TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT   SILICON MONOLITHIC
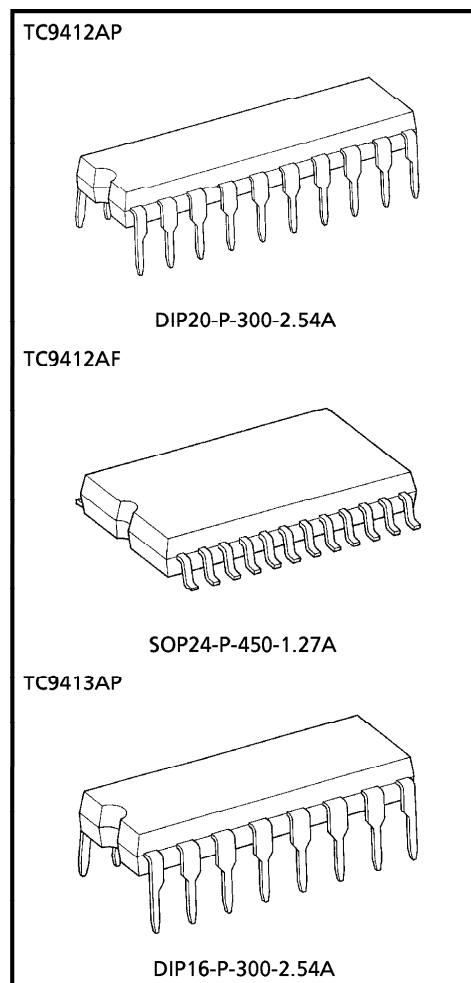
TC9412AP, TC9412AF, TC9413AP

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.
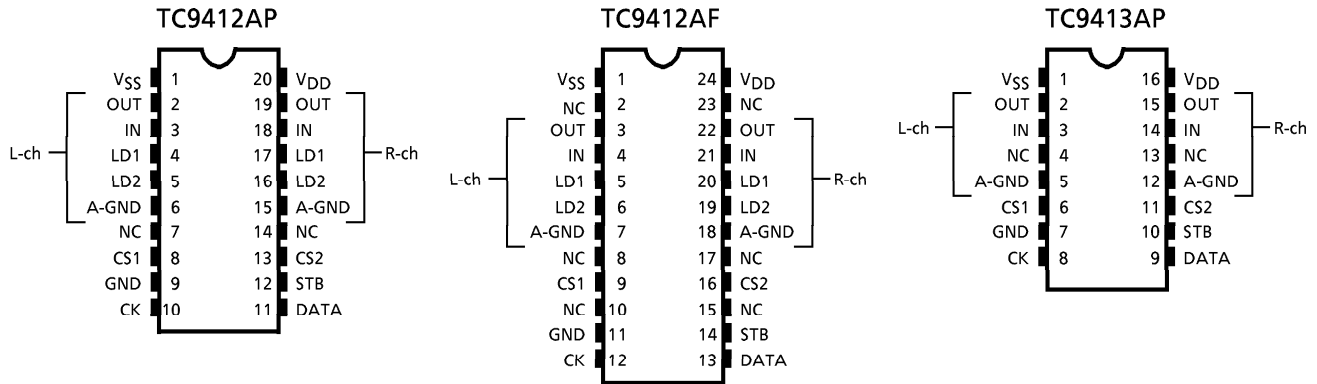
TC9412AP

DIP20-P-300-2.54A

TC9412AF

SOP24-P-450-1.27A

TC9413AP

DIP16-P-300-2.54A

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

PIN CONNECTIONS

TC9412AP

L-ch						R-ch
	V_{SS}	1		20	V_{DD}	
	OUT	2		19	OUT	
	IN	3		18	IN	
	LD1	4		17	LD1	
	LD2	5		16	LD2	
	A-GND	6		15	A-GND	
	NC	7		14	NC	
	CS1	8		13	CS2	
	GND	9		12	STB	
	CK	10		11	DATA	

