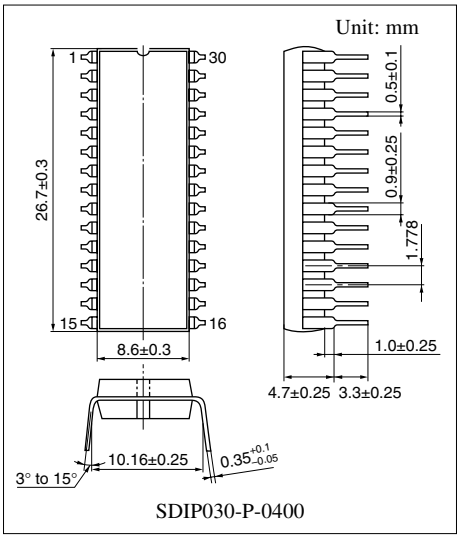
# AN7396K

## Sound signal processing with built-in Spatializer IC

### ■ Overview

Spatializer Audio Processor is a signal processing technology, monopolized by Desper Products, Inc., that was developed for commercial electronics and multimedia markets, and is based on Desper's "PRO Spatializer" that is a 3-D audio production system for business use. The AN7396K utilizes the innovative technology adopted in that system. It provides sound enhancement effect and sound expansion with the conventional 2-speaker stereo system. Moreover, the AN7396K is a sound processing IC which incorporates the I²C Bus-controllable mute, sound AGC, bass reinforcement, tone (bass and treble), balance, and volume circuits.




SDIP030-P-0400

Note) The package of this product will be changed to lead-free type (SDIP030-P-0400B). See the new package dimensions section later of this datasheet.

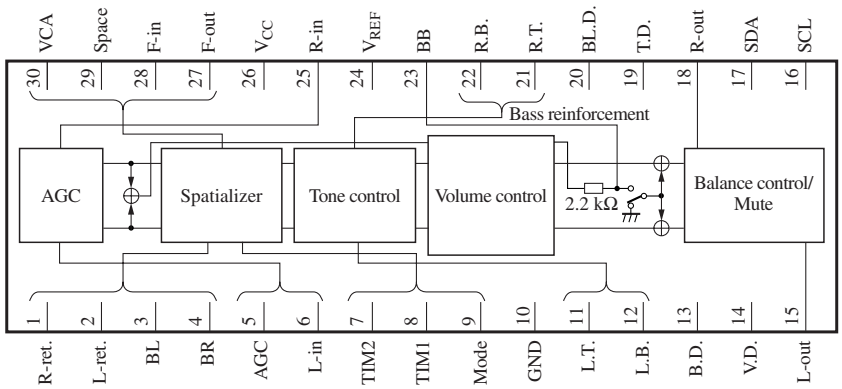
### ■ Features

- Provides deep 3-D sound with conventional 2-speaker system.
- Performs optimal processing to the sound source recorded with surround-effect so as not to give double effects.
- Provides the functions of muting, AGC, bass reinforcement, tone, balance, and volume control.
- Supports I²C Bus controls.

### ■ Applications

- Televisions, videos, audio equipment, and game machines

### ■ Block Diagram




Note) Spatializer® and the device trademark of circle-in-square ◙ are owned by Desper Products Inc.
This product can be used with the consent of the Desper Products Inc.
Under the terms of the agreement between Matsushita Electric and Desper Products Inc., no technical information on the Spatializer, which is applied to this product, shall be provided.

## ■ Pin Descriptions

| Pin No. | Description | Pin No. | Description |
|---|---|---|---|
| 1 | R-ret. | 16 | $I^2C$ communication clock |
| 2 | L-ret. | 17 | $I^2C$ communication data |
| 3 | BL out | 18 | R-ch. output |
| 4 | BR out | 19 | Treble DAC output |
| 5 | AGC | 20 | Balance DAC output |
| 6 | L-ch. input | 21 | R-ch. treble $F_C$ set |
| 7 | TIM2 | 22 | R-ch. bass $F_C$ set |
| 8 | TIM1 | 23 | Bass MIX $F_C$ adjustment |
| 9 | Mode DAC output | 24 | 1/2 $V_{CC}$ |
| 10 | GND | 25 | R-ch. input |
| 11 | L-ch. treble $F_C$ set | 26 | Power supply |
| 12 | L-ch. bass $F_C$ set | 27 | F-out |
| 13 | Bass DAC output | 28 | F-in |
| 14 | Volume DAC output | 29 | Space |
| 15 | L-ch. output | 30 | VCA |

## ■ Absolute Maximum Ratings

| Parameter | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | 11.0 | V |
| Supply current | $I_{CC}$ | 90 | mA |
| Power dissipation | $P_D$ | 990 | mW |
| Operating ambient temperature * | $T_{opr}$ | −25 to +75 | °C |
| Storage temperature * | $T_{stg}$ | −55 to +150 | °C |

Note) ∗: Except for the operating ambient temperature and storage temperature, all ratings are for $T_a$ = 25°C.

