

TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

# TC9412AP, TC9412AF, TC9413AP

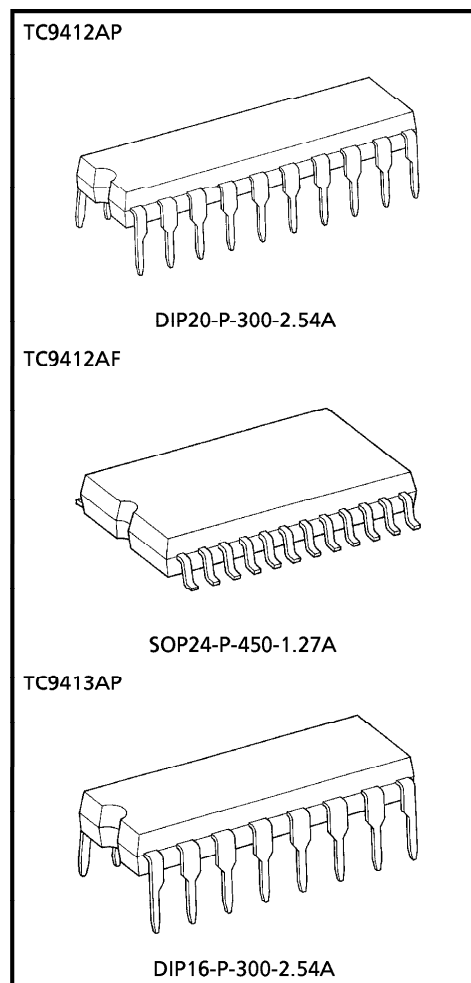
## ELECTRONIC VOLUME CONTROL

The TC9412AP, TC9412AF, TC9413AP are electronic volume control ICs developed for use in home stereos and other audio equipment.

Using serial data input from external sources, it controls the sound volume, balance and loudness circuits.

### FEATURES

- Sound volume can be controlled in 62 steps from 0 to 78dB or up to an infinite level in 1 or 2dB increments.
- Incorporating two channels of volume control circuits, the device allows independent volume control : therefore, it also provides the balancing function.
- A loudness circuit (20dB tap) is built in TC9412AP and TC9412AF.
- Can operate with a single or dual power supplies.
- Can control up to 4 chips on the same bus by using chip select input.
- Thanks to its polysilicon resistor, the device allows you to configure a low-distortion, high-performance volume control system.

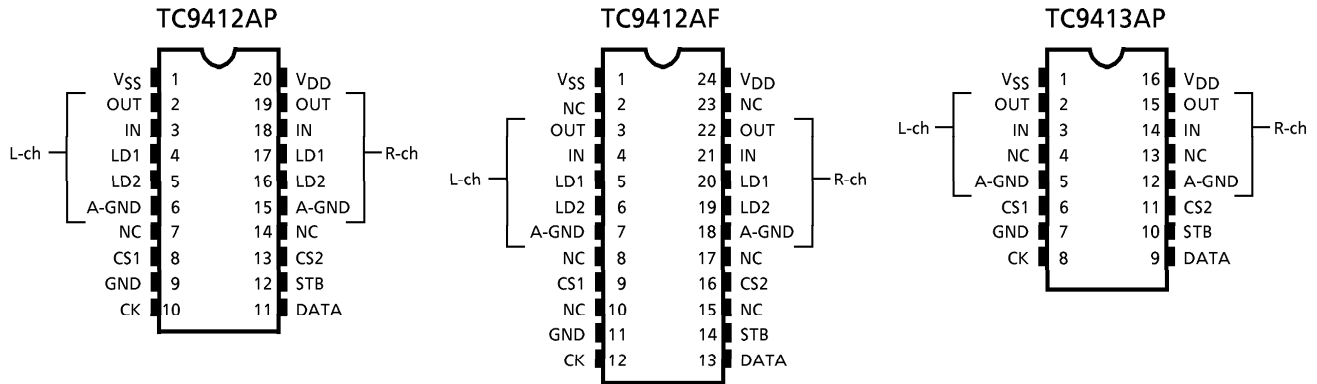


Weight	
DIP20-P-300-2.54A	: 1.4g (Typ.)
SOP24-P-450-1.27A	: 0.44g (Typ.)
DIP16-P-300-2.54A	: 1.0g (Typ.)

