Pre / power amplifier and motor governor for 3V headphone stereos

BA3528AFP / BA3529AFP

The BA3528AFP and AB3529AFP have been developed for headphone stereos. They run off a 3V power supply, and include dual pre- and power amplifiers, and a motor governor.
The preamplifiers are direct-coupled, and the power amplifiers use a fixed-gain NF circuit. An on-chip V_{REF} amplifier makes output coupling capacitors unnecessary, and the motor governor uses a bridge ratio system to minimize the external parts count and make reliable and compact designs possible.

●Applications
3V portable stereo equipment

●Features
1) All the functions required for headphone stereo units on a single chip.
2) Preamplifier includes a mute amplifier.
3) Direct-coupled preamplifier.
4) No output coupling capacitors required for the power amplifiers.
5) Power amplifiers do not require oscillation prevention measures.
6) Power amplifier gain allows use of noise reduction (BA3529AFP).

●Absolute maximum ratings (Ta = 25°C)

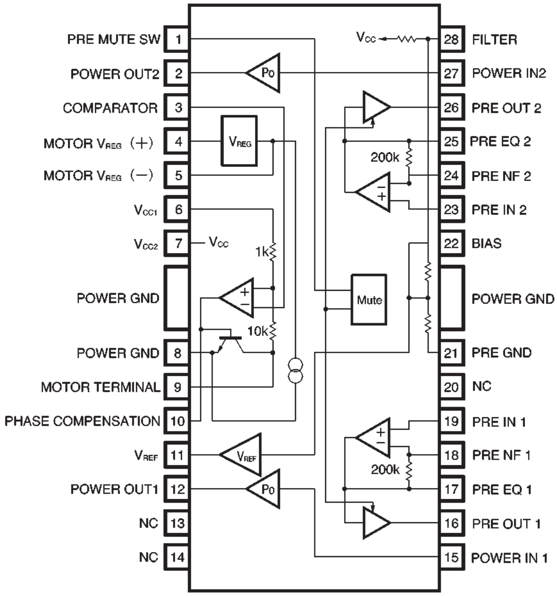
Parameter	Symbol	Limits	Unit
Power supply voltage	V_{CC}	6	V
Power dissipation	Pd	1.7*	W
Operating temperature	Topr	−25～+75	℃
Storage temperature	Tstg	−55～+150	℃

* Reduced by 13.6mW for each increase in Ta of 1°C over 25°C
(when mounted on a 90mm ×50mm×1.6mm glass epoxy board).

●Recommended operating conditions (Ta = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power supply voltage	V_{CC}	1.8	3.0	6.0	V

●Block diagram



●Electrical characteristics (unless otherwise noted, Ta = 25°C, V_{CC} = 3V, and f = 1kHz)
BA3528AFP

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Quiescent current	I_Q	—	11	18	mA	V_{IN}=0V_{rms}
Channel separation	CS L-R	30	40	—	dB	R_g=2.2kΩ, R_L=32Ω
〈Preamplifier〉						R_L=10kΩ
Open loop voltage gain	G_{VO}	72	80	—	dB	V_O=200mV_{rms}
Closed loop voltage gain	G_{VC1}	33	36	39	dB	V_O=100mV_{rms}
Maximum output voltage	V_{OM}	350	500	—	mV_{rms}	THD=1%
Total harmonic distortion	THD1	—	0.03	0.2	%	V_O=200mV_{rms}
Input conversion noise voltage	V_{NIN}	—	1.0	1.8	μV_{rms}	R_g=2.2kΩ, BPF=20〜20kHz
Ripple rejection ratio	RR1	43	53	—	dB	f_{RR}=100Hz, V_{RR}=−20dBm
Input bias current	I_B	—	365	850	nA	V_{IN}=0V_{rms}
Mute level	MUTE	—	80	—	dB	
〈Power amplifier〉						R_L=32Ω (excluding P_{OUT1})
Rated output 1	P_{OUT1}	25	34	—	mW/ch	R_L=16Ω, THD=10%
Rated output 2	P_{OUT2}	14.5	20	—	mW/ch	R_L=32Ω, THD=10%
Total harmonic distortion	THD 2	—	0.2	1.0	%	P_O=1mW
Output noise voltage	V_{NO}	—	65	100	μV_{rms}	BPF=20〜20kHz
Ripple rejection ratio	RR2	53	61	—	dB	f_{RR}=100Hz, V_{RR}=−20dBm
Closed loop voltage gain	G_{VC2}	33	36	39	dB	V_O=300mV_{rms}
Input resistance	R_{IN}	13	18	23	kΩ	
〈Motor controller〉						
Quiescent current	I_Q	—	2	3.5	mA	
Reference voltage	V_{REG}	1.16	1.23	1.31	V	Voltage between pins 4 and 5 ($R_{5\text{-}4}$≧20kΩ)
Saturation voltage	V_{SAT}	—	0.2	0.6	V	V_{CC}=1.8V, R_a=4.7Ω
Voltage characteristic 1	$\frac{\Delta V_{REG}}{V_{REG}}/V_{CC}$	−1.25	0.1	1.25	% / V	V_{CC}=1.8V〜6V
Voltage characteristic 2	$\frac{\Delta V_a}{V_a}/V_{CC}$	−1.2	0.1	1.2	% / V	V_{CC}=1.8V〜6V
Current characteristic	$\frac{\Delta V_{REG}}{V_{REG}}/I_g$	−0.2	0.01	0.2	% / A	I_g=1mA〜20mA
Temperature characteristic	$\frac{\Delta V_{REG}}{V_{REG}}/T_a$	—	0.01	—	% / ℃	Ta=−25〜+75℃