## ■ Recommended Operating Range

| Parameter | Symbol | Range | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | 6.0 to 10.0 | V |

■ Electrical Characteristics at $V_{CC}$ = 9 V, $T_a$ = 25°C ± 2°C

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Volume max. level *1 | $VV_{max}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | –1 | 0 | 1 | dB |
| Volume 1/2 level *1 | $VV_{1/2}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | –14.5 | –12.5 | –10.5 | dB |
| Volume min. level *1 | $VV_{min}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | — | –100 | –90 | dB |
| Balance max. level *1 | $VB_{max}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | –1 | 0 | 1 | dB |
| Balance min. level *1 | $VB_{min}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | — | –82 | –80 | dB |
| Bus bootstrap level | $V_{BB}$ | $V_{IN}$ = 400 mV[rms], f = 50 Hz | 10 | 12.5 | 15 | dB |
| Bus cut level | $V_{BC}$ | $V_{IN}$ = 400 mV[rms], f = 50 Hz | –13.5 | –11.0 | –8.5 | dB |
| Treble bootstrap level | $V_{TB}$ | $V_{IN}$ = 400 mV[rms], f = 20 kHz | 10 | 12.5 | 15 | dB |
| Treble cut level | $V_{TC}$ | $V_{IN}$ = 400 mV[rms], f = 20 kHz | –13.5 | –11.0 | –8.5 | dB |
| Circuit current *1 | $I_{CCT}$ | $V_{IN}$ = 0 mV | 45 | 65 | 90 | mA |
| Total harmonic distortion max. *1 | $THD_{max}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | — | 0.1 | 0.3 | % |
| Maximum input voltage *1 | $V_{Imax}$ | THD = 1%, f = 1 kHz | 2.0 | 2.2 | — | V[rms] |
| Muting level *1 | VMUTE | $V_{IN}$ = 1 V[rms], f = 1 kHz | — | –100 | –90 | dB |
| Noise level at volume max. *2 | $V_{Nmax}$ | $V_{IN}$ = 0 mV, $R_G$ = 4.7 kΩ | — | 82 | 120 | µV[rms] |
| Noise level at volume min. *2 | $V_{Nmin}$ | $V_{IN}$ = 0 mV, $R_G$ = 4.7 kΩ | — | 4 | 10 | µV[rms] |
| Bass reinforcement max. level | $VXB_{max}$ | $V_{IN}$ = 400 mV[rms], f = 50 Hz | 7 | 9 | 11 | dB |
| Bass reinforcement min. level | $VXB_{min}$ | $V_{IN}$ = 400 mV[rms], f = 50 Hz | 2 | 4 | 6 | dB |
| Level at surround max. *1 | $V_{SU1}$ | $V_{IN}$ = 50 mV[rms], f = 1 kHz | 415 | 600 | 750 | mV[rms] |
| Noise level at surround max. *2 | $V_{SN}$ | $V_{IN}$ = 0 mV, $R_G$ = 4.7 kΩ | — | 110 | 150 | µV[rms] |
| Total harmonic distortion at surround max. *1 | $THD_{SU}$ | $V_{IN}$ = 50 mV[rms], f = 1 kHz | — | 0.1 | 0.3 | % |
| Crosstalk *2 | CT | $V_{IN}$ = 1 V[rms], f = 1 kHz | — | –78 | –66 | dB |
| Channel balance (max.) *1 | $CB_{max}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | –1 | 0 | 1 | dB |
| Channel balance (1/4) *1 | $CB_{1/4}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | –2 | 0 | 2 | dB |
| AGC | | | | | | |
| AGC gain 1 *1 | $V_{AGC1}$ | $V_{IN}$ = 50 mV[rms], f = 1 kHz | 77 | 110 | 150 | mV[rms] |
| AGC gain 2 *1 | $V_{AGC2}$ | $V_{IN}$ = 1 V[rms], f = 1 kHz | 230 | 345 | 470 | mV[rms] |
| I²C interface | | | | | | |
| Sink current at ACK | $I_{ACK}$ | The maximum value of sink current of pin 17 at ACK | 2.0 | 10 | — | mA |
| SCL, SDA signal input high-level | $V_{IHI}$ | | 3.5 | — | 5.0 | V |
| SCL, SDA signal input low-level | $V_{ILO}$ | | 0 | — | 0.5 | V |
| Maximum input frequency | $f_{Imax}$ | | — | — | 100 | Kbit/s |