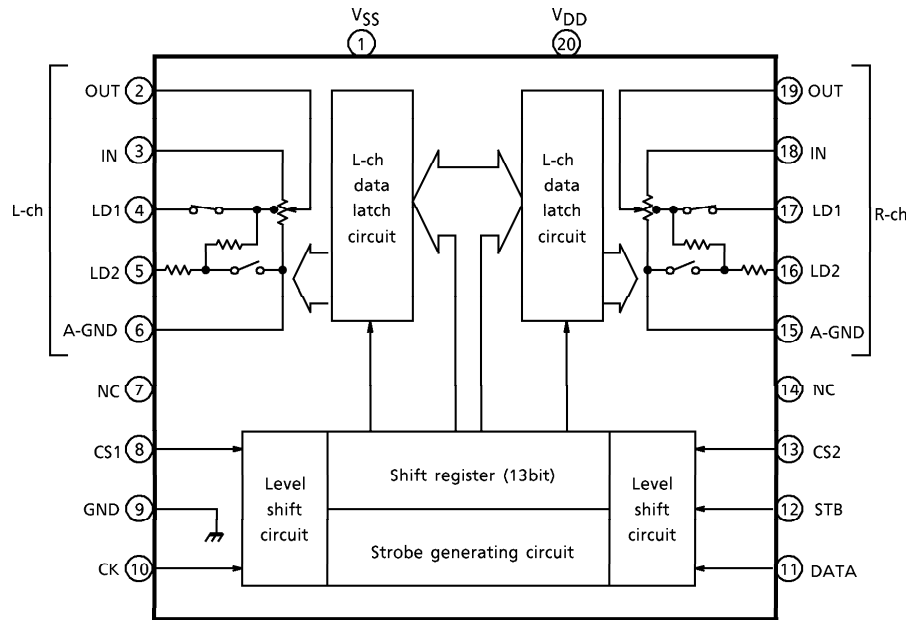
961001EBA2

- TOSHIBA is continually working to improve the quality and the reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to observe standards of safety, and to avoid situations in which a malfunction or failure of a TOSHIBA product could cause loss of human life, bodily injury or damage to property. In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent products specifications. Also, please keep in mind the precautions and conditions set forth in the TOSHIBA Semiconductor Reliability Handbook.
- The products described in this document are subject to foreign exchange and foreign trade control laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.

