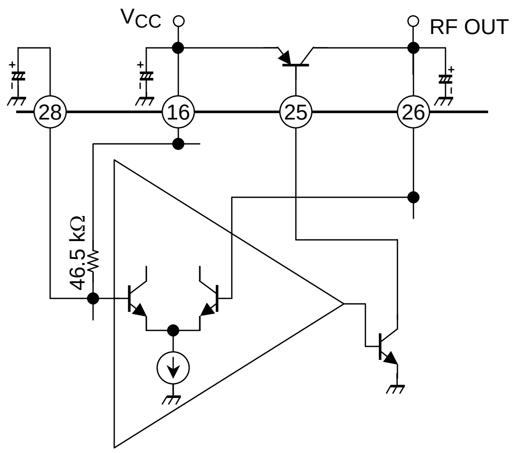
- Low consumption current
  Current value (f = 1 kHz, R_L = 32 Ω, Ta = 25°C, typ.)
  - V_{CC} = 1.3 V
    I_{CCQ} = 1.6 mA (No signal)
    I_{CC} = 4.6 mA (0.1 mW × 2 ch)
    I_{CC} = 8.6 mA (0.5 mW × 2 ch)
  - V_{CC} = 3 V
    I_{CCQ} = 3.0 mA (No signal)
    I_{CC} = 4.8 mA (0.1 mW × 2 ch)
    I_{CC} = 8.8 mA (0.5 mW × 2 ch)
- Built-in ripple filter
- Preamplifier stage
  - Built-in input capacitor for reducing buzz noise
  - Input coupling condensor-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 = 25dB (typ.)
  - Built-in power amplifier mute
- Operating supply voltage range (Ta = 25°C)
  $V_{CC\ (opr)}$ = 0.95 to 4.5 V

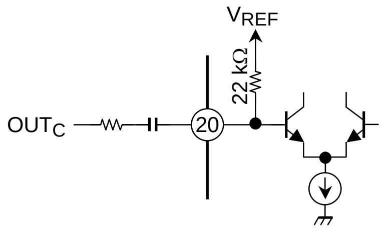
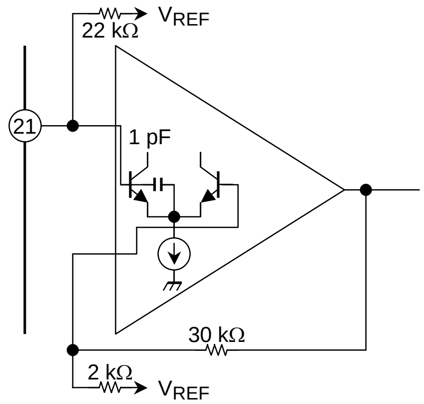
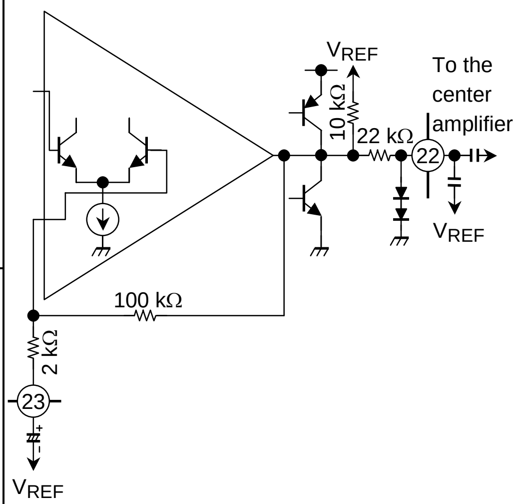
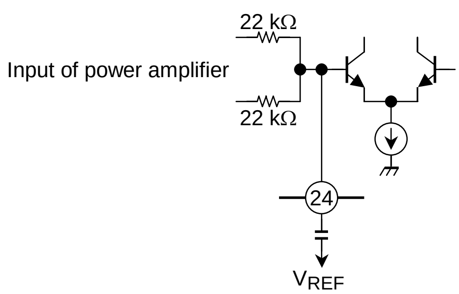
Block Diagram