TC9412AF

L-ch						R-ch
	V_{SS}	1		24	V_{DD}	
	NC	2		23	NC	
	OUT	3		22	OUT	
	IN	4		21	IN	
	LD1	5		20	LD1	
	LD2	6		19	LD2	
	A-GND	7		18	A-GND	
	NC	8		17	NC	
	CS1	9		16	CS2	
	NC	10		15	NC	
	GND	11		14	STB	
	CK	12		13	DATA	

TC9413AP

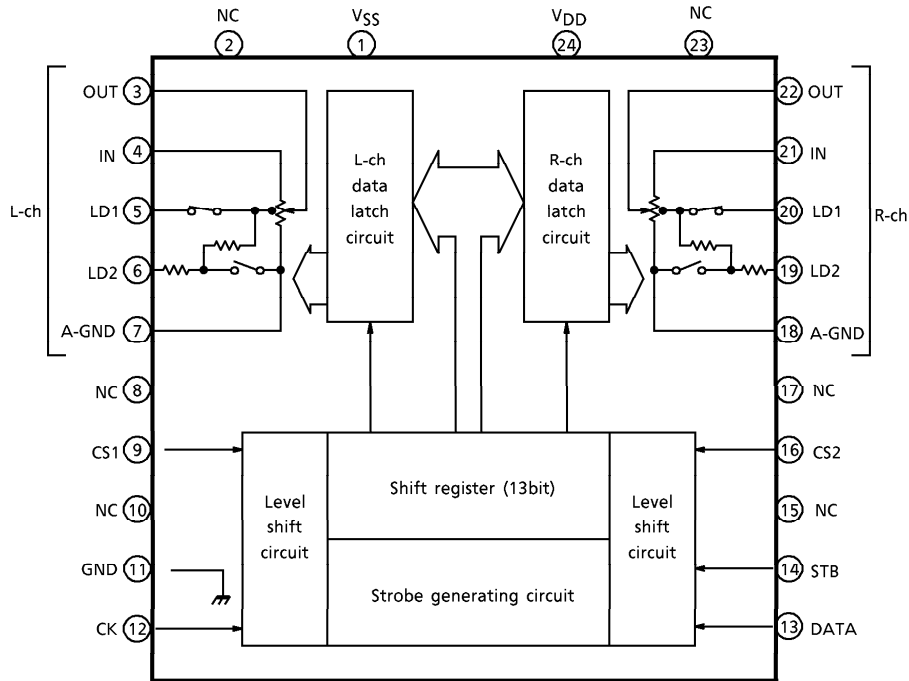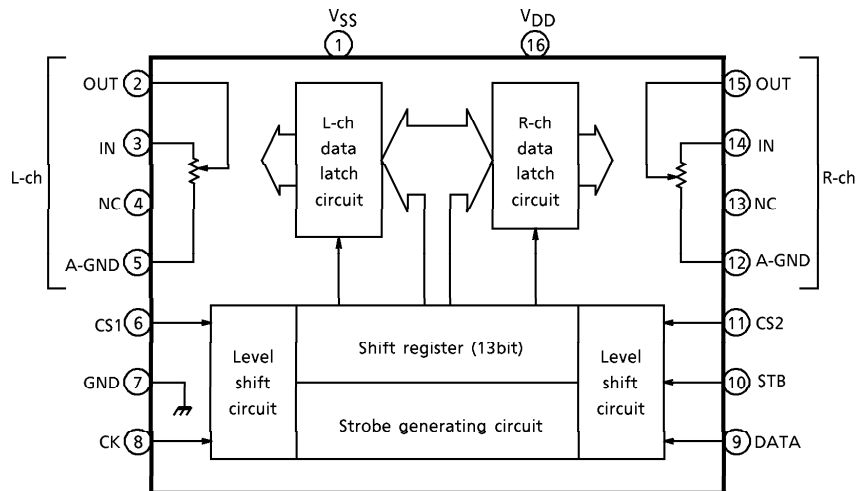| L-ch						R-ch
	V_{SS}	1		16	V_{DD}	
	OUT	2		15	OUT	
	IN	3		14	IN	
	NC	4		13	NC	
	A-GND	5		12	A-GND	
	CS1	6		11	CS2	
	GND	7		10	STB	
	CK	8		9	DATA	