Note) ∗1: The DIN audio filter is used.
∗2: The A-curve filter is used.

## ■ Electrical Characteristics at $V_{CC}$ = 9 V, $T_a$ = 25°C ± 2°C (continued)

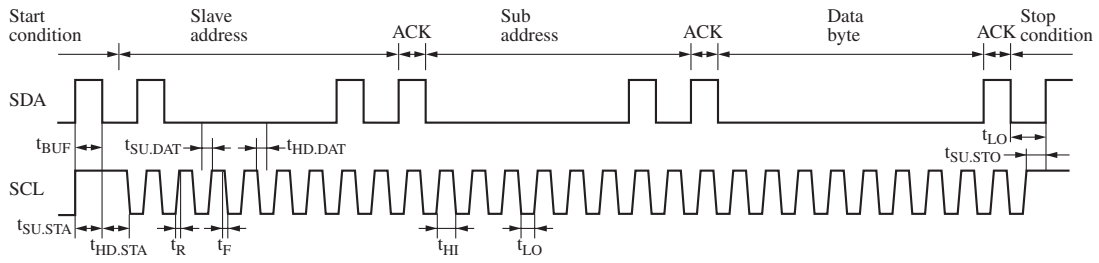
• Design reference data

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

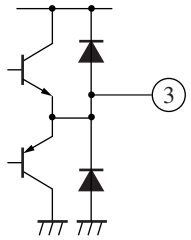
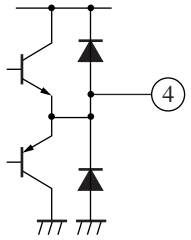
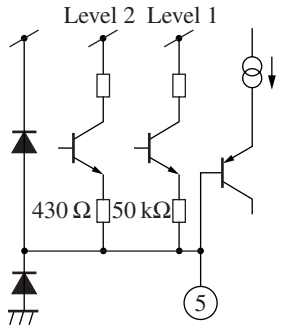
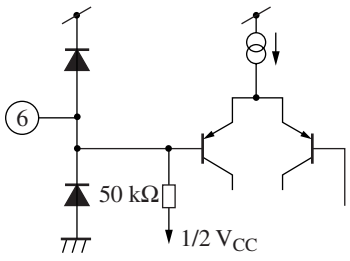
| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| I²C Interface | | | | | | |
| Bus free before start | $t_{BUF}$ | | 4.0 | — | — | µs |
| Start condition set-up time | $t_{SU, STA}$ | | 4.0 | — | — | µs |
| Start condition hold time | $t_{HD, STA}$ | | 4.0 | — | — | µs |
| SCL/SDA low period | $t_{LO}$ | | 4.0 | — | — | µs |
| SCL high period | $t_{HI}$ | | 4.0 | — | — | µs |
| SCL/SDA rise time | $t_R$ | | — | — | 1.0 | µs |
| SCL/SDA fall time | $t_F$ | | — | — | 0.35 | µs |
| Data set-up time (write) | $t_{SU, DAT}$ | | 0.25 | — | — | µs |
| Data hold time (write) | $t_{HD, DAT}$ | | 0 | — | — | µs |
| Acknowledge set-up time | $t_{SU, ACK}$ | | — | — | 3.5 | µs |
| Acknowledge hold time | $t_{HD, ACK}$ | | 0 | — | — | µs |
| Stop condition set-up time | $t_{SU, STO}$ | | 4.0 | — | — | µs |
| DAC | | | | | | |
| 6-bit DAC DNLE | $L_6$ | 1 LSB = (Data(max.) – Data(00))/63 | 0.1 | 1.0 | 1.9 | $\frac{LSB}{step}$ |
| AGC gain 3 (Sub address 04H: 05H) *1 | $V_{AGC3}$ | $V_{IN}$ = 100 mV[rms], f = 1 kHz | — | 150 | — | mV[rms] |
| AGC gain 4 (Sub address 04H: 03H) *1 | $V_{AGC4}$ | $V_{IN}$ = 140 mV[rms], f = 1 kHz | — | 200 | — | mV[rms] |
| AGC gain 5 (Sub address 04H: 01H) *1 | $V_{AGC5}$ | $V_{IN}$ = 200 mV[rms], f = 1 kHz | — | 250 | — | mV[rms] |
| AGC gain 6 (Sub address 04H: 07H) *1 | $V_{AGC6}$ | $V_{IN}$ = 280 mV[rms], f = 1 kHz | — | 350 | — | mV[rms] |
| AGC gain 7 (Sub address 04H: 03H) *1 | $V_{AGC7}$ | $V_{IN}$ = 500 mV[rms], f = 1 kHz | 180 | 290 | 430 | mV[rms] |