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Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Quiescent current	I_Q	—	11	18	mA	V_{IN}=0V_{rms}
Channel separation	CS L-R	35	45	—	dB	R_g=2.2kΩ, R_L=32Ω
〈Preamplifier〉						R_L=10kΩ
Open loop voltage gain	G_{VO}	72	80	—	dB	V_O=200mV_{rms}
Closed loop voltage gain	G_{VC1}	33	36	39	dB	V_O=100mV_{rms}
Maximum output voltage	V_{OM}	350	500	—	mV_{rms}	THD=1%
Total harmonic distortion	THD1	—	0.03	0.2	%	V_O=200mV_{rms}
Input conversion noise voltage	V_{NIN}	—	1.0	1.8	μV_{rms}	Rg=2.2kΩ, BPF=20～20kHz
Ripple rejection ratio	RR1	43	53	—	dB	f_{RR}=100Hz, V_{RR}=−20dBm
Input bias current	I_B	—	365	850	nA	V_{IN}=0V_{rms}
Mute level	MUTE	—	80	—	dB	
〈Power amplifier〉						R_L=32Ω (excluding P_{OUT1})
Rated output 1	P_{OUT1}	25	34	—	mW/ch	R_L=16Ω, THD=10%
Rated output 2	P_{OUT2}	14.5	20	—	mW/ch	R_L=32Ω, THD=10%
Total harmonic distortion	THD 2	—	0.1	0.9	%	P_O=1mW
Output noise voltage	V_{NO}	—	26	50	μV_{rms}	BPF=20～20kHz
Ripple rejection ratio	RR2	61	69	—	dB	f_{RR}=100Hz, V_{RR}=−20dBm
Closed loop voltage gain	G_{VC2}	25	27	29	dB	V_{IN}=300V_{rms}
Input resistance	R_{IN}	13	18	23	kΩ	
〈Motor controller〉						
Quiescent current	I_Q	—	2	3.5	mA	
Reference voltage	V_{REG}	1.16	1.23	1.31	V	Voltage between pins 4 and 5 ($R_{5\text{-}4}$≧20kΩ)
Saturation voltage	V_{SAT}	—	0.2	0.6	V	V_{CC}=1.8V, R_a=4.7Ω
Voltage characteristic 1	$\frac{\triangle V_{REG}}{V_{REG}}/V_{CC}$	−1.25	0.1	1.25	% / V	V_{CC}=1.8V～6V
Voltage characteristic 2	$\frac{\triangle V_a}{V_a}/V_{CC}$	−1.2	0.1	1.2	% / V	V_{CC}=1.8V～6V
Current characteristic	$\frac{\triangle V_{REG}}{V_{REG}}/I_g$	−0.2	0.01	0.2	% / A	I_g=1mA～20mA
Temperature characteristic	$\frac{\triangle V_{REG}}{V_{REG}}/Ta$	—	0.01	—	% / ℃	Ta=−25～+75℃