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	PRE OUT_B	Input of preamplifier		0.44
4	PRE OUT_A			
17	OUT_B	Output of power amplifier		0.56
18	OUT_C			
19	OUT_A			
2	PRE NF_B	NF of preamplifier		0.7
3	PRE NF_A			
29	IN_A	Input of preamplifier		0.73
30	IN_B			
5	V_{REF}	Reference circuit		0.73
27	$V_{REF\ IN}$	Input of reference circuit		0.73
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 No.	Terminal Name	Function	Internal Circuit	Terminal Voltage (V)
8	PW IN_A	Input of power amplifier (This terminal also has function of ADD amplifier input.)		0.73
11	PW IN_B			
9	PW NF_A	NF of power amplifier		0.72
10	PW NF_B			
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_{CC}	—		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		1.24
28	RF IN	Ripple filter terminal		1.24

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 kΩ (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		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.

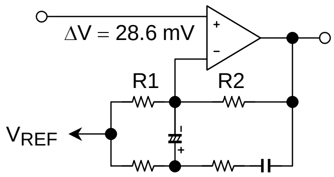


Figure 1 Output DC Voltage of Preamplifier

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

- 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)).
- 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 V − 28.6 mV (200 kΩ/22 kΩ + 1)
= 0.44 V

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.

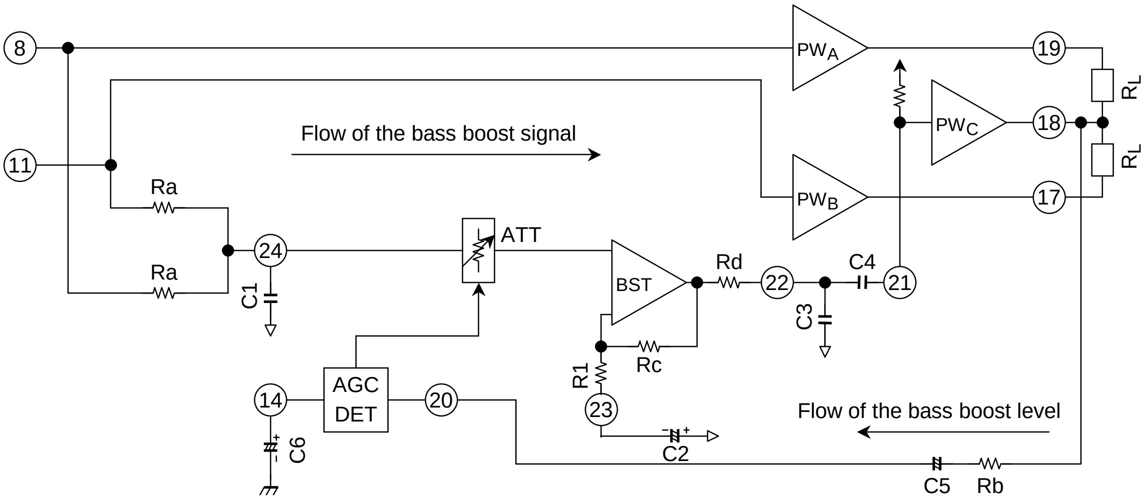


Figure 2 Bass Boost System

(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.