BLOCK DIAGRAM (TC9412AP)

BLOCK DIAGRAM (TC9412AF)

BLOCK DIAGRAM (TC9413AP)

PIN DESCRIPTION

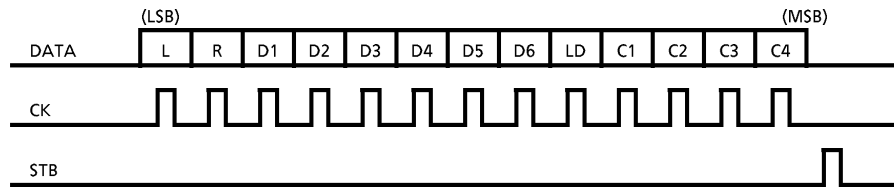Numeral in [   ] means the pin No. of TC9412AF and (   ) means the pin No. of TC9413AP.

PIN No.	SYMBOL	PIN NAME	FUNCTION	REMARK
1 [1] (1)	V_{SS}	Negative power supply pin	When using two power supplies — $V_{DD} = 6.0 \sim 17V$ / $GND = 0V$ / $V_{SS} = -6.0 \sim -17V$	—
9 [11] (7)	GND	Digital GND pin		
20 [24] (16)	V_{DD}	Positive power supply pin	When using a single power supply — $V_{DD} = 6.0 \sim 18V$ / $GND = V_{SS} = 0V$	
2 [3] (2)	L-OUT	Volume output pin	● Volume circuit (TC9412AP / AF)	—
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		
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		—

	LA1	LA2
Loudness "ON"	ON	OFF
Loudness "OFF"	OFF	ON

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

	(LSB)												(MSB)
DATA	L	R	D1	D2	D3	D4	D5	D6	LD	C1	C2	C3	C4

   CK

   STB

   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	VOLUME VALUE	D1	D2	D3	D4	D5	D6
0dB	0	0	0	0	0	0	− 32dB	0	0	0	0	0	1
− 1	1	0	0	0	0	0	− 33	1	0	0	0	0	1
− 2	0	1	0	0	0	0	− 34	0	1	0	0	0	1
− 3	1	1	0	0	0	0	− 35	1	1	0	0	0	1
− 4	0	0	1	0	0	0	− 36	0	0	1	0	0	1
− 5	1	0	1	0	0	0	− 37	1	0	1	0	0	1
− 6	0	1	1	0	0	0	− 38	0	1	1	0	0	1
− 7	1	1	1	0	0	0	− 39	1	1	1	0	0	1
− 8	0	0	0	1	0	0	− 40	0	0	0	1	0	1
− 9	1	0	0	1	0	0	− 41	1	0	0	1	0	1
− 10	0	1	0	1	0	0	− 42	0	1	0	1	0	1
− 11	1	1	0	1	0	0	− 43	1	1	0	1	0	1
− 12	0	0	1	1	0	0	− 44	0	0	1	1	0	1
− 13	1	0	1	1	0	0	− 46	1	0	1	1	0	1
− 14	0	1	1	1	0	0	− 48	0	1	1	1	0	1
− 15	1	1	1	1	0	0	− 50	1	1	1	1	0	1
− 16	0	0	0	0	1	0	− 52	0	0	0	0	1	1
− 17	1	0	0	0	1	0	− 54	1	0	0	0	1	1
− 18	0	1	0	0	1	0	− 56	0	1	0	0	1	1
− 19	1	1	0	0	1	0	− 58	1	1	0	0	1	1
− 20	0	0	1	0	1	0	− 60	0	0	1	0	1	1
− 21	1	0	1	0	1	0	− 62	1	0	1	0	1	1
− 22	0	1	1	0	1	0	− 64	0	1	1	0	1	1
− 23	1	1	1	0	1	0	− 66	1	1	1	0	1	1
− 24	0	0	0	1	1	0	− 68	0	0	0	1	1	1
− 25	1	0	0	1	1	0	− 70	1	0	0	1	1	1
− 26	0	1	0	1	1	0	− 72	0	1	0	1	1	1
− 27	1	1	0	1	1	0	− 74	1	1	0	1	1	1
− 28	0	0	1	1	1	0	− 76	0	0	1	1	1	1
− 29	1	0	1	1	1	0	− 78	1	0	1	1	1	1
− 30	0	1	1	1	1	0	− ∞	0	1	1	1	1	1
− 31	1	1	1	1	1	0	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.
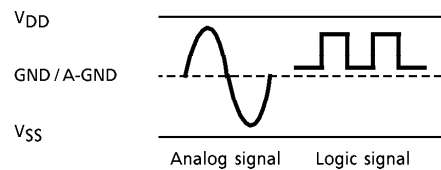