●Measurement circuit

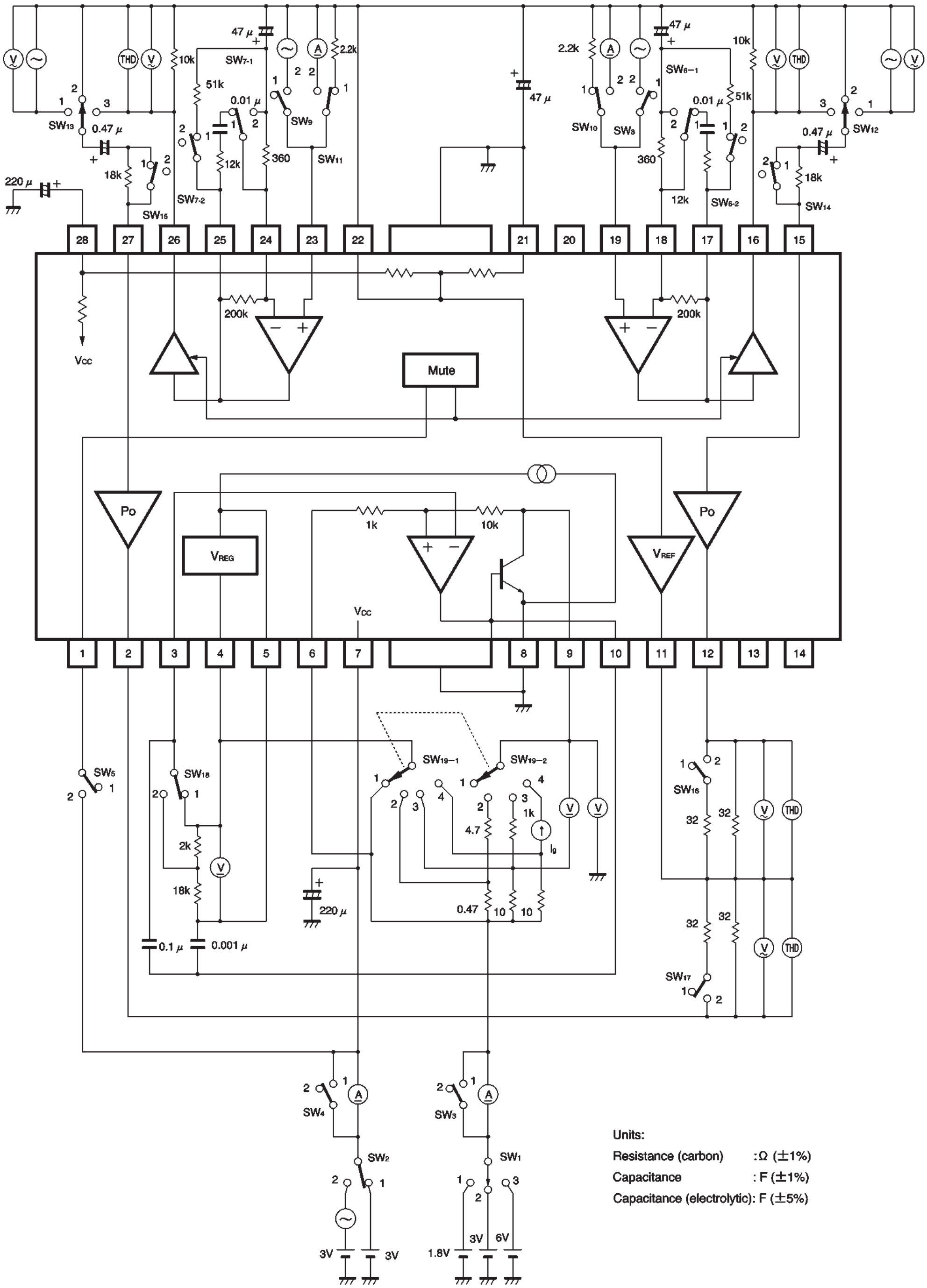


Fig. 1

●Circuit operation

(1) Preamplifier

In the preamplifier input stage the pin 22 bias is the input and the negative feedback virtual earth, and the bias for the input stage transistor is taken from pin 22 via the tape head to allow direct coupling. Connect a 1000pF capacitor in parallel with the tape head to prevent high-frequency interference (see Fig. 2).