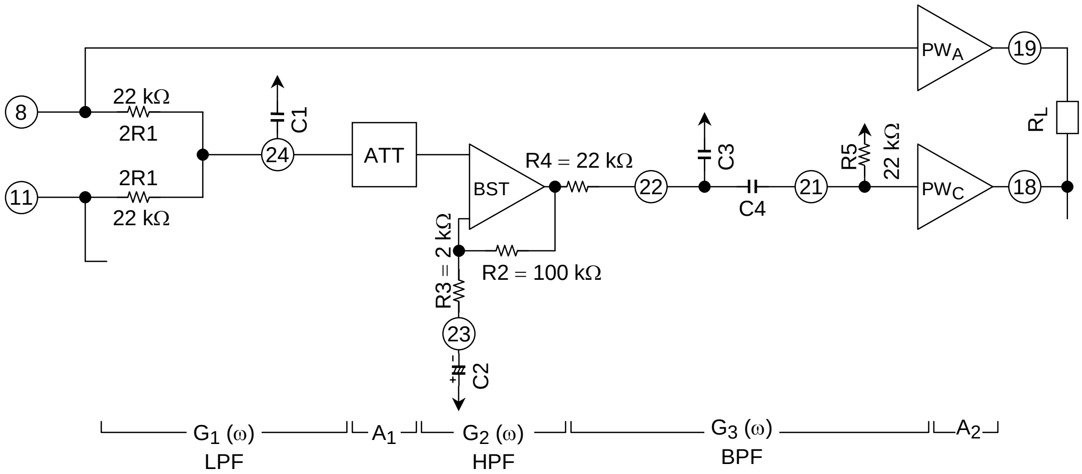


Figure 3 Block Diagram of Bass Boost

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

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

$$f_L = 1/2\pi C1\cdot R1$$

ii Transfer function of BPF

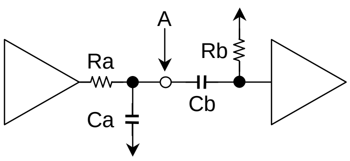
$$G_3(\omega) = j\omega C4\cdot R5/[1 + j\omega\ (R4\cdot C3 + R5\cdot C3 + C4\cdot R4) - \omega^2 R4\cdot C3\cdot R5\cdot C4]$$

$$f_O = 1/2\pi\sqrt{R4\cdot C3\cdot R5\cdot C4}$$

iii HPF gain and ct of frequency

$$G_2(\omega) = 1 + R2/(R3 + 1/j\omega C2)$$

$$f_{HC} = 1/(2\pi R3\cdot C2)$$



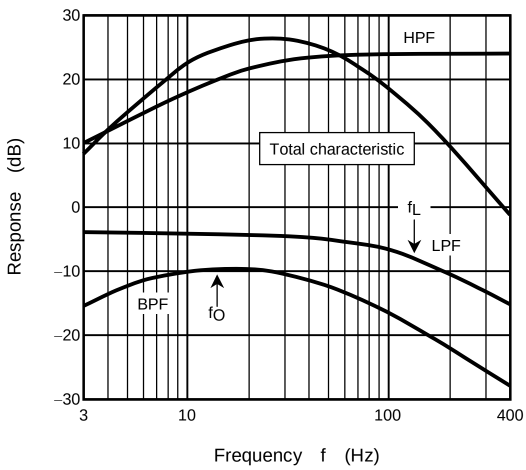


Figure 4 BPF

Graph 1 Characteristic of Bass Boost

iv 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.

v HPF

The f_{HC} should be made 1/2 or less frequency as compared with the f_L and 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 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 $V_{REF\ IN}$ terminal.

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

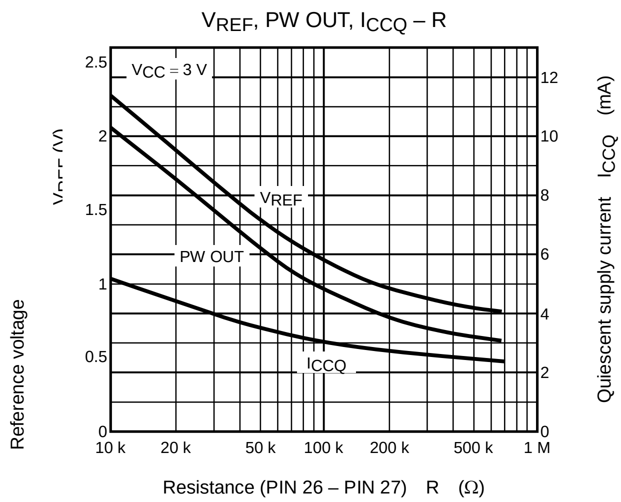


Figure 5 Adjutment of output DC voltage

(2) Switch

(a) Switch terminal

The current flows through each terminal, in case that these terminals are connected with H level independently, evevn 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.

