

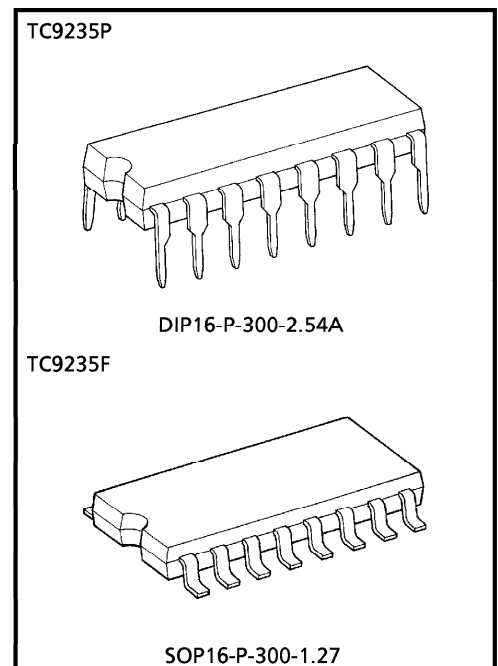
# TC9235P, TC9235F

## ELECTRONIC VOLUME

The TC9235P and TC9235F are an optimum CMOS IC which has been designed for electronization of volume control of audio equipment, etc.

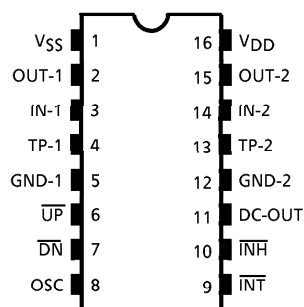
### FEATURES

- Attenuation can be controlled from 0dB to -78dB by up, down input.
- This IC have 20dB tap for loudness circuit.
- This IC features a built-in DC output circuit (7 level) for volume level meter.
- Polysilicon resistors enables low-distortion, high-performance volume systems.
- Volume level remains in backup mode with low current consumption.
- Package is DIP16 and SOP16.

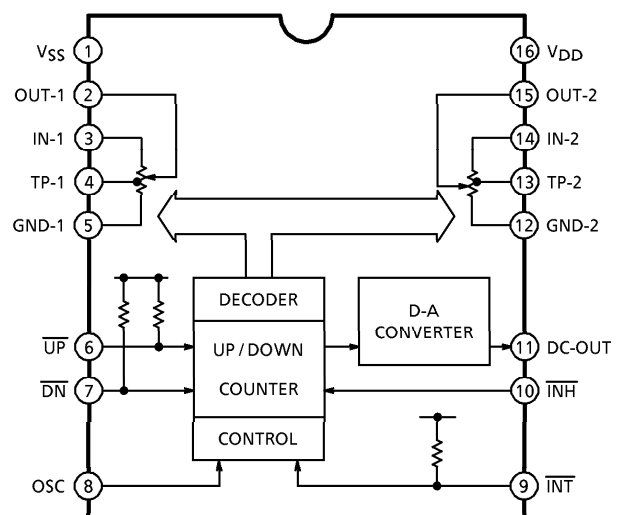


Weight  
 DIP16-P-300-2.54A : 1.0g (Typ.)  
 SOP16-P-300-1.27 : 0.16g (Typ.)