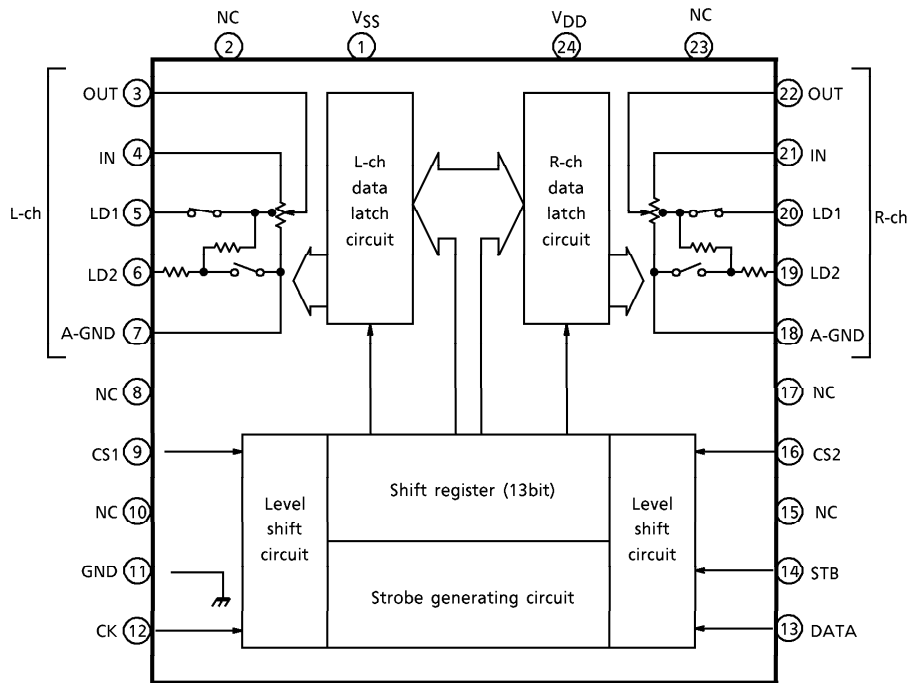
**PIN CONNECTIONS**



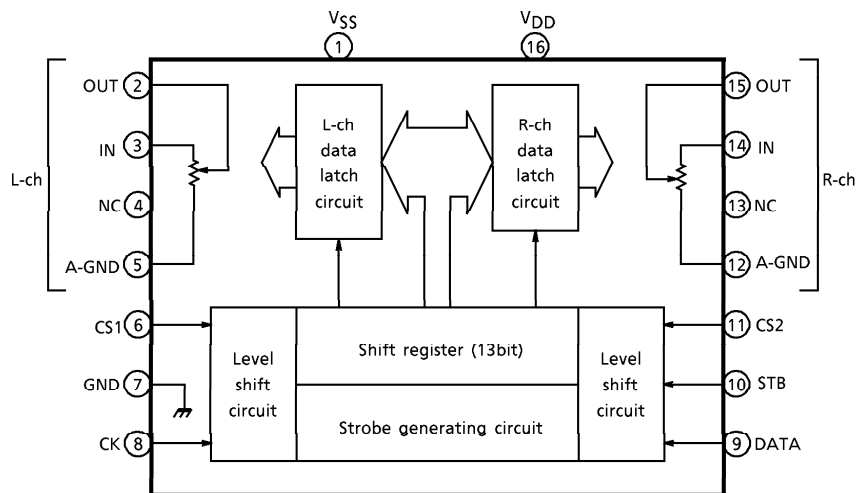
**BLOCK DIAGRAM (TC9412AP)**



**BLOCK DIAGRAM (TC9412AF)**



**BLOCK DIAGRAM (TC9413AP)**



**PIN DESCRIPTION**

Numeral in [ ] means the pin No. of TC9412AF and ( ) means the pin No. of TC9413AP.

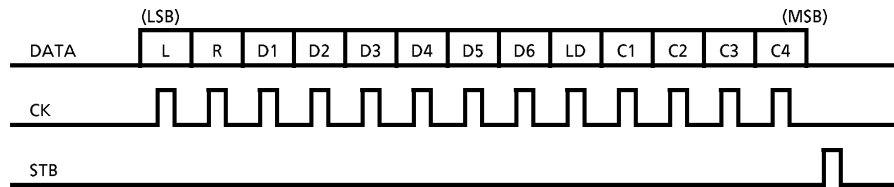
PIN No.	SYMBOL	PIN NAME	FUNCTION	REMARK										
1 [ 1 ] ( 1 )	V <sub>SS</sub>	Negative power supply pin	When using two power supplies <ul style="list-style-type: none"> <li>— V<sub>DD</sub> = 6.0~17V</li> <li>— GND = 0V</li> <li>— V<sub>SS</sub> = -6.0~-17V</li> </ul>	—										
9 [ 11 ] ( 7 )	GND	Digital GND pin												
20 [ 24 ] ( 16 )	V <sub>DD</sub>	Positive power supply pin	When using a single power supply <ul style="list-style-type: none"> <li>— V<sub>DD</sub> = 6.0~18V</li> <li>— GND = V<sub>SS</sub> = 0V</li> </ul>											
2 [ 3 ] ( 2 )	L-OUT	Volume output pin	<ul style="list-style-type: none"> <li>• Volume circuit (TC9412AP / AF)</li> </ul>	—										
19 [ 22 ] ( 15 )	R-OUT													
3 [ 4 ] ( 3 )	L-IN	Volume input pin												
18 [ 21 ] ( 14 )	R-IN													
4 [ 5 ] ( — )	L-LD1	Loudness tap output pin			<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">/</td> <td style="text-align: center;">LA1</td> <td style="text-align: center;">LA2</td> </tr> <tr> <td>Loudness "ON"</td> <td style="text-align: center;">ON</td> <td style="text-align: center;">OFF</td> </tr> <tr> <td>Loudness "OFF"</td> <td style="text-align: center;">OFF</td> <td style="text-align: center;">ON</td> </tr> </table>	/	LA1	LA2	Loudness "ON"	ON	OFF	Loudness "OFF"	OFF	ON
/	LA1					LA2								
Loudness "ON"	ON					OFF								
Loudness "OFF"	OFF					ON								
17 [ 20 ] ( — )	R-LD1													
5 [ 6 ] ( — )	L-LD2													
16 [ 19 ] ( — )	R-LD2													
6 [ 7 ] ( 5 )	L-A-GND	Analog GND pin												
15 [ 18 ] ( 12 )	R-A-GND													
8 [ 9 ] ( 6 )	CS1	Chip select input pin	Up to 4 chips on the same bus can be used by switching over chip select code.	—										
13 [ 16 ] ( 11 )	CS2													
10 [ 12 ] ( 8 )	CK	Clock input pin	Data transfer clock input	Low threshold value input pin										
11 [ 13 ] ( 9 )	DATA	Data input pin	Volume setup serial data input											
12 [ 14 ] ( 10 )	STB	Strobe input pin	Data write strobe input											
7, 14 [ 2, 8, 10, 15, 17, 23 ] ( 4, 13 )	NC	No connection		—										

**DEVICE OPERATION**

1. Setting up volume value (amount of attenuation)

Serial data consisting of 13 bits is used to set a volume value.

