

TC9235P, TC9235F

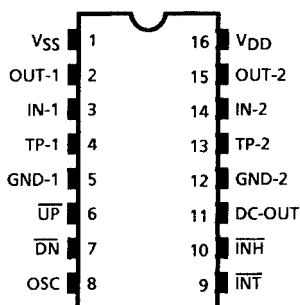
Electronic Volume Control IC

The TC9235P/F is an electronic volume control IC developed for use in audio equipment such as car stereo and portable stereo system.

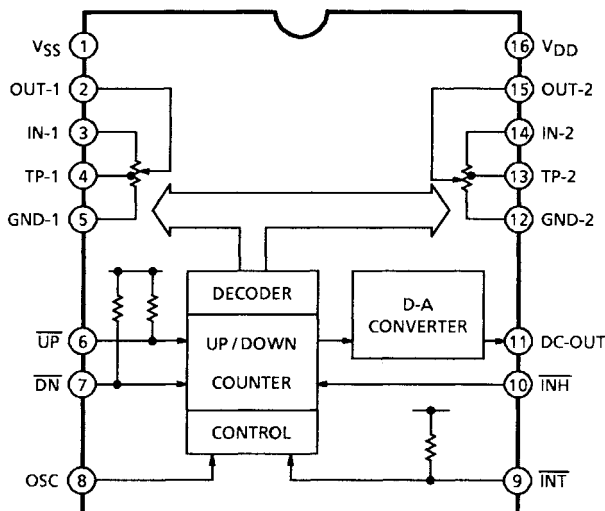
Features

- 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.

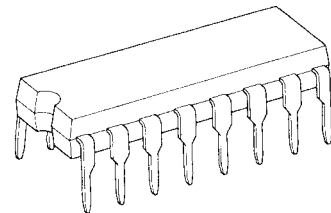
Pin Assignment



Block Diagram

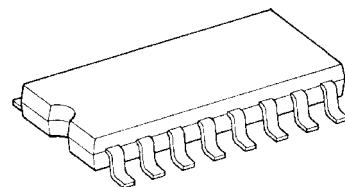


TC9235P



DIP16-P-300-2.54A

TC9235F



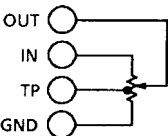
SOP16-P-300-1.27

Weight

DIP16-P-300-2.54A: 1.0 g (typ.)

SOP16-P-300-1.27: 0.16 g (typ.)

Pin Function

Pin No.	Symbol	Pin Name	Function and Operation	Note
1	V _{SS}	Negative power supply pin	Power supply terminal	—
16	V _{DD}	Positive power supply pin		
2	OUT-1	Volume output pins	<div>Volume circuit</div> 	—
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	$\overline{\text{UP}}$	Volume up input pin		
7	$\overline{\text{DN}}$	Volume down input pin	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.	
8	OSC	Oscillation pin	Oscillation pin. Oscillator circuit consist of C·R connection. Oscillation is executed while key is pushed.	—
9	$\overline{\text{INT}}$	Initializing pin	Input pin for setting initial volume level volume level set to 46dB by “L” input.	Built-in pull-up resistor
10	$\overline{\text{INH}}$	Inhibit terminal	Back up mode input pin. 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. DC voltage which is corresponded to volume step is generated.	—

Operation

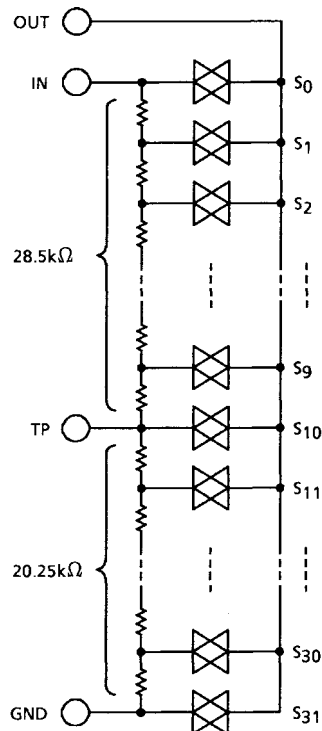
1. Volume Circuit

Volume circuit consist of ladder resistor and analog switch.

Tap for loudness is connected to step 10 (20dB).

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

Equivalence Circuit



Volume Step and Attenuation

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

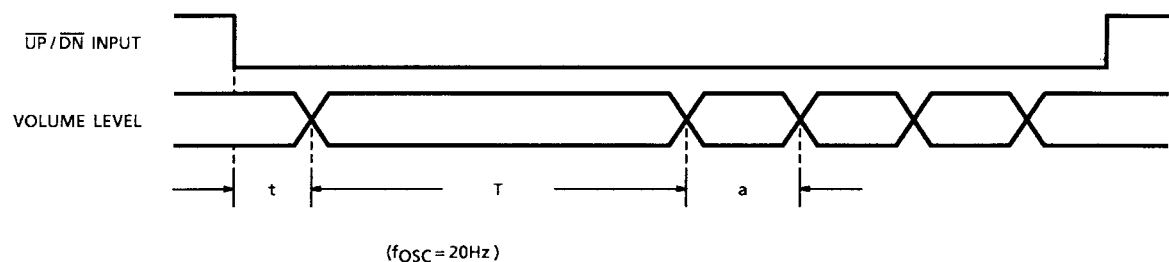
Step	Attenuation	Step	Attenuation
0	0 (dB)	16	32 (dB)
1	2	17	34
2	4	18	36
3	6	19	38
4	8	20	40
5	10	21	42
6	12	22	46
7	14	(Note 1)	
8	16	23	50
9	18	24	54
10	20	25	58
11	22	26	62
12	24	27	66
13	26	28	70
14	28	29	74
15	30	30	78
		31	∞