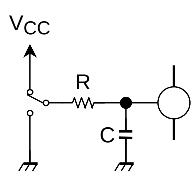
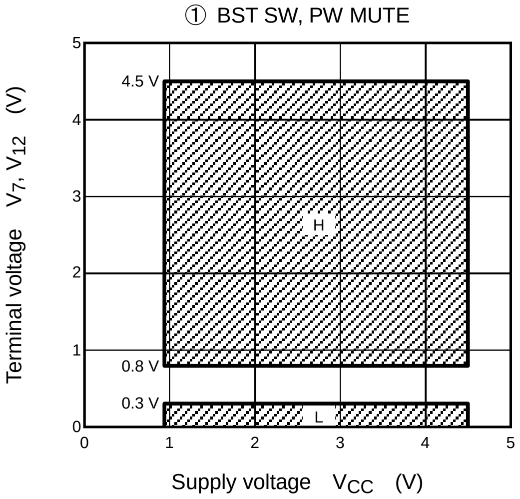
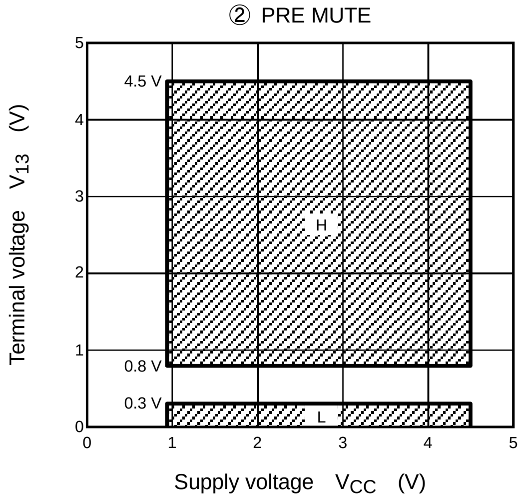


Figure 6 Pop noise

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





	BST SW (V_7)	PW MUTE (V_{12})
H level/open	BST ON	Power mute off
L level	BST OFF	Power mute on

	PRE MUTE (V_{13})
H level	Pre mute on
L level	Pre mute off

(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 V_{REF} and GND
- Capacitor between V_{CC} and GND
- Capacitor between RF OUT and GND

Maximum Ratings (Ta = 25°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

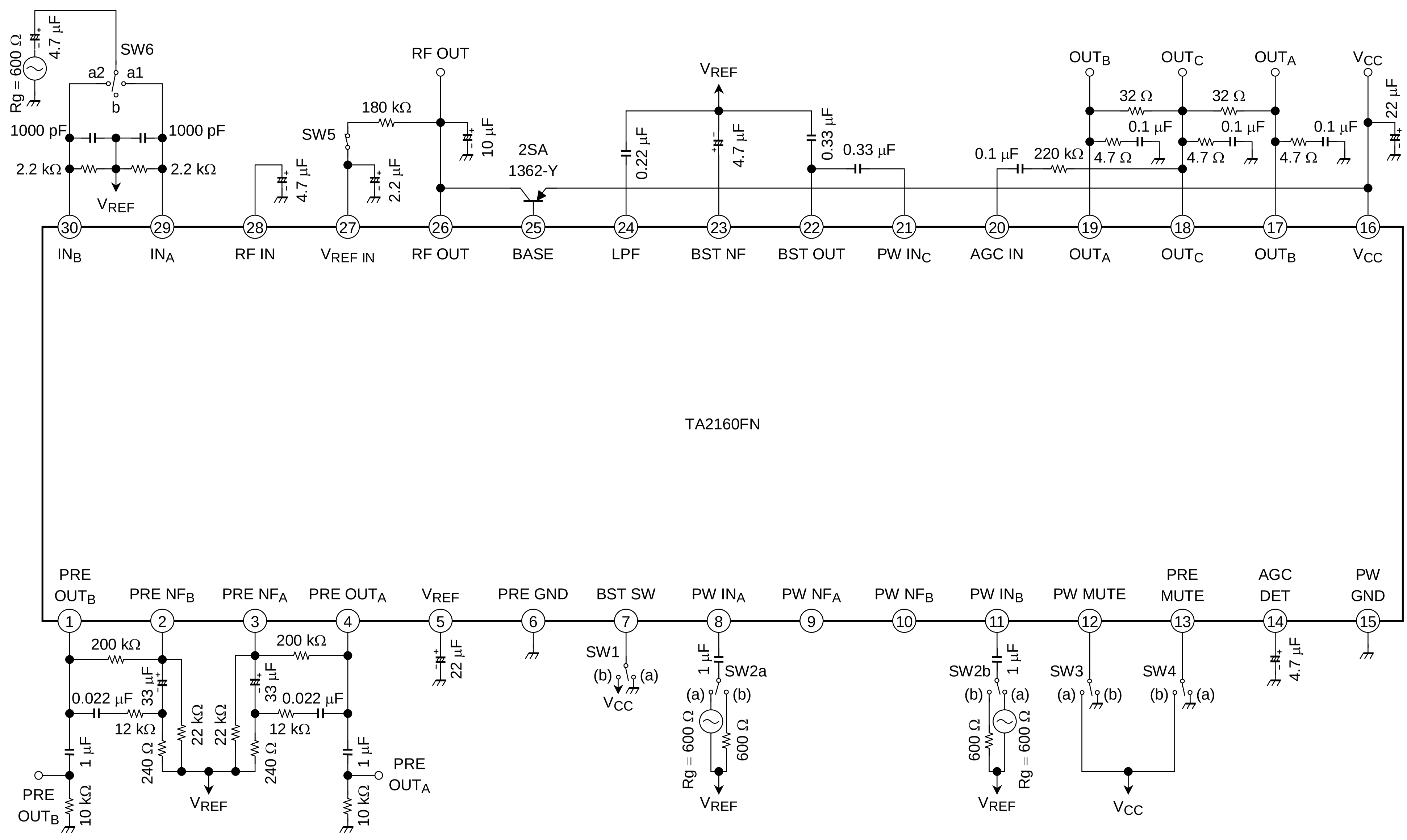
Note: Derated above Ta = 25°C in proportion of 4.4 mW/°C.