- Data format



- 1) The bits "L" and "R" respectively are the left- and right-channel select data. The left-channel volume is set when L = 1 : the right-channel volume is set when R = 1. (L = R = 1 are set simultaneously.)
- 2) The bit "LD" is the loudness setup data. Loudness is turned on when LD = 1. (This only applies to the TC9412AP and TC9412AF. Set this bit to "0" for the TC9413AP.)

3) The bits "D1" through "D6" are the volume setup data. For details, see the tables below.

VOLUME VALUE	D1	D2	D3	D4	D5	D6
0dB	0	0	0	0	0	0
-1	1	0	0	0	0	0
-2	0	1	0	0	0	0
-3	1	1	0	0	0	0
-4	0	0	1	0	0	0
-5	1	0	1	0	0	0
-6	0	1	1	0	0	0
-7	1	1	1	0	0	0
-8	0	0	0	1	0	0
-9	1	0	0	1	0	0
-10	0	1	0	1	0	0
-11	1	1	0	1	0	0
-12	0	0	1	1	0	0
-13	1	0	1	1	0	0
-14	0	1	1	1	0	0
-15	1	1	1	1	0	0
-16	0	0	0	0	1	0
-17	1	0	0	0	1	0
-18	0	1	0	0	1	0
-19	1	1	0	0	1	0
-20	0	0	1	0	1	0
-21	1	0	1	0	1	0
-22	0	1	1	0	1	0
-23	1	1	1	0	1	0
-24	0	0	0	1	1	0
-25	1	0	0	1	1	0
-26	0	1	0	1	1	0
-27	1	1	0	1	1	0
-28	0	0	1	1	1	0
-29	1	0	1	1	1	0
-30	0	1	1	1	1	0
-31	1	1	1	1	1	0

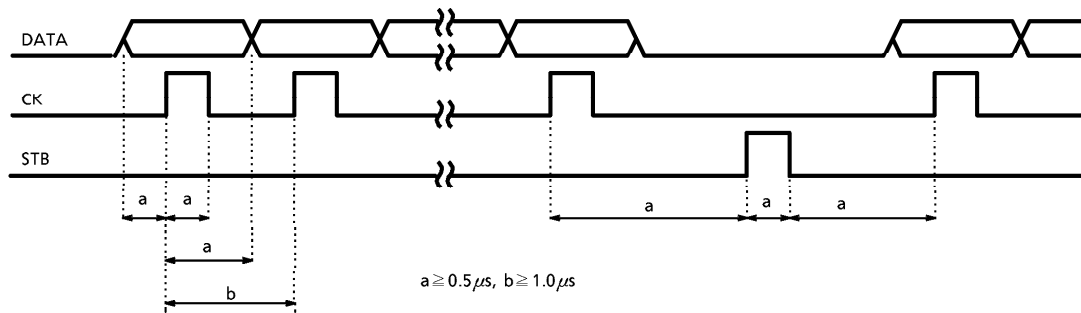
VOLUME VALUE	D1	D2	D3	D4	D5	D6
-32dB	0	0	0	0	0	1
-33	1	0	0	0	0	1
-34	0	1	0	0	0	1
-35	1	1	0	0	0	1
-36	0	0	1	0	0	1
-37	1	0	1	0	0	1
-38	0	1	1	0	0	1
-39	1	1	1	0	0	1
-40	0	0	0	1	0	1
-41	1	0	0	1	0	1
-42	0	1	0	1	0	1
-43	1	1	0	1	0	1
-44	0	0	1	1	0	1
-46	1	0	1	1	0	1
-48	0	1	1	1	0	1
-50	1	1	1	1	0	1
-52	0	0	0	0	1	1
-54	1	0	0	0	1	1
-56	0	1	0	0	1	1
-58	1	1	0	0	1	1
-60	0	0	1	0	1	1
-62	1	0	1	0	1	1
-64	0	1	1	0	1	1
-66	1	1	1	0	1	1
-68	0	0	0	1	1	1
-70	1	0	0	1	1	1
-72	0	1	0	1	1	1
-74	1	1	0	1	1	1
-76	0	0	1	1	1	1
-78	1	0	1	1	1	1
-∞	0	1	1	1	1	1
Use Inhibited	1	1	1	1	1	1

- 4) The bits "C1" through "C4" are the chip select code data.  
 These bits set the code data that corresponds to the CS1 and CS2 inputs.