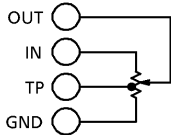
### PIN CONNECTION



### BLOCK DIAGRAM



## PIN FUNCTION

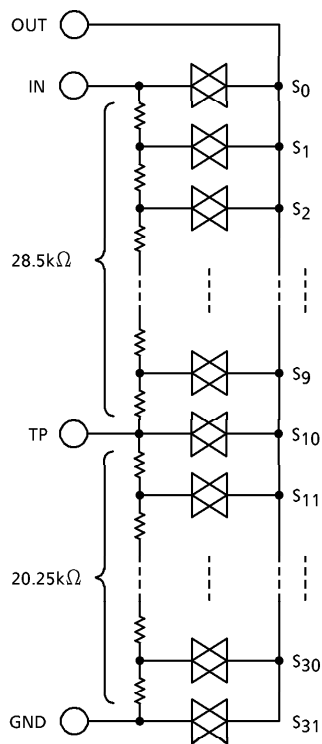
| PIN No. | SYMBOL          | PIN NAME                      | FUNCTION AND OPERATION                                                                                                                                                                | NOTE                      |
|---------|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| 1       | V <sub>SS</sub> | Negative power supply pin     | Power supply terminal                                                                                                                                                                 | —                         |
| 16      | V <sub>DD</sub> | Positive power supply pin     |                                                                                                                                                                                       |                           |
| 2       | OUT-1           | Volume output pins            | Volume circuit<br>                                                                                   | —                         |
| 15      | OUT-2           |                               |                                                                                                                                                                                       |                           |
| 3       | IN-1            | Volume input pins             |                                                                                                                                                                                       |                           |
| 14      | IN-2            |                               |                                                                                                                                                                                       |                           |
| 4       | TP-1            | Tap output pins for loudness  |                                                                                                                                                                                       |                           |
| 13      | TP-2            |                               |                                                                                                                                                                                       |                           |
| 5       | GND-1           | Analog ground pins            |                                                                                                                                                                                       |                           |
| 12      | GND-2           |                               |                                                                                                                                                                                       |                           |
| 6       | UP              | Volume up input pin           | Volume up, down control input pin.<br>The 1 step / 1 push volume is controlled by pushing the Up or Down key. If the key has been pushed continuously, the continuous volume control. | Built-in pull-up resistor |
| 7       | DN              | Volume down input pin         |                                                                                                                                                                                       |                           |
| 8       | OSC             | Oscillation pin               | Oscillation pin.<br>Oscillator circuit consist of C-R connection.<br>Oscillation is executed while key is pushed.                                                                     | —                         |
| 9       | INT             | Initializing pin              | Input pin for setting initial volume level<br>volume level set to 46dB by "L" input.                                                                                                  | Built-in pull-up resistor |
| 10      | INH             | Inhibit terminal              | Back up mode input pin.<br>Internal all operation is stopped by "L" input, and volume level remains with low current consumption.                                                     | —                         |
| 11      | DC-OUT          | DC output pin for level meter | DC output pin for volume level meter.<br>DC voltage which is corresponded to volume step is generated.                                                                                | —                         |

OPERATION

1. Volume circuit

Volume circuit consist of ladder resistor and analog switch.  
Tap for loudness is connected to step 10 (20dB).  
Attenuation is as follows when resistor (3.9kΩ) is connected between TP pin and GND pin.

● Equivalence circuit



● Volume step and attenuation  
(Attenuation is as follows when resistor (3.9kΩ) is connected between TP pin and GND pin.)

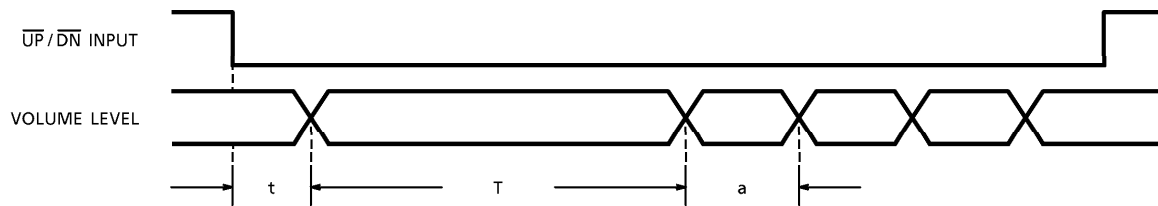
| STEP | ATTENUATION | STEP | ATTENUATION |
|------|-------------|------|-------------|
| 0    | 0 (dB)      | 16   | 32 (dB)     |
| 1    | 2           | 17   | 34          |
| 2    | 4           | 18   | 36          |
| 3    | 6           | 19   | 38          |
| 4    | 8           | 20   | 40          |
| 5    | 10          | 21   | 42          |
| 6    | 12          | * 22 | 46          |
| 7    | 14          | 23   | 50          |
| 8    | 16          | 24   | 54          |
| 9    | 18          | 25   | 58          |
| 10   | 20          | 26   | 62          |
| 11   | 22          | 27   | 66          |
| 12   | 24          | 28   | 70          |
| 13   | 26          | 29   | 74          |
| 14   | 28          | 30   | 78          |
| 15   | 30          | 31   | ∞           |