Note 1: 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



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 $\approx 2 \times 1/f_{OSC} (\approx 100 \text{ ms})$

$f_{OSC} \approx C_X \cdot R_X (\text{Hz})$: $R_X = 12 \sim 220 \text{ k}\Omega$

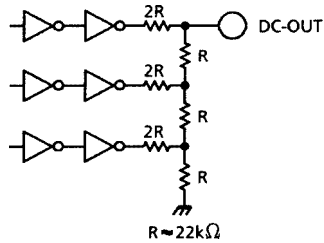
3. DC Output Circuit for Volume Level

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



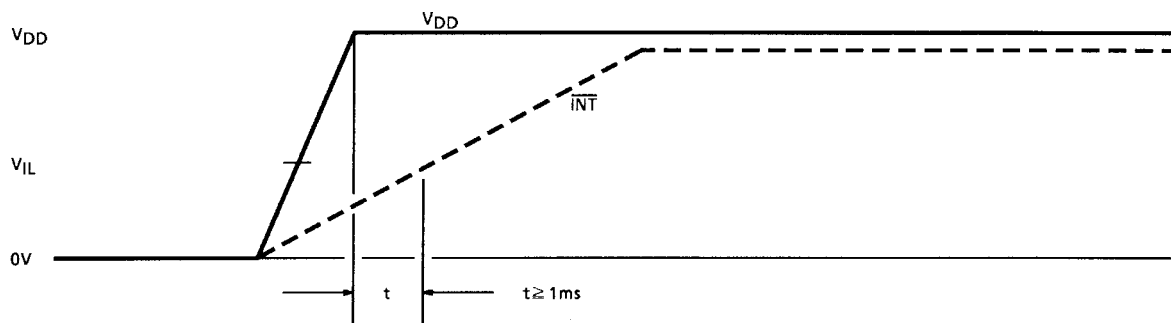
Volume Step and Output Voltage

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~∞	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.

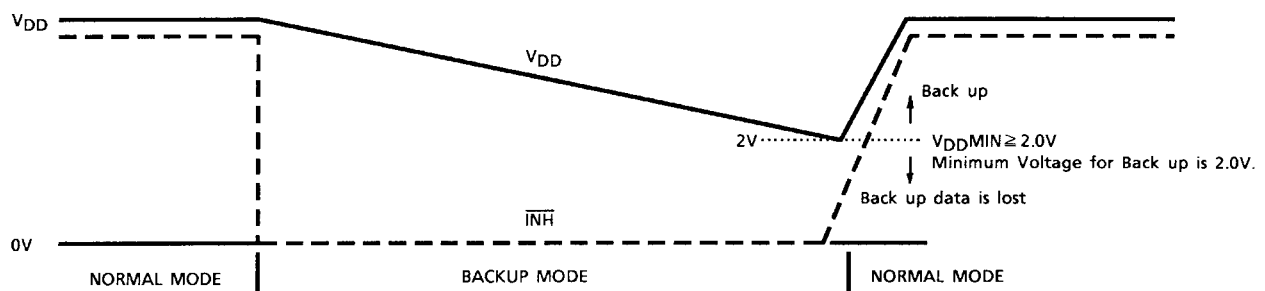


Adjust condenser value which is set $\overline{\text{INT}}$ pin to the period while $\overline{\text{INT}}$ pin is "L" level is longer than 1 ms when power on.

(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.



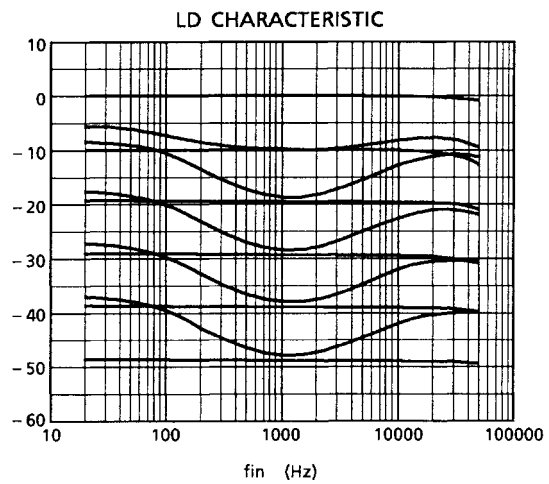