$a \geqq 0.5\mu s, \ b \geqq 1.0\mu s$

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
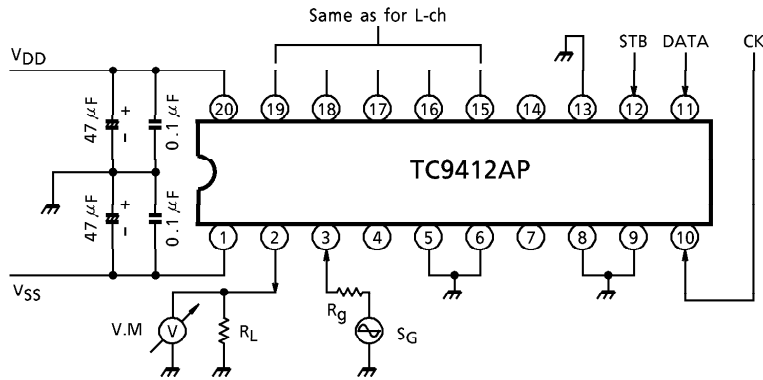
MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage (1)	V_{DD}-V_{SS}	$-0.3 \sim 36$	V
Supply Voltage (2)	V_{DD}-GND	$-0.3 \sim 20$	V
GND Block Input Voltage	V_{IN} (1)	$-0.3 \sim V_{DD}+0.3$	V
V_{SS} Block Input Voltage	V_{IN} (2)	$V_{SS}-0.3 \sim V_{DD}+0.3$	V
Power Dissipation	P_D	300	mW
Operating Temperature	T_{opr}	$-40 \sim 85$	°C
Storage Temperature	T_{stg}	$-65 \sim 150$	°C