CS1	CS2	C1	C2	C3	C4
L	L	0	0	1	1
H	L	1	0	1	1
L	H	0	1	1	1
H	H	1	1	1	1

**2. Serial data timing**

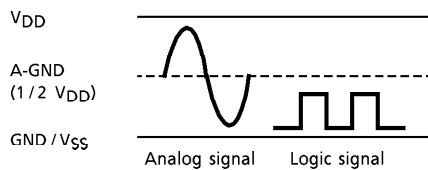
Make sure that CK, DATA and STB are input to the device at the timings shown below.



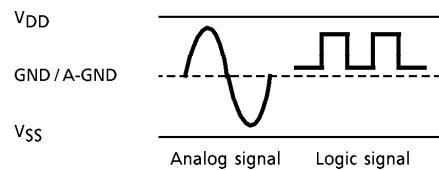
**3. Operating with a single or dual power supplies**

The TC9412AP, TC9412AF, TC9413AP can operate with either a single power supply or dual power supplies.

- Operation with single power supply



- Operation with dual power supplies



## MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage (1)	V <sub>DD</sub> -V <sub>SS</sub>	-0.3~36	V
Supply Voltage (2)	V <sub>DD</sub> -GND	-0.3~20	V
GND Block Input Voltage	V <sub>IN</sub> (1)	-0.3~V <sub>DD</sub> +0.3	V
V <sub>SS</sub> Block Input Voltage	V <sub>IN</sub> (2)	V <sub>SS</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>	-65~150	°C

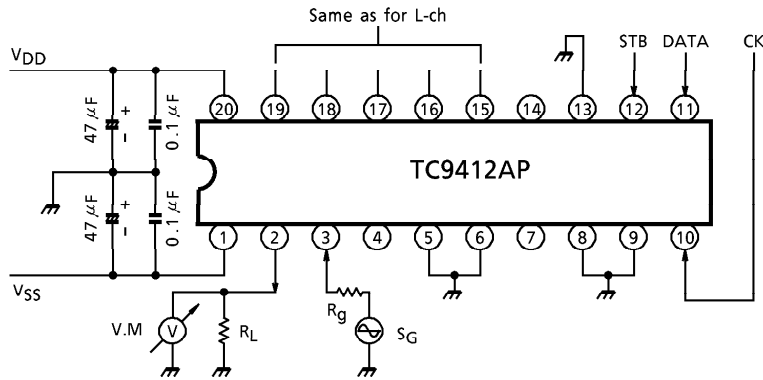
## ELECTRICAL CHARACTERISTICS

(Referenced to V<sub>DD</sub> = 15V, V<sub>SS</sub> = -15V, GND = 0V at Ta = 25°C unless otherwise noted)