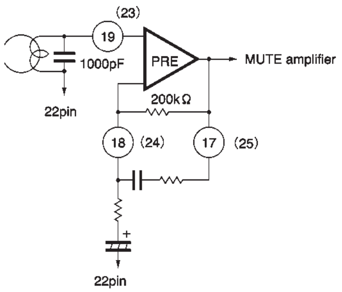


Fig. 2

(2) Mute amplifier

Preamplifier output muting can be switched on and off. The mute is off when the mute switch input (pin 1) is low or open, and on when the mute switch input is high (tied to V_{CC} via a resistor), see Fig. 3.

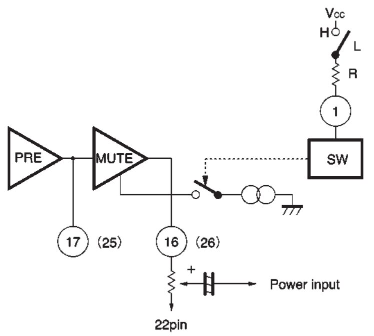


Fig. 3

(3) Equalizer

The preamplifier is based on an NAB120µs NF-type equalizer. It is possible to add a switching function for the equalizer using the mute amplifier. Switching of the equalizer constant is controlled by the voltage on pin 1 (low or high). Note, however, when this is done, preamplifier muting no longer operates (see Fig. 4).

(4) Power amplifier

The power amplifier employs an NF circuit with fixed gain. G_{VC} = 36dB (BA3528AFP) and G_{VC} = 27dB (BA3529AFP).

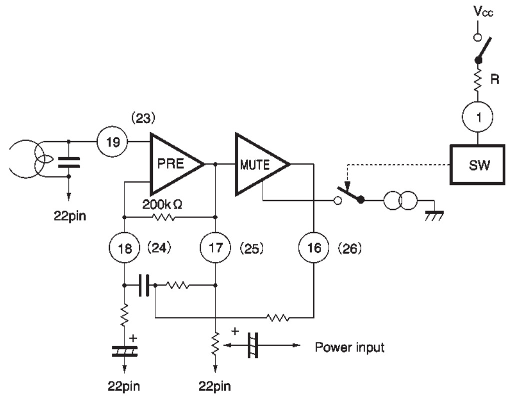


Fig. 4

For the input stage, the pin 22 bias point is the input and the negative feedback virtual earth point, and the first stage transistor bias is taken from pin 22. The built-in V_{REF} amplifier uses the same bias point as its input, and its output voltage is about the same as DC output voltage from the power amplifier. This becomes the virtual earth for the headphones (see Fig. 5).

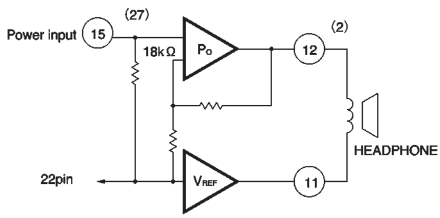


Fig. 5

(5) Motor controller circuit

The motor controller circuit uses a resistance bridge to maintain uniform motor speed regardless of changes in supply voltage, ambient temperature and load torque. Speed control is performed by a comparator and a stable on-chip reference voltage (V_{REG} = 1.23V). See Fig. 6.