Electrical Characteristics
(unless otherwise specified, V_{CC} = 1.3 V, Ta = 25°C, f = 1 kHz, SW1: a, SW3: a, SW4: a, SW5: OPEN
Preamplifier stage: Rg = 2.2 kΩ, R_L = 10 kΩ, SW6: a
Power amplifier stage: Rg = 600 Ω, R_L = 32 Ω, SW2: a)

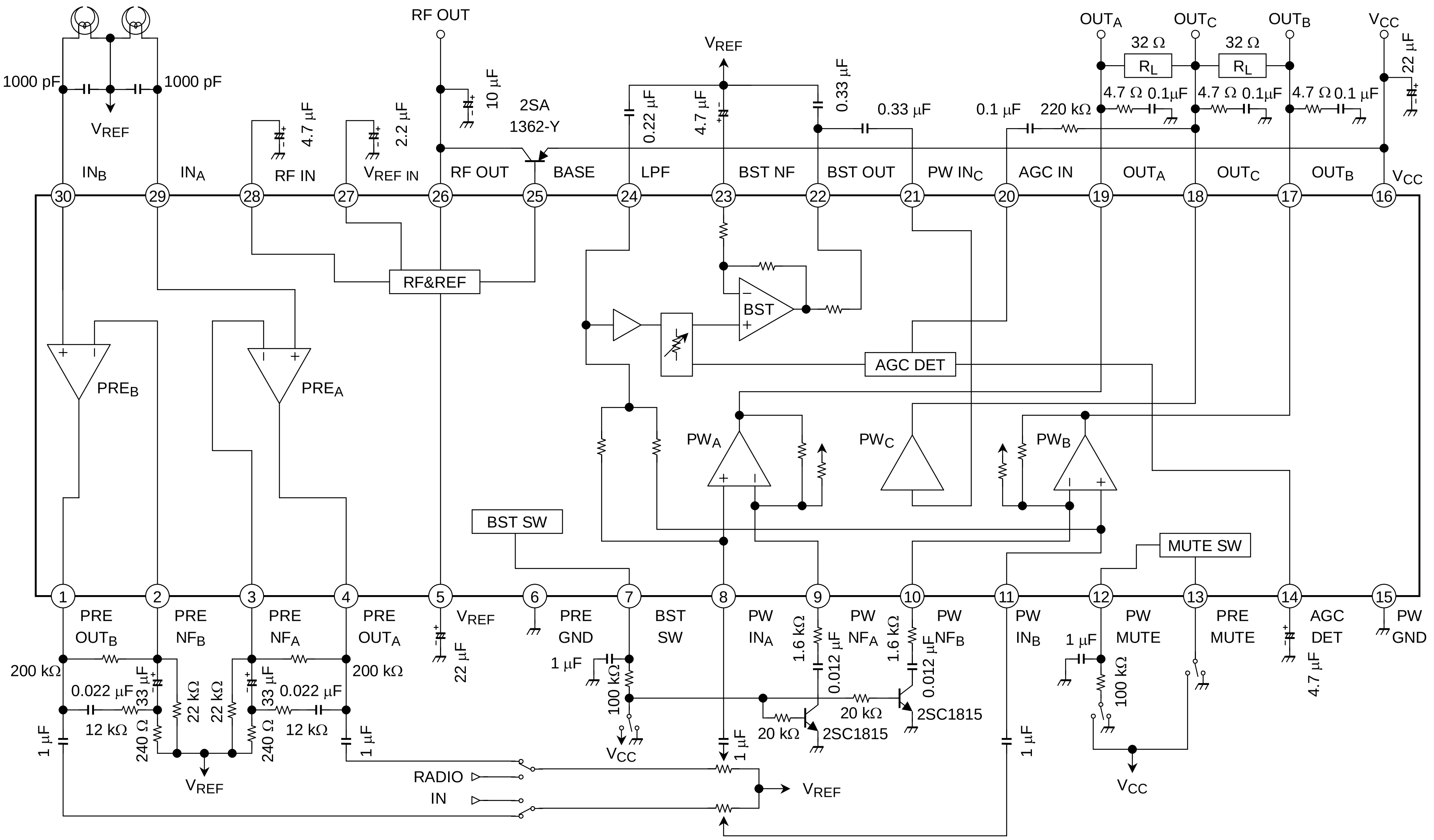
Characteristics		Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current		I_{CCQ1}		PRE + PW	—	1.6	3.0	mA
		I_{CCQ2}		PRE: OFF, SW4: b	—	1.3	2.4	
		I_{CCQ3}		V_{CC} = 3 V, PRE + PW, SW5: ON	—	3.0	5.5	
		I_{CCQ4}	—	V_{CC} = 3 V, PRE: OFF, SW4: b, SW5: ON	—	2.7	5.0	
Power supply current during drive		I_{CC1}	—	PRE + PW, 0.1 mW/32 Ω × 2 ch	—	4.6	—	mA
		I_{CC2}	—	V_{CC} = 3 V, PRE + PW, 0.1 mW/32 Ω × 2 ch, SW5: ON	—	4.8	—	
Preamp. stage	Open loop voltage gain	G_{VO}	—	V_o = −22dBV, NF resistor (240 Ω): short	65	80	—	dB
	Closed loop voltage gain	G_{VC}	—	V_o = −22dBV	—	35	—	dB
	Maximum output voltage	V_{om1}	—	THD = 1%	160	250	—	mVrms
	Total harmonic distortion	THD1	—	V_{CC} = 1 V, V_o = −22dBV	—	0.1	0.3	%
	Equivalent input noise voltage	V_{ni}	—	Rg = 2.2 kΩ, DIN/AUDIO NAB (G_V = 35 dB,f = 1 kHz), SW6: b	—	1.5	2.7	μVrms
	Cross talk	CT1	—	V_o = −22dBV	—	60	—	dB