\* Step 22 (46dB) initial value.

## 2. Volume up, down control circuit

Volume up, down control is executed by  $\overline{UP}$ ,  $\overline{DN}$  key input.

- The 1 step / 1 push volume is controlled by "L" level of  $\overline{UP}$ ,  $\overline{DN}$  key.
- If  $\overline{UP}$ ,  $\overline{DN}$  key is input "L" continuously, volume level is changed continuously.
- Timing of key input



( $f_{OSC} = 20\text{Hz}$ )  
 $t$  : Prevent time for chattering  $\approx 2.2 \times 1 / f_{OSC} (\approx 110\text{ms})$   
 $T$  : Switching time to automatic mode  $\approx 10 \times 1 / f_{OSC} (\approx 500\text{ms})$   
 $a$  : Up, Down speed  $\approx 2 \times 1 / f_{OSC} (\approx 100\text{ms})$   
 $f_{OSC} \approx C_X \cdot R_X \text{ (Hz)} : R_X = 12 \sim 220\text{k}\Omega$

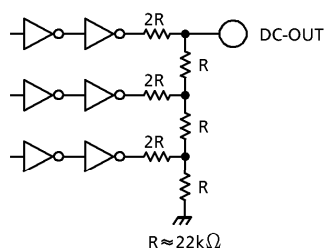
## 3. DC output circuit for volume level

DC output for volume level meter is internally connected to D-A converter (R/2R type).

8 stage output voltage which is corresponded to volume level is generated.

Because output impedance  $\approx 22\text{k}\Omega$  (typ.) is high, If input impedance of next setting level meter IC is low, set to Buffer.

### • Equivalence circuit



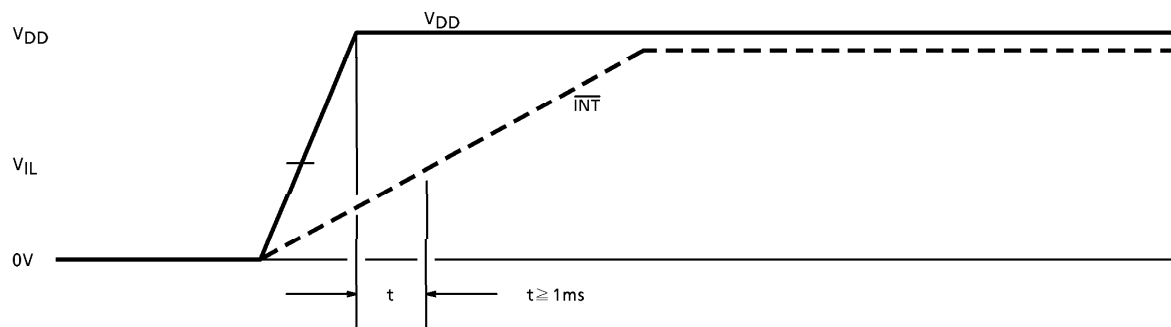
### • Volume step and Output voltage

| STEP  | ATTENUATION (dB) | OUTPUT VOLTAGE (V) |
|-------|------------------|--------------------|
| 0~ 3  | 0~ 6             | $7/8 V_{DD}$       |
| 4~ 7  | 8~14             | $6/8 V_{DD}$       |
| 8~11  | 16~22            | $5/8 V_{DD}$       |
| 12~15 | 24~30            | $4/8 V_{DD}$       |
| 16~19 | 32~38            | $3/8 V_{DD}$       |
| 20~23 | 40~50            | $2/8 V_{DD}$       |
| 24~27 | 54~66            | $1/8 V_{DD}$       |
| 28~31 | 70~ $\infty$     | 0                  |