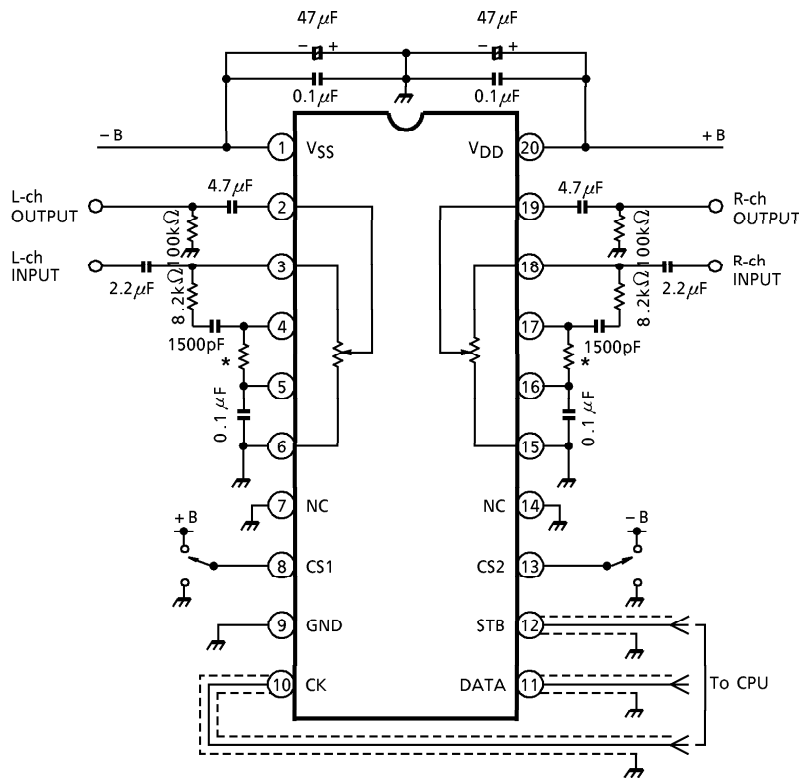## ELECTRICAL CHARACTERISTICS

(Referenced to V_{DD} = 15V, V_{SS} = -15V, GND = 0V at Ta = 25°C unless otherwise noted)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Operating Supply Voltage (1)		V_{DD}-V_{SS}	—	Operating with dual power supplies		12	~	34	V
Operating Supply Voltage (2)		V_{DD}-GND	—	Operating with single power supply		6.0	~	18	V
Operating Supply Current		I_{DD}	1	Non-loaded, no input		—	0.5	2.0	mA
Input Voltage	"H" Level	V_{IH} (1)	—	CK, DATA, STB pins $V_{DD}=6.0 \sim 18$V		4.0	~	V_{DD}	V
	"L" Level	V_{IL} (1)				GND	~	1.0	
Input Voltage	"H" Level	V_{IH} (2)	—	CS1 and CS2 pins		$V_{DD} \times 0.7$	~	V_{DD}	V
	"L" Level	V_{IL} (2)				GND	~	$V_{DD} \times 0.3$	
Input Current	"H" Level	I_{IH}	—	CK, DATA, STB, CS1, CS2 pins	$V_{IH}=15$V	-1.0	~	1.0	μA
	"L" Level	I_{IL}			$V_{IL}=0$V	-1.0	~	1.0	
Operating Frequency		fop	—	CK, DATA, STB pins		0	~	1.0	MHz
Min. Operating Clock Width		Tck				0.5	—	—	μs
Volume Resistance		R_{VR}	—	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_{ON}	—	Internal analog switch		—	750	1500	Ω
Analog Switch Leakage Current		I_{OFF}				-0.1	~	0.1	μA
Total Harmonic Distortion		THD	1	$f_{IN}=1$kHz $V_{IN}=1$Vrms $R_g=600\Omega$, $R_L=100$kΩ BW = 20Hz~20kHz		—	0.005	—	%
Maximum Attenuation		ATT_{MAX}				—	100	—	dB
Output Noise Voltage		V_N				—	1.0	—	μV_{rms}
Crosstalk		C·T				—	100	—	dB