	Ripple Rejection ratio	RR1	—	f_r = 100 Hz, V_r = −32dBV BPF = 100 Hz	—	70	—	dB
	Preamplifier muting attenuation	ATT1	—	V_o = −22dBV, SW4: a → b	—	84	—	dB
Power amp. stage	Voltage gain	G_{V1}	—	V_o = −22dBV	23	25	27	dB
	Channel balance	CB	—	V_o = −22dBV	−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}	—	Rg = 600 Ω, DIN/AUDIO, SW2: b	—	30	60	μVrms
	Cross talk	CT2	—	V_o = −22dBV	34	43	—	dB
	Ripple rejection ratio	RR2	—	V_{CC} = 1 V, f_r = 100 Hz, V_r = −32dBV, BPF = 100 Hz	—	80	—	dB
	Power amplifier muting attenuation	ATT2	—	V_o = −22dBV, SW3: a → b	—	80	—	dB
Boost stage	Voltage gain	G_{V2}	—	f = 40 Hz, V_{in} = −64dBV, SW1: b, MONI: C-AMP - GND	45	48.5	52	dB
	Voltage gain	G_{V3}	—	f = 40 Hz, V_{in} = −47dBV, 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 = −32dBV, SW1: b → 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 V, I_{RF} = 20 mA f_r = 100 Hz, V_r = −32dBV BPF = 100 Hz	35	42	—	dB
Preamplifier on voltage	V_{13}	—	V_{CC} = 0.95 V	0	—	0.3	V
Preamplifier off current	I_{13}	—		5	—	—	μA
Power amplifier on current	I_{12}	—		5	—	—	μA
Power amplifier off voltage	V_{12}	—		0	—	0.3	V
Boost switch on current	I_7	—		5	—	—	μA
Boost switch off voltage	V_7	—		0	—	0.3	V