#### 4. Initialization and Backup operation

##### (1) Initialization operation

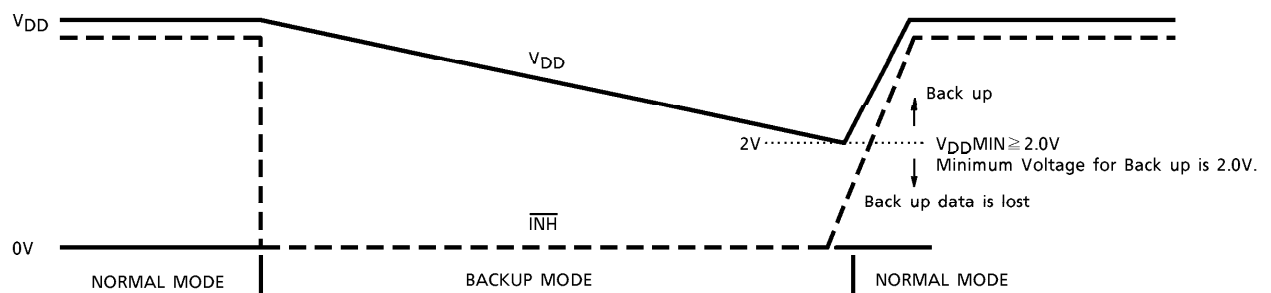
When power on, volume level is set to initial value (46dB) by setting  $\overline{\text{INT}}$  pin to "L" level for a while.



Adjust condenser value which is set  $\overline{\text{INT}}$  pin to the period while  $\overline{\text{INT}}$  pin is "L" level is longer than 1ms when power on.

##### (2) Backup operation

Internal operation is all stopped when  $\overline{\text{INH}}$  pin is "L" level, and prohibit input and output. Volume data is remains while Backup mode with low current consumption.



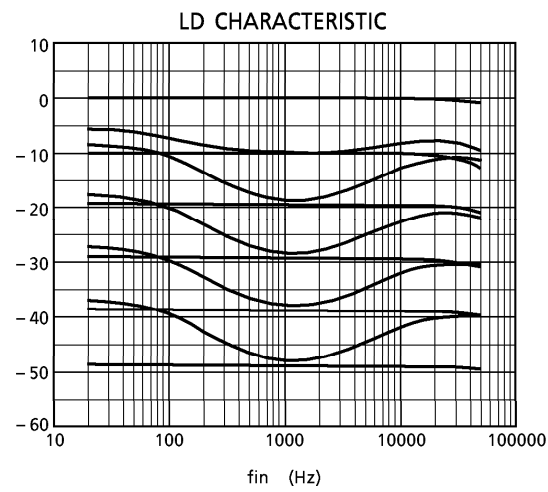
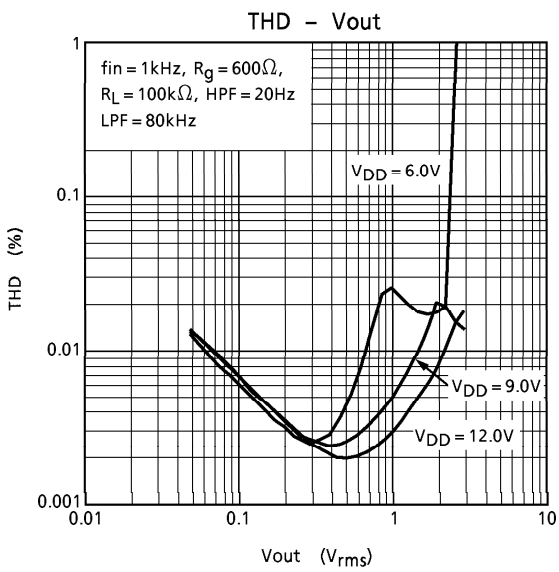
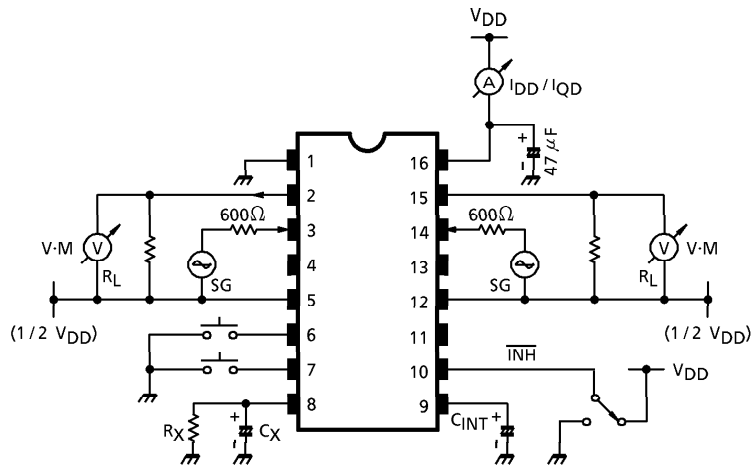
## MAXIMUM RATINGS (Ta = 25°C)