TEST CIRCUIT (I_{DD} / THD / ATT_{MAX} / V_N / C·T)
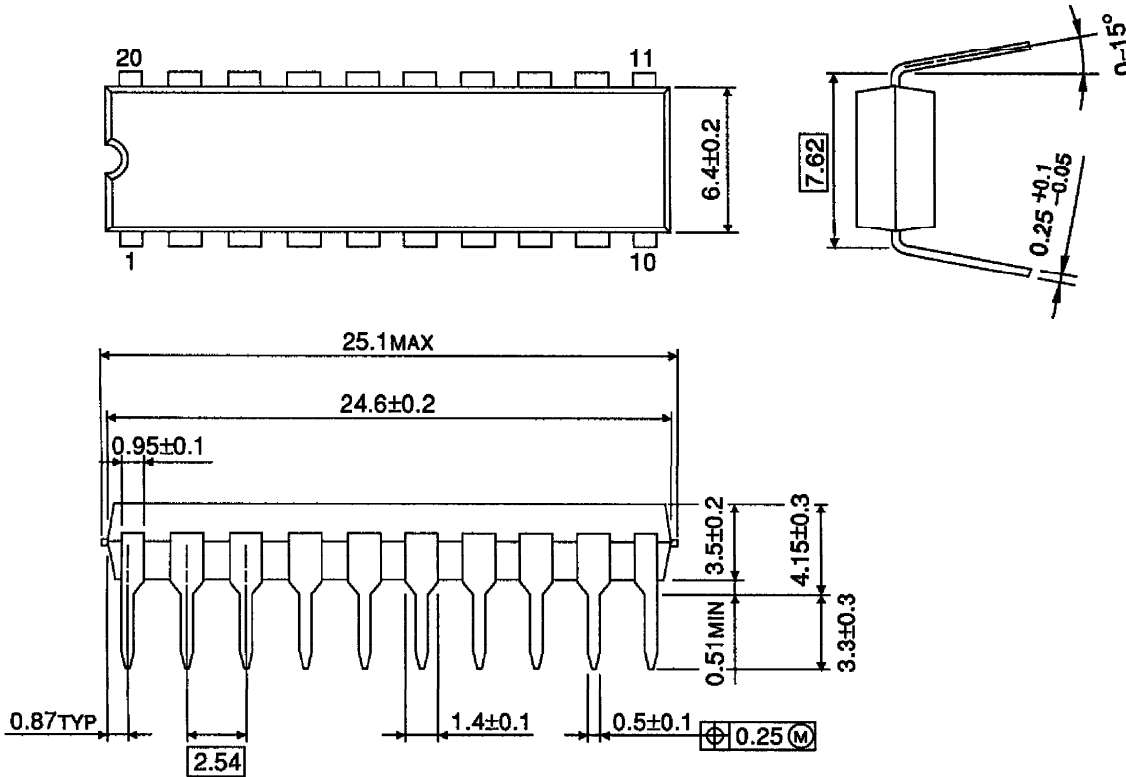

EXAMPLE OF APPLICATION CIRCUIT (TC9412AP)

* Used to prevent noise when loudness control is turned on or off. R = 220~470kΩ

(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.
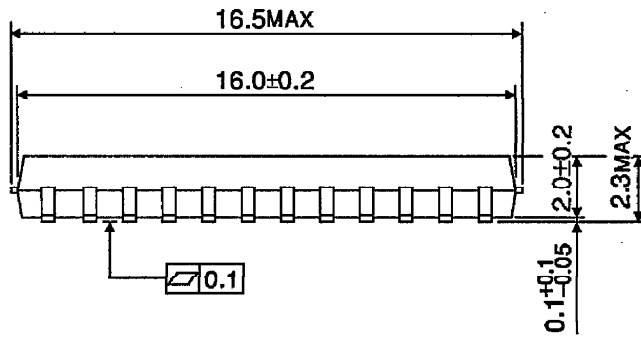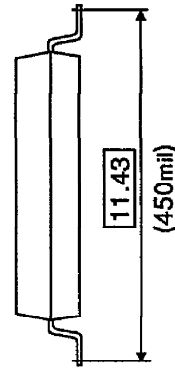
OUTLINE DRAWING

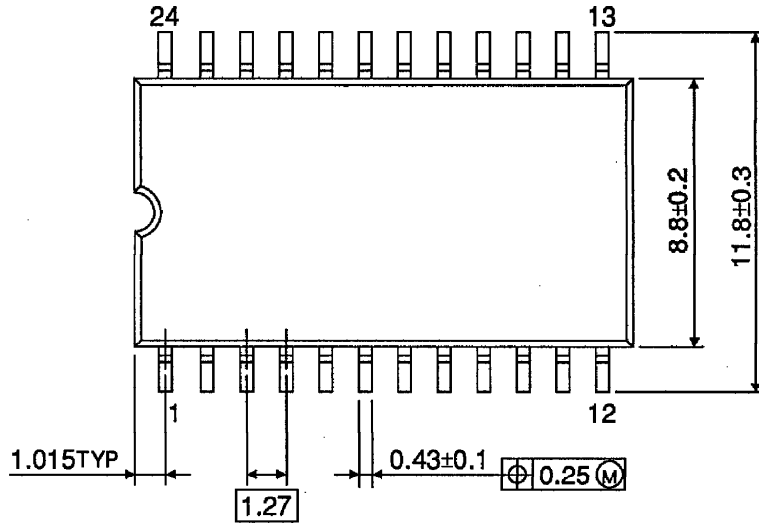   DIP20-P-300-2.54A   Unit : mm

Weight : 1.4g (Typ.)