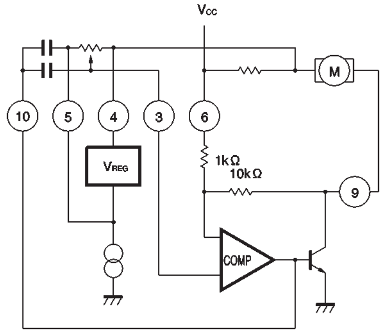
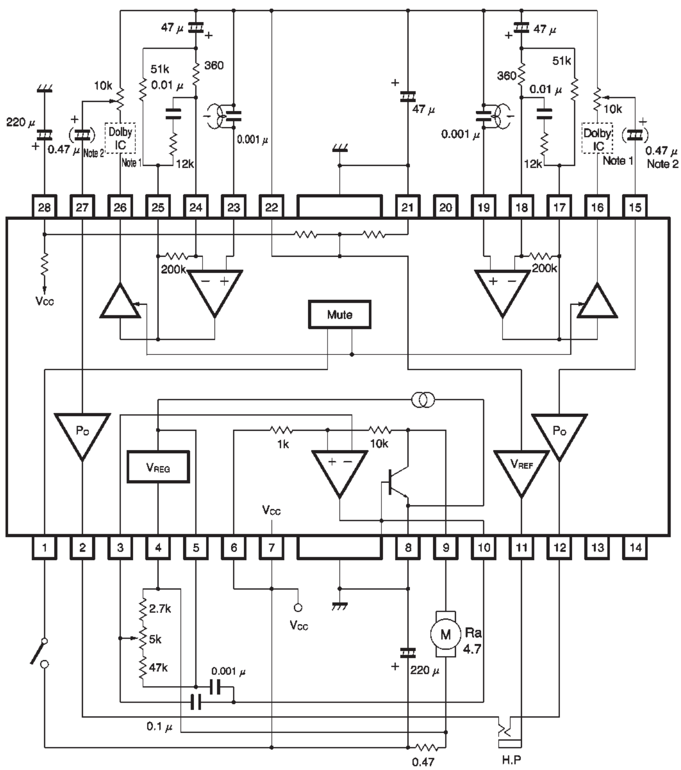


Fig. 6

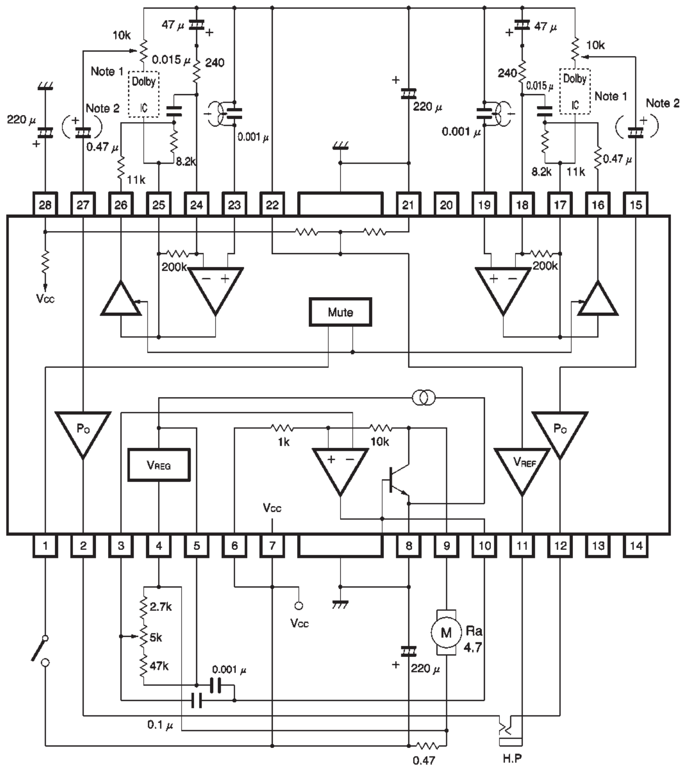
●Application examples



Units
Resistors : Ω (±5%)
Capacitors : F (±10%)
Capacitors (electrolytic): F (±20%)

Note 1:
For Dolby use (BA3529AFP only).
Note 2:
Coupling capacitors not required.

Fig. 7 Headphone stereo with pre-mute



Units
Resistors : Ω (±5%)
Capacitors : F (±10%)
Capacitors (electrolytic): F (±20%)

Note 1:
For Dolby use (BA3529AFP only).
Note 2:
Coupling capacitors not required.