| CHARACTERISTIC        | SYMBOL           | RATING                      | UNIT |
|-----------------------|------------------|-----------------------------|------|
| Supply Voltage        | V <sub>DD</sub>  | - 0.3~15                    | V    |
| Input Voltage         | V <sub>IN</sub>  | - 0.3~V <sub>DD</sub> + 0.3 | V    |
| Power Dissipation     | P <sub>D</sub>   | 300                         | mW   |
| Operating Temperature | T <sub>opr</sub> | - 40~85                     | °C   |
| Storage Temperature   | t <sub>stg</sub> | - 55~150                    | °C   |

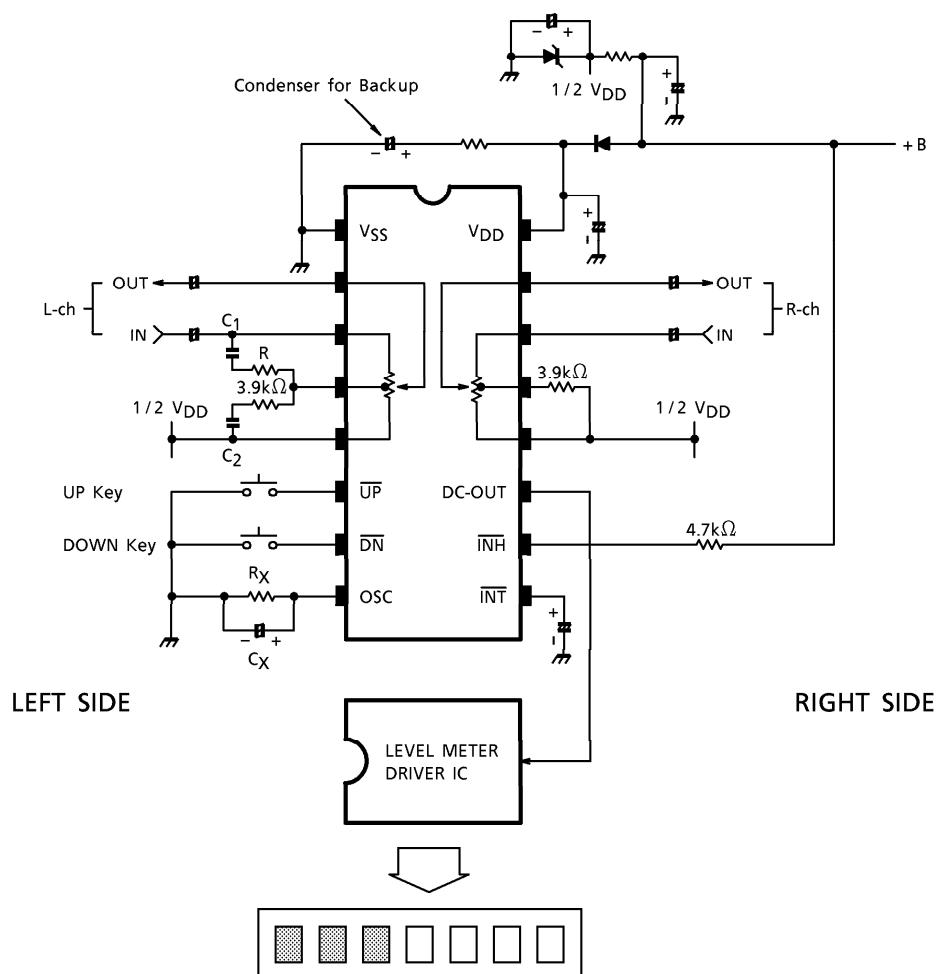
ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Ta = 25°C, V<sub>DD</sub> = 9V)