Note) ∗1: The DIN audio filter is used.

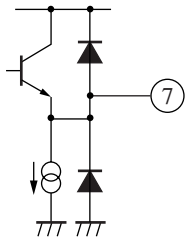
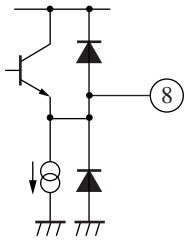
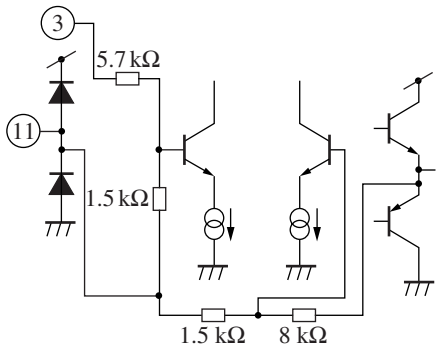
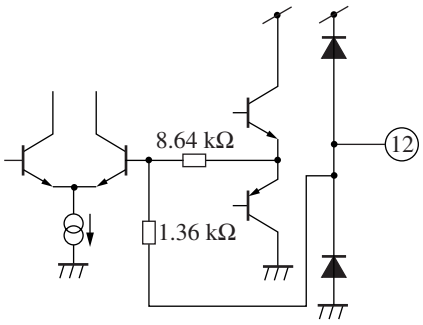
• DAC timing chart



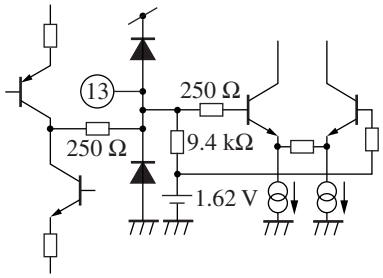
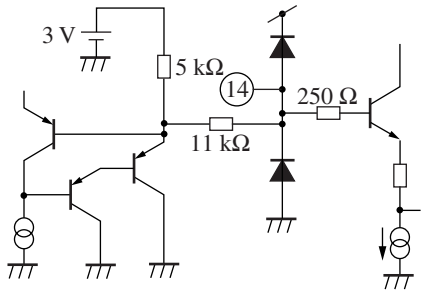
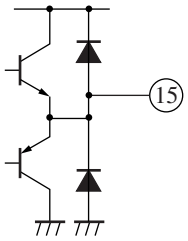
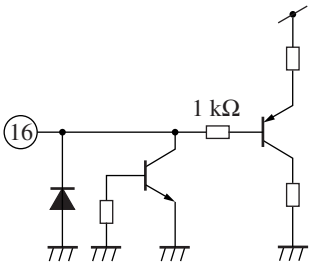
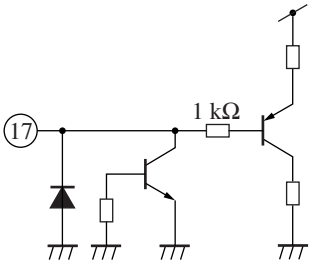
■ Terminal Equivalent Circuits at $V_{CC}$ = 9 V, $T_a$ = 25°C

| Pin No. | Pin name | Equivalent circuit | Description | Voltage (V) |
|---|---|---|---|---|
| 1 | R-ret. | — | R return | 4.5 |
| 2 | L-ret. | — | L return | 4.5 |
| 3 | BL out |   | L-ch. Spatializer output | 4.5 |
| 4 | BR out |   | R-ch. Spatializer output | 4.5 |
| 5 | AGC |   | AGC level sensor | This parameter fluctuates with the input level. 0.5 to 2.0 |
| 6 | L-in |   | L-ch. input | 4.5 |