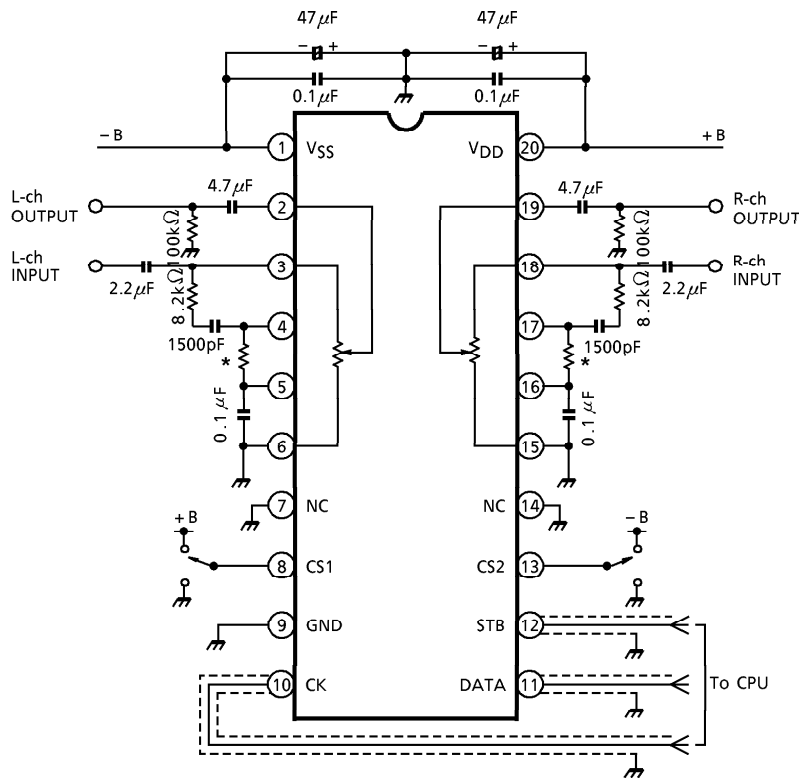
CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Supply Voltage (1)	V <sub>DD</sub> -V <sub>SS</sub>	—	Operating with dual power supplies	12	~	34	V
Operating Supply Voltage (2)	V <sub>DD</sub> -GND	—	Operating with single power supply	6.0	~	18	V
Operating Supply Current	I <sub>DD</sub>	1	Non-loaded, no input	—	0.5	2.0	mA
Input Voltage	"H" Level	V <sub>IH</sub> (1)	CK, DATA, STB pins V <sub>DD</sub> = 6.0~18V	4.0	~	V <sub>DD</sub>	V
	"L" Level	V <sub>IL</sub> (1)		GND	~	1.0	
Input Voltage	"H" Level	V <sub>IH</sub> (2)	CS1 and CS2 pins	V <sub>DD</sub> × 0.7	~	V <sub>DD</sub>	V
	"L" Level	V <sub>IL</sub> (2)		GND	~	V <sub>DD</sub> × 0.3	
Input Current	"H" Level	I <sub>IH</sub>	CK, DATA, STB, CS1, CS2 pins V <sub>IH</sub> = 15V V <sub>IL</sub> = 0V	-1.0	~	1.0	μA
	"L" Level	I <sub>IL</sub>		-1.0	~	1.0	
Operating Frequency	f <sub>op</sub>	—	CK, DATA, STB pins	0	~	1.0	MHz
Min. Operating Clock Width	T <sub>ck</sub>			0.5	—	—	
Volume Resistance	R <sub>VR</sub>	—	When loudness OFF	18.5	27.5	36.5	kΩ
Step Deviation	ΔVR	—	Deviation between volume steps	-1.2	~	1.2	dB
Analog Switch ON-Resistance	R <sub>ON</sub>	—	Internal analog switch	—	750	1500	Ω
Analog Switch Leakage Current	I <sub>OFF</sub>			-0.1	~	0.1	μA
Total Harmonic Distortion	THD	1	f <sub>IN</sub> = 1kHz V <sub>IN</sub> = 1V <sub>rms</sub> R <sub>g</sub> = 600Ω, R <sub>L</sub> = 100kΩ BW = 20Hz~20kHz	—	0.005	—	%
Maximum Attenuation	ATT <sub>MAX</sub>			—	100	—	dB
Output Noise Voltage	V <sub>N</sub>			—	1.0	—	μV <sub>rms</sub>
Crosstalk	C·T			—	100	—	dB



TEST CIRCUIT ( $I_{DD}/THD/ATT_{MAX}/V_N/C\cdot T$ )



EXAMPLE OF APPLICATION CIRCUIT (TC9412AP)