| CHARACTERISTIC                 |           | SYMBOL             | TEST CIR-<br>CUIT | TEST CONDITION                                                                                                   |                                   | MIN.                  | TYP. | MAX.                  | UNIT              |
|--------------------------------|-----------|--------------------|-------------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|------|-----------------------|-------------------|
| Operating Supply Voltage       |           | V <sub>DD</sub>    | —                 | Ta = - 40~85°C                                                                                                   |                                   | 4.5                   | 9.0  | 12                    | V                 |
| Operating Supply Current       |           | I <sub>DD</sub>    | 1                 | No load, f <sub>OSC</sub> = 20Hz                                                                                 |                                   | —                     | 0.3  | 1.0                   | mA                |
| Backup Voltage                 |           | V <sub>QD</sub>    | —                 | $\overline{\text{INH}} = \text{“L”}$                                                                             |                                   | 2.0                   | ~    | 12                    | V                 |
| Backup Current                 |           | I <sub>QD</sub>    | 1                 |                                                                                                                  |                                   | —                     | 0.01 | 1.0                   | μA                |
| Input Voltage                  | “H” Level | V <sub>IH</sub>    | —                 | All input pin                                                                                                    |                                   | V <sub>DD</sub> × 0.7 | ~    | V <sub>DD</sub>       | V                 |
|                                | “L” Level | V <sub>IL</sub>    |                   |                                                                                                                  |                                   | 0                     | ~    | V <sub>DD</sub> × 0.3 |                   |
| Input Current                  | “H” Level | I <sub>IH</sub>    | —                 | $\overline{\text{INH}}$ input pin                                                                                | V <sub>IH</sub> = V <sub>DD</sub> | - 1                   | —    | 1                     | μA                |
|                                | “L” Level | I <sub>IL</sub>    |                   |                                                                                                                  | V <sub>IL</sub> = 0V              | - 1                   | —    | 1                     |                   |
| Pull Up Resistor               |           | R <sub>UP</sub>    | —                 | $\overline{\text{UP}}$ , $\overline{\text{DN}}$ , $\overline{\text{INT}}$ input pin                              |                                   | 23                    | 47   | 71                    | kΩ                |
| Volume Resistor                |           | R <sub>VR</sub>    | —                 | Between IN→GND resistor                                                                                          |                                   | 31                    | 44   | 58                    | kΩ                |
| Analog Switch ON Resistor      |           | R <sub>ON</sub>    | —                 | Analog switch ON resistor                                                                                        |                                   | —                     | 500  | 800                   | Ω                 |
| Attenuation Error              |           | ΔATT               | —                 | —                                                                                                                |                                   | —                     | 0    | ± 2.0                 | dB                |
| Balance Between Left And Right |           | ΔR <sub>VR</sub>   | —                 | Volume resistor error between left and right                                                                     |                                   | —                     | 0    | ± 3.0                 | %                 |
| Total Harmonic Distortion      |           | THD                | 1                 | f <sub>IN</sub> = 1kHz<br>V <sub>IN</sub> = 1V <sub>rms</sub><br>R <sub>L</sub> = 100kΩ<br>R <sub>g</sub> = 600Ω | 0dB                               | —                     | 0.01 | —                     | %                 |
| Maximum Attenuation            |           | ATT <sub>MAX</sub> |                   |                                                                                                                  | ∞ dB                              | —                     | 100  | —                     | dB                |
| Cross Talk                     |           | C·T                |                   |                                                                                                                  | 0dB                               | —                     | 100  | —                     | dB                |
| Output Noise Voltage           |           | V <sub>N</sub>     |                   |                                                                                                                  |                                   | —                     | 2.0  | —                     | μV <sub>rms</sub> |
| OSC Frequency                  |           | f <sub>OSC</sub>   | 1                 | C <sub>X</sub> = 2.2μF, R <sub>X</sub> = 33kΩ                                                                    |                                   | —                     | 20   | —                     | Hz                |