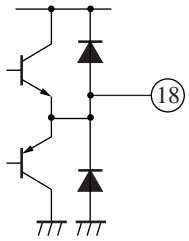
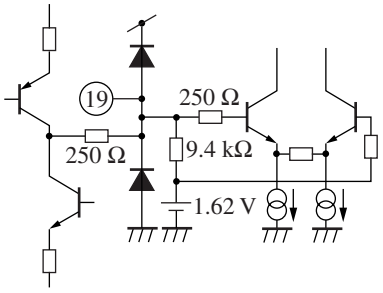
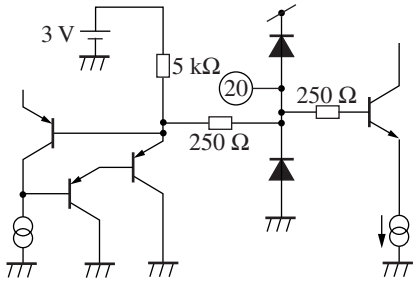
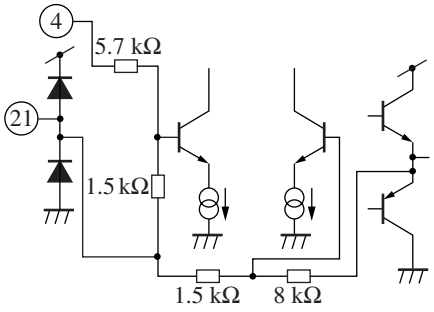
■ Terminal Equivalent Circuits at $V_{CC}$ = 9 V, $T_a$ = 25°C (continued)

| Pin No. | Pin name | Equivalent circuit | Description | Voltage (V) |
|---|---|---|---|---|
| 7 | TIM2 |   | RMS detector 2 | 0.6 |
| 8 | TIM1 |   | RMS detector 1 | 0.6 |
| 9 | MD | — | Mode DAC output | This parameter fluctuates with $I^2C$ data. 0.7 to 2.4 |
| 10 | GND | — | Ground | 0 |
| 11 | L.T. |   | L-ch. treble $F_C$ set | 4.5 |
| 12 | L.B. |   | L-ch. bass $F_C$ set | 4.5 |

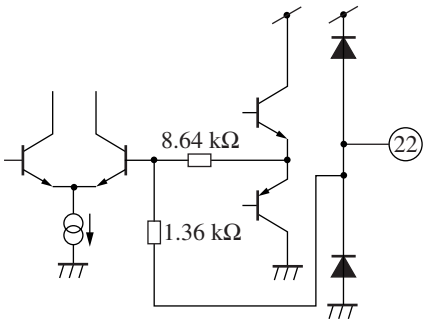
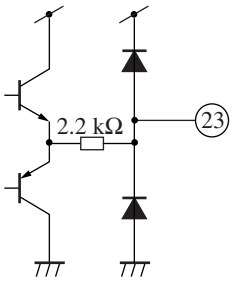
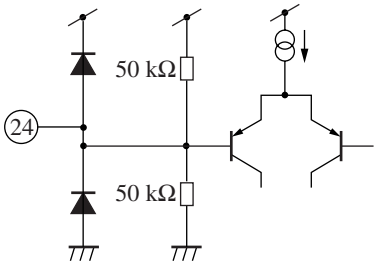
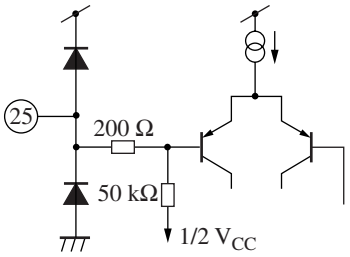
■ Terminal Equivalent Circuits at $V_{CC}$ = 9 V, $T_a$ = 25°C (continued)

| Pin No. | Pin name | Equivalent circuit | Description | Voltage (V) |
|---|---|---|---|---|
| 13 | B.D. |  | Bass DAC output | This parameter fluctuates with I²C data.<br>1.1 to 2.3 |
| 14 | V.D. |  | Volume DAC output | This parameter fluctuates with I²C data.<br>2 to 3.8 |
| 15 | L-out |  | L-ch. output | 4.5 |
| 16 | SCL |  | I²C Bus clock input | — |
| 17 | SDA |  | I²C Bus data input | — |