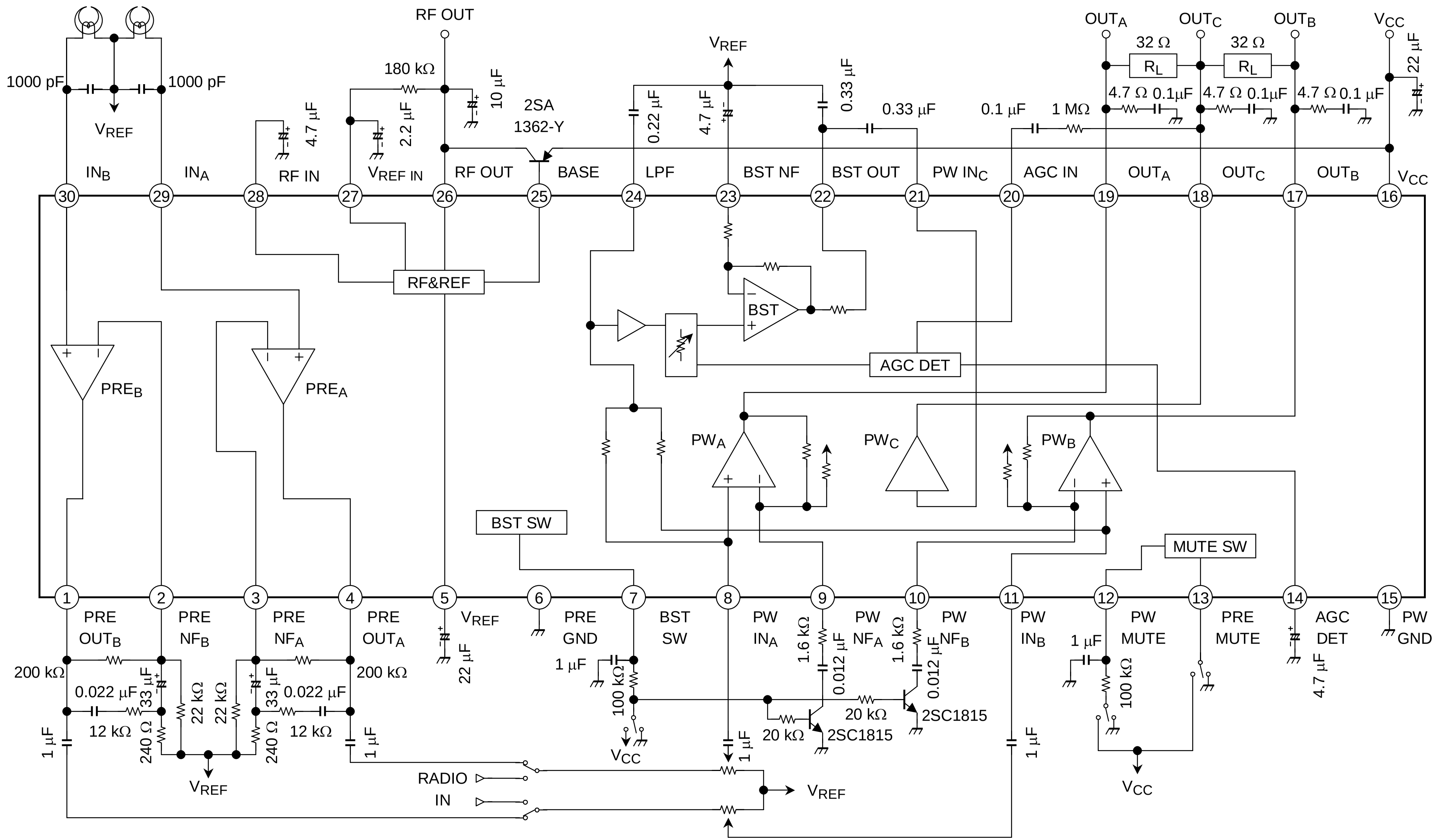
Test Circuit



Application Note 1 (1.5 V set)