Fig. 8 Headphone stereo metal / normal switch

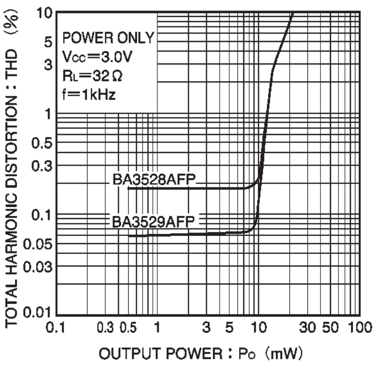


Fig. 27 Total harmonic distortion vs. output voltage

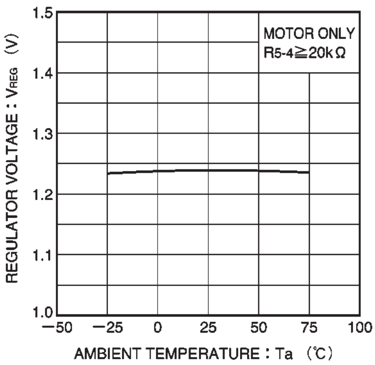


Fig. 28 Regulator voltage vs. ambient temperature

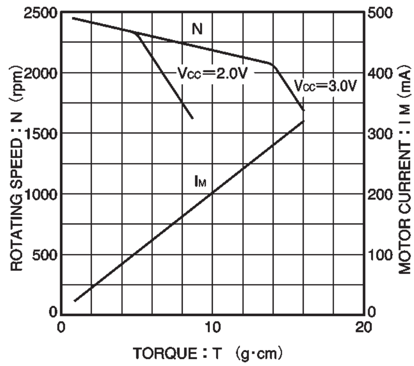
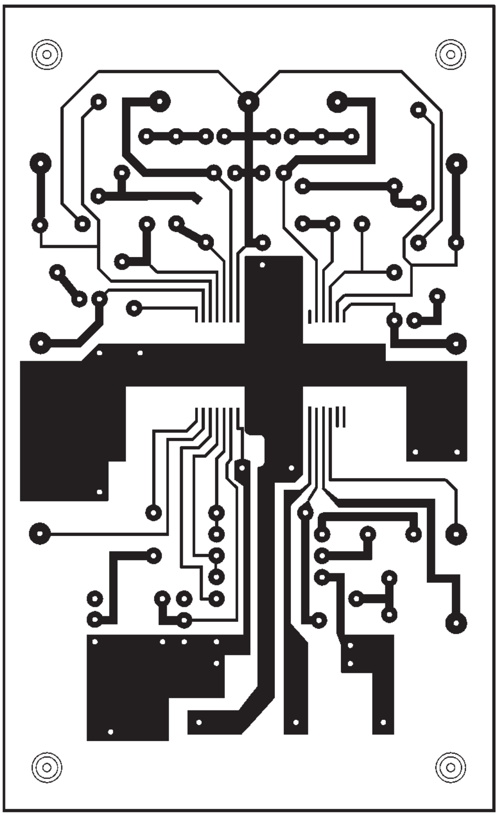


Fig. 29 Rotation speed and motor current vs. torque

●Application board patterns

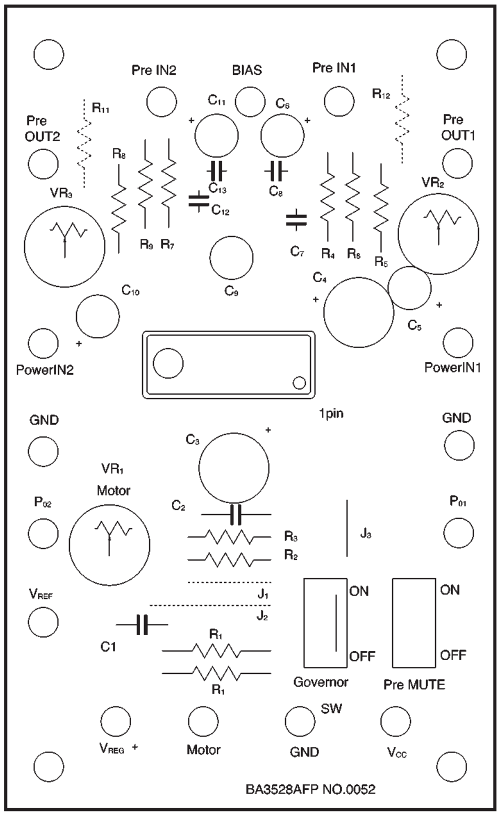


PCB thickness: 1.6mm

Copper thickness: 35 μm

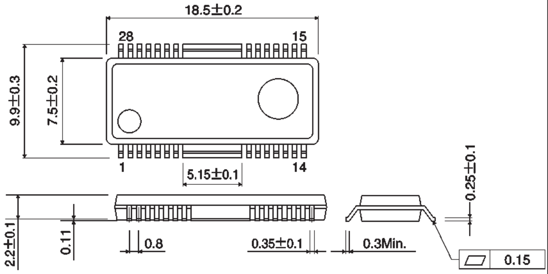
Copper side

●Application board component layout



Silk side

●External dimensions (Units: mm)



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