OUTLINE DRAWING
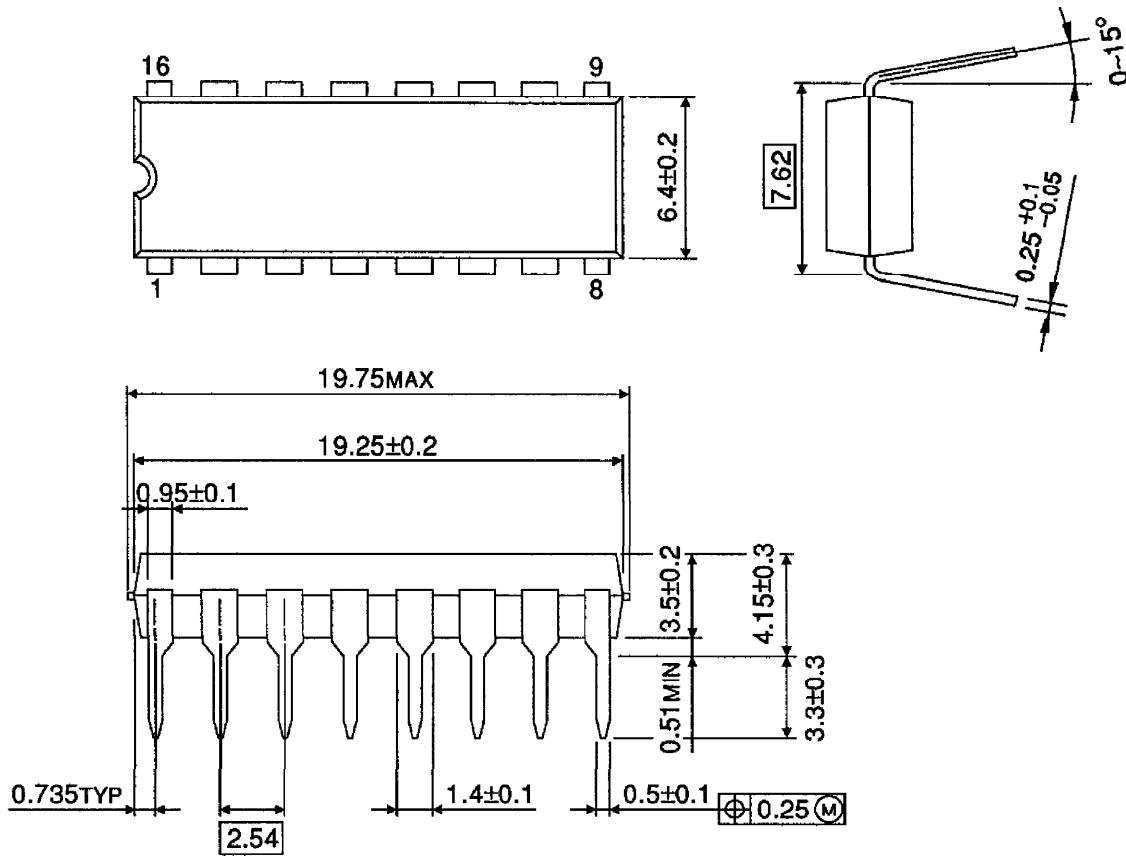SOP24-P-450-1.27A   Unit : mm

Weight : 0.44g (Typ.)

OUTLINE DRAWING

DIP16-P-300-2.54A

Weight : 1.0g (Typ.)