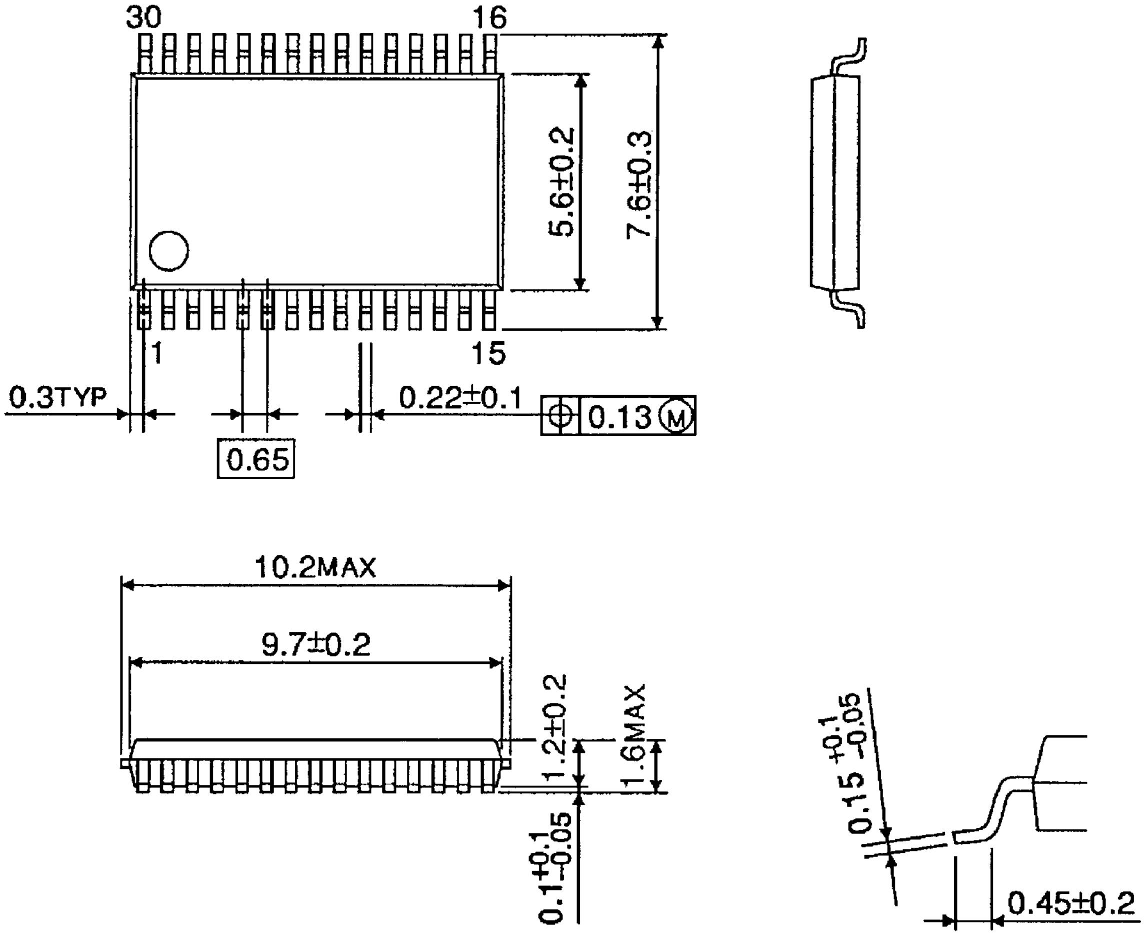


Application Note 2 (3 V Set)



Package Dimensions

SSOP30-P-300-0.65 Unit : mm



Weight: 0.17 g (typ.)

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