TEST CIRCUIT 1



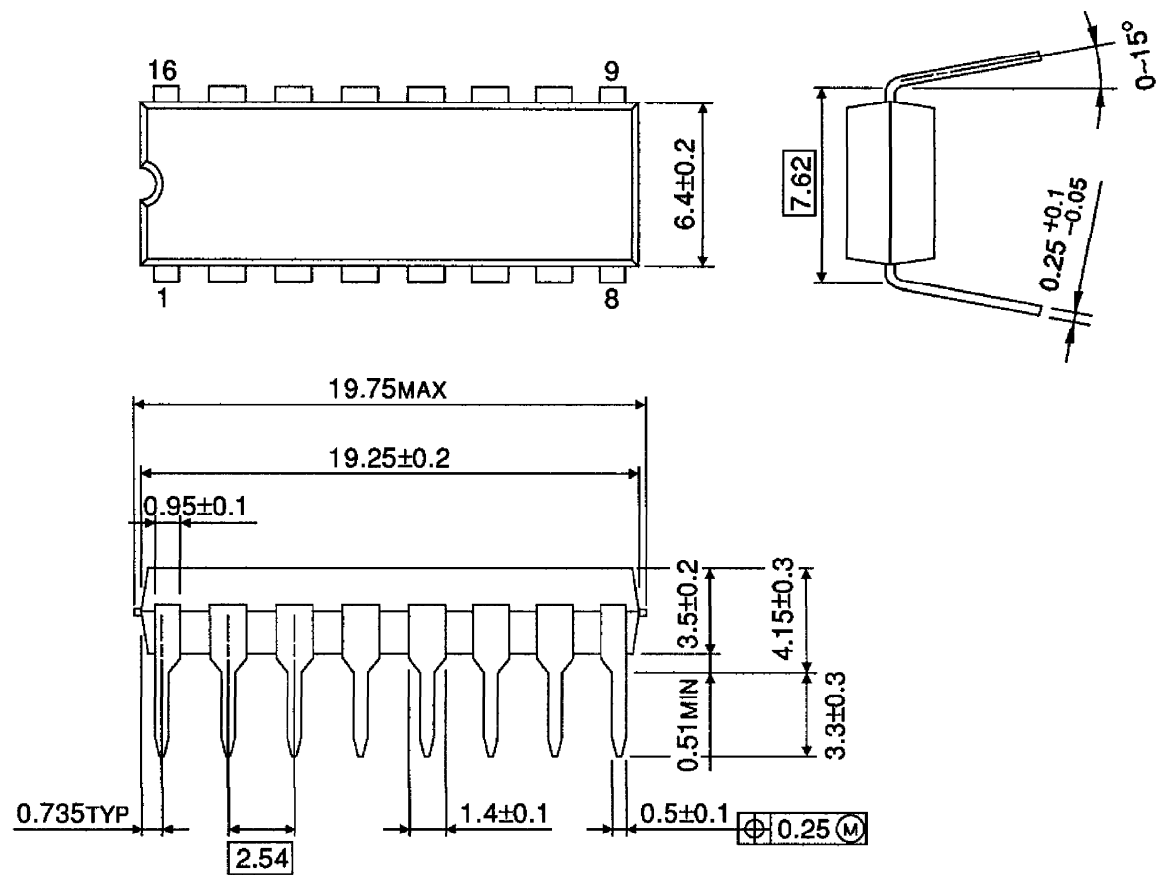
## EXAMPLE OF APPLICATION CIRCUIT



(Note) Loudness circuit is left side, only volume (without loudness) circuit is right side.  
 $C_1 = 1500\text{pF}$   $C_2 = 0.1\mu\text{F}$   $R = 8.2\text{k}\Omega$

PACKAGE DIMENSIONS  
DIP16-P-300-2.54A

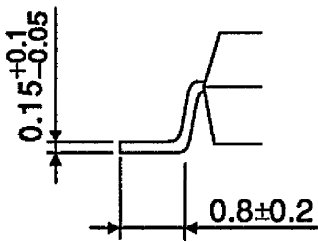