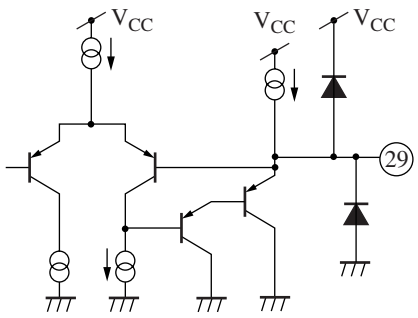
■ Terminal Equivalent Circuits at $V_{CC}$ = 9 V, $T_a$ = 25°C (continued)

| Pin No. | Pin name | Equivalent circuit | Description | Voltage (V) |
|---|---|---|---|---|
| 18 | R-out |  | R-ch. output | 4.5 |
| 19 | T.D. |  | Treble DAC output | This parameter fluctuates with $I^2C$ data.<br>1.1 to 2.3 |
| 20 | BL.D. |  | Balance DAC output | This parameter fluctuates with $I^2C$ data.<br>2 to 3 |
| 21 | R.T. |  | R-ch. treble $F_C$ set | 4.5 |

■ Terminal Equivalent Circuits at $V_{CC}$ = 9 V, $T_a$ = 25°C (continued)

| Pin No. | Pin name | Equivalent circuit | Description | Voltage (V) |
|---|---|---|---|---|
| 22 | R.B. |  | R-ch. bass $F_C$ set | 4.5 |
| 23 | BB |  | Bass MIX gain adjustment | 4.5 |
| 24 | $V_{REF}$ |  | Reference voltage stabilization | 4.5 |
| 25 | R-in |  | R-ch. input | 4.5 |
| 26 | $V_{CC}$ | None | Power supply | $V_{CC}$ |
| 27 | F-out | — | F out | 4.5 |
| 28 | F-in | — | F in | 4.5 |

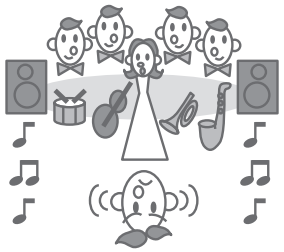
■ Terminal Equivalent Circuits at $V_{CC}$ = 9 V, $T_a$ = 25°C (continued)

| Pin No. | Pin name | Equivalent circuit | Description | Voltage (V) |
|---|---|---|---|---|
| 29 | Space |   | Space | This parameter fluctuates with I²C data. 2 to 3 |
| 30 | VCA | — | VCA | This parameter fluctuates with I²C data. 2 to 3 |

## ■ Conceptual Explanation of Spatializer Operation

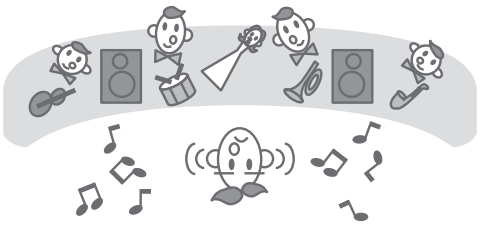
• Normal stereo

All sounds are heard from only between two speakers, right and left.



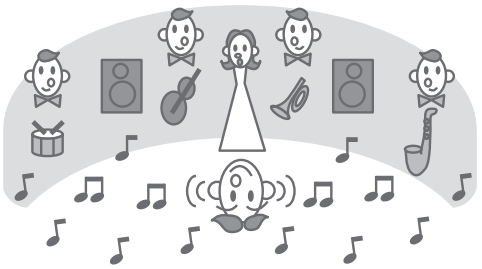
• Conventional surround

The sound expands toward the outside of the speaker system, but the sound position comes apart mostly in the conventional systems.



• Spatializer

The sound expands toward the outside of the two speakers, and yet their positions are stable and an expanded, deep sound are gotten.