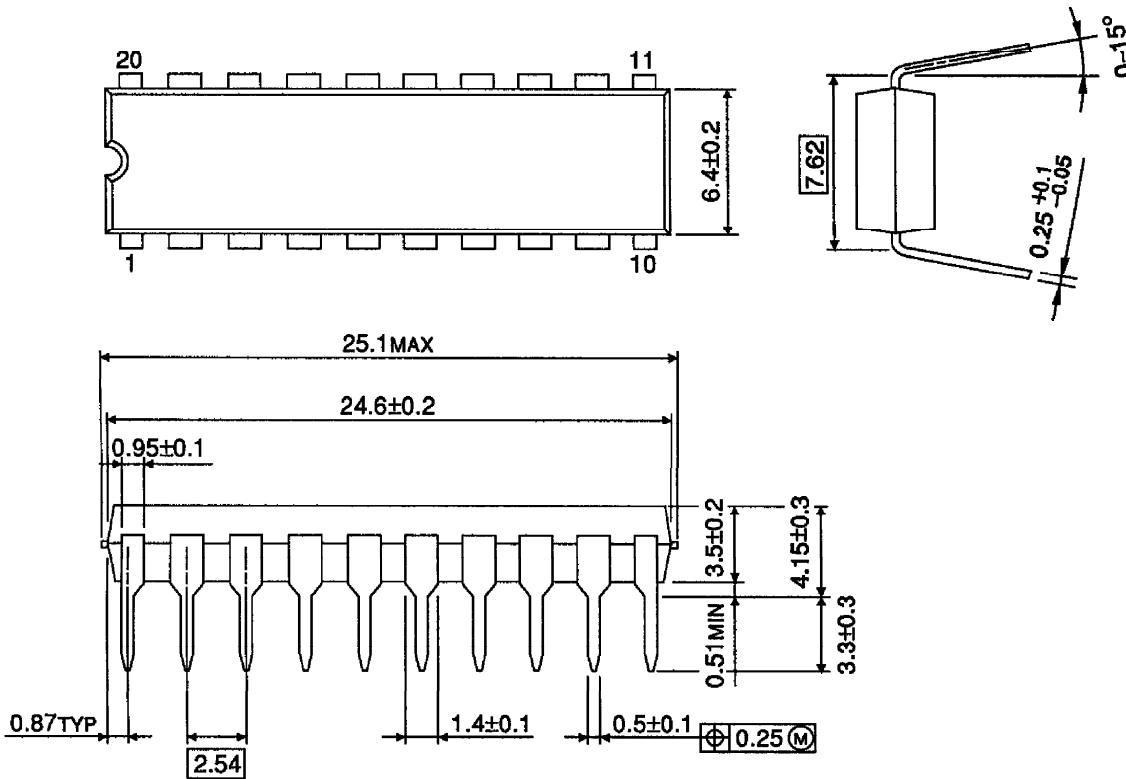


\* Used to prevent noise when loudness control is turned on or off.  $R = 220 \sim 470k\Omega$

(Note) Since a high-frequency digital signal is input to the CK, DATA and STB pins, corrective measures must be taken to prevent it from getting mixed in the analog circuit to generate noise by, for example, guarding the above signal lines with ground patterns or using shielding wire for these lines.