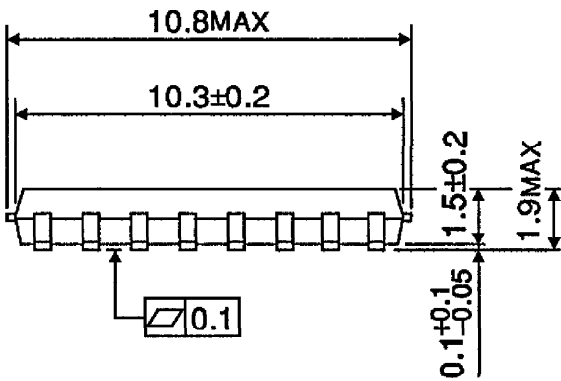
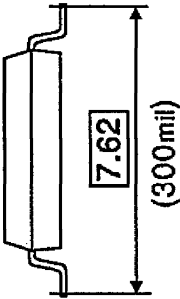
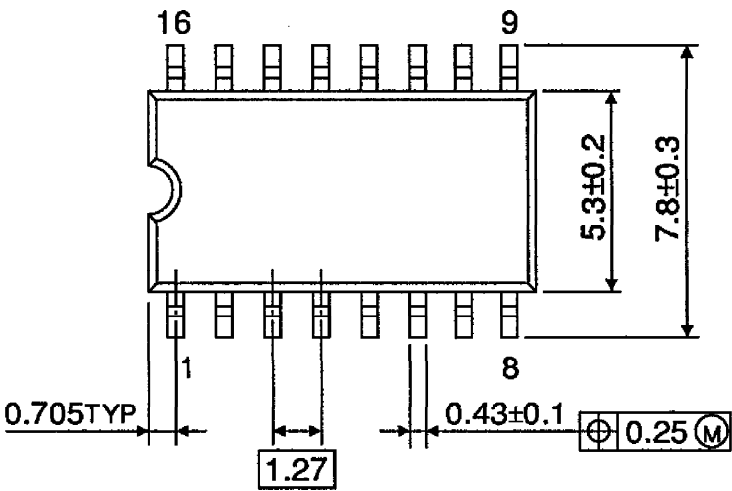
Unit : mm



Weight : 1.0g (Typ.)

PACKAGE DIMENSIONS  
SOP16-P-300-1.27

Unit : mm



Weight : 0.16g (Typ.)

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000707EBA

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