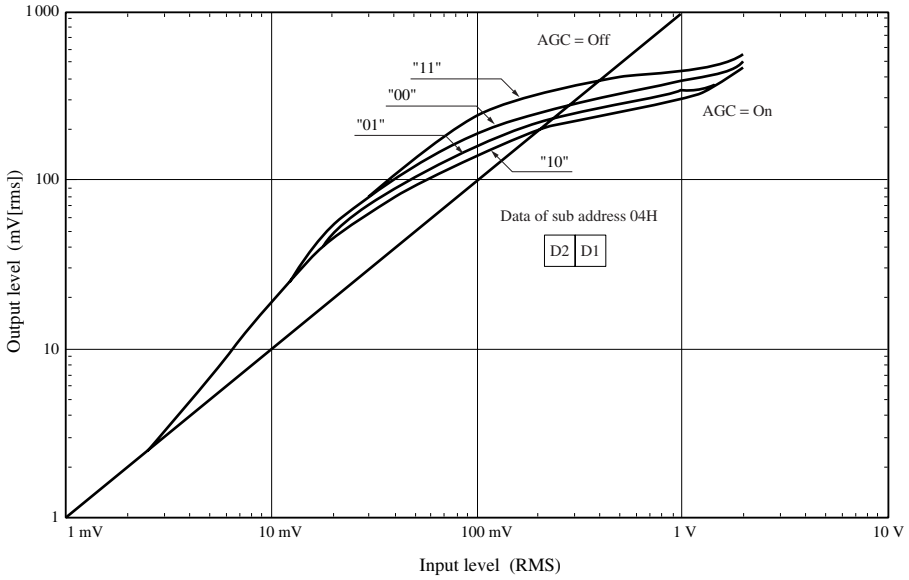


## ■ Precautions in Use and Application Method

• Method of setting AGC control

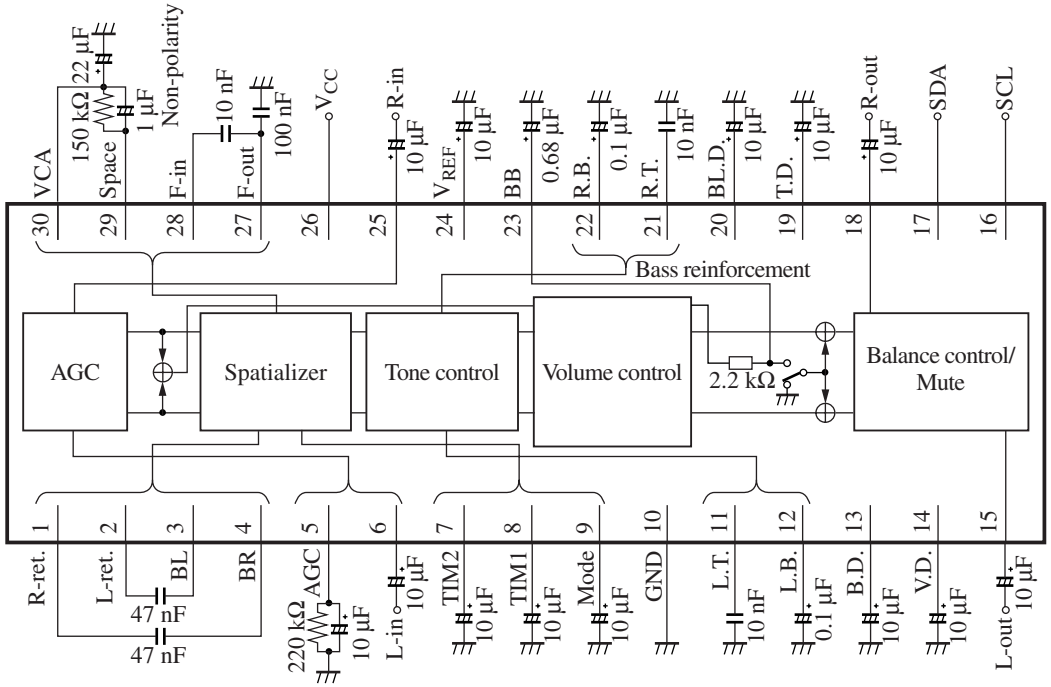
Turning on AGC, AGC is set to 0 dB for small signals, “Bootstrap” for medium signals, and “Gain Reduction” for large signals. The AGC input-output characteristics can be controlled by $I^2C$ as follows.