**OUTLINE DRAWING**  
DIP20-P-300-2.54A

Unit : mm

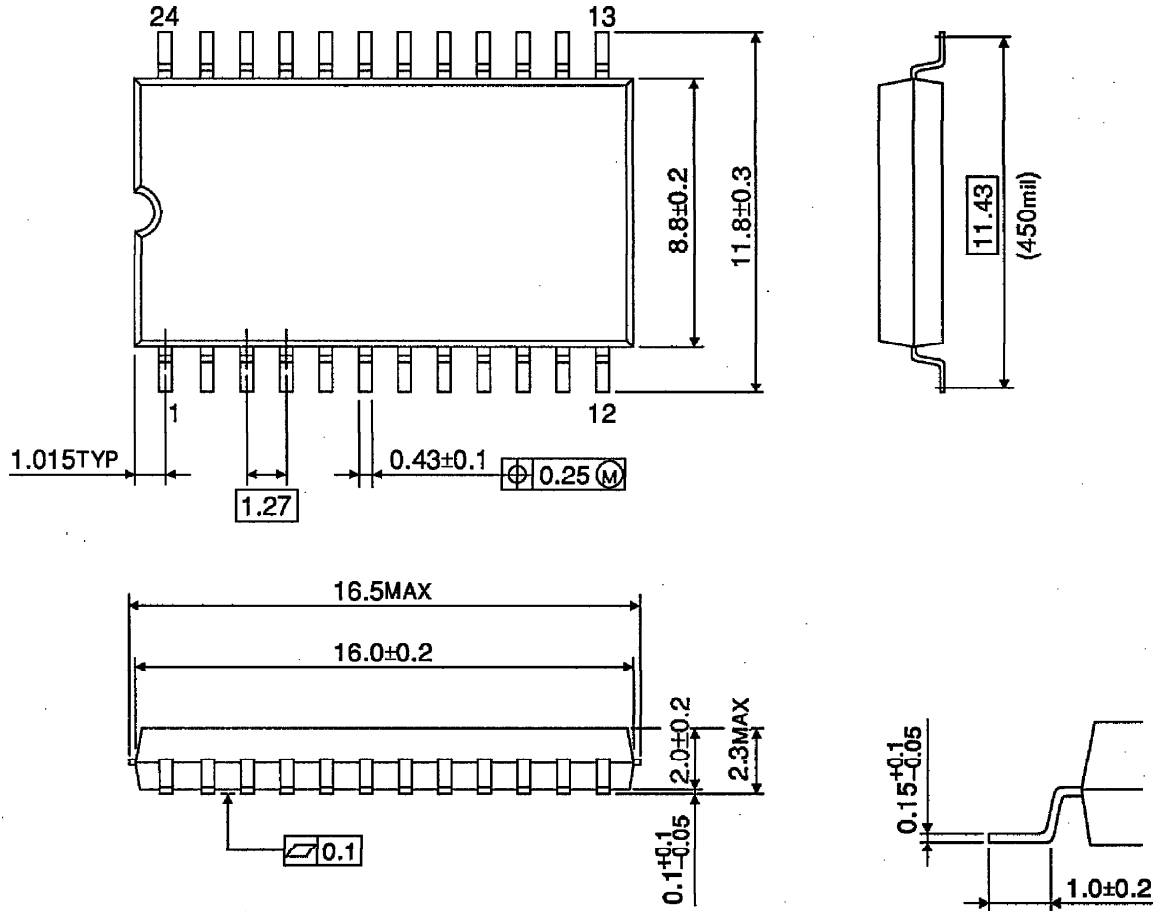


Weight : 1.4g (Typ.)

**OUTLINE DRAWING**

SOP24-P-450-1.27A

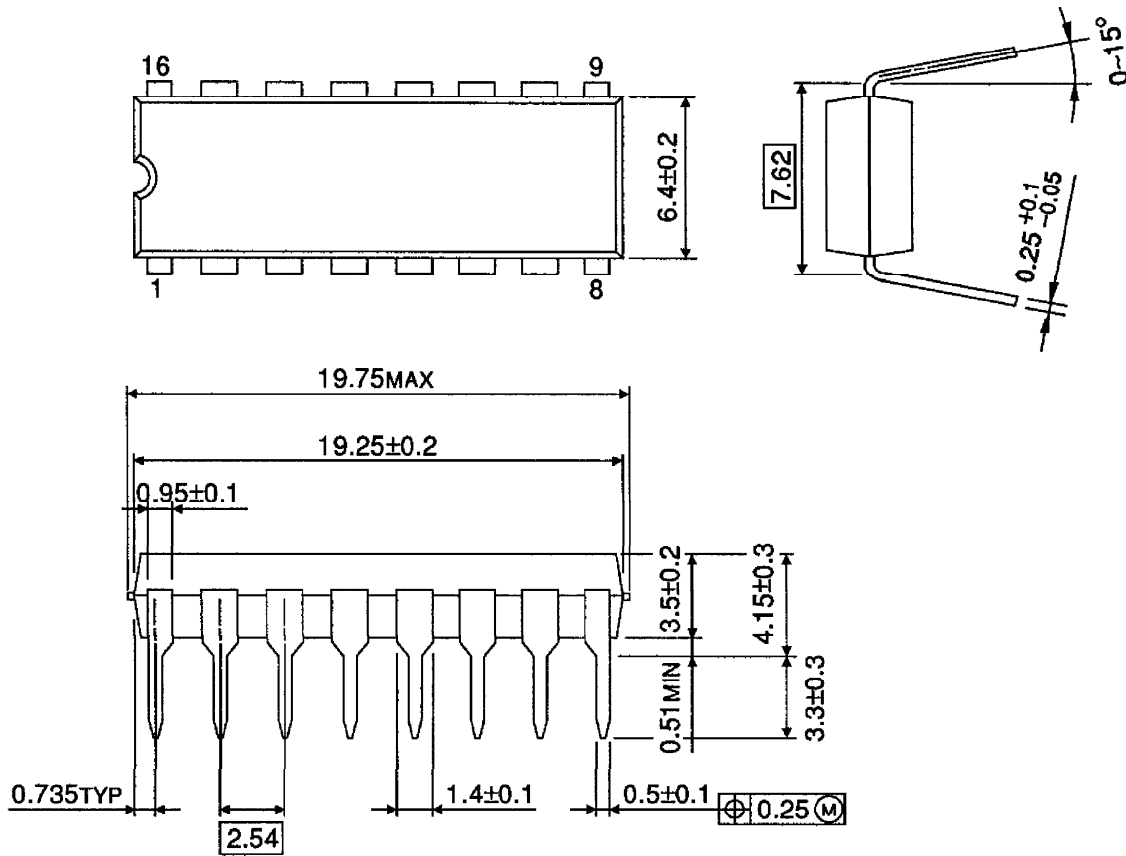
Unit : mm



Weight : 0.44g (Typ.)

**OUTLINE DRAWING**  
DIP16-P-300-2.54A

Unit : mm



Weight : 1.0g (Typ.)