AGC characteristic

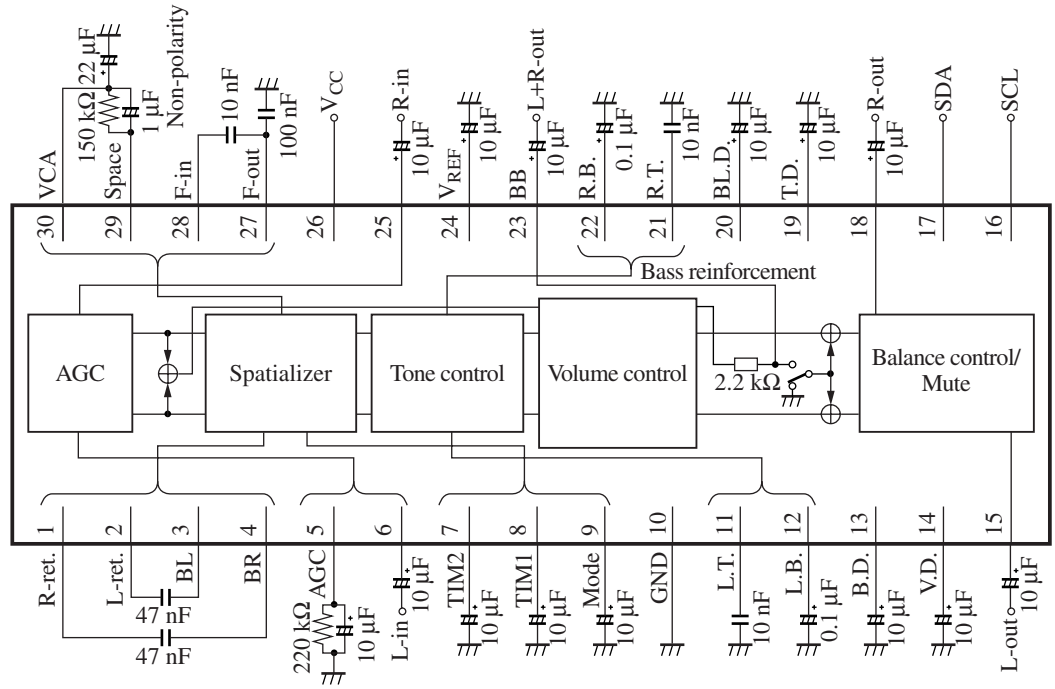


## ■ Application Circuit Examples

• Bass reinforcement circuit example

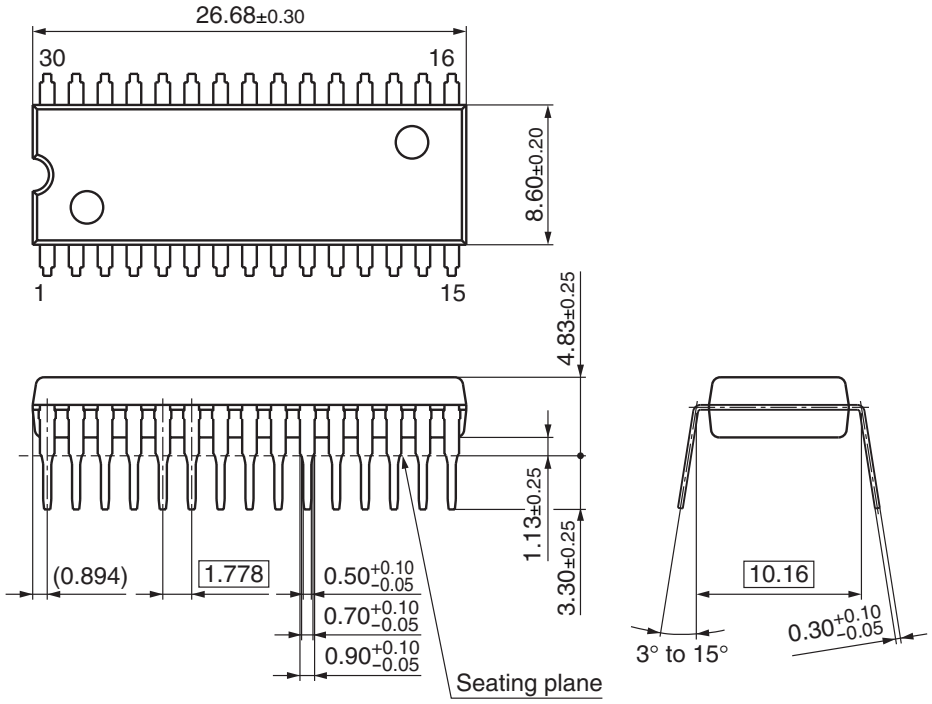



• Application circuit example of obtaining L+R output instead of bass reinforcement



■ New Package Dimensions (Unit: mm)

• SDIP030-P-0400B (Lead-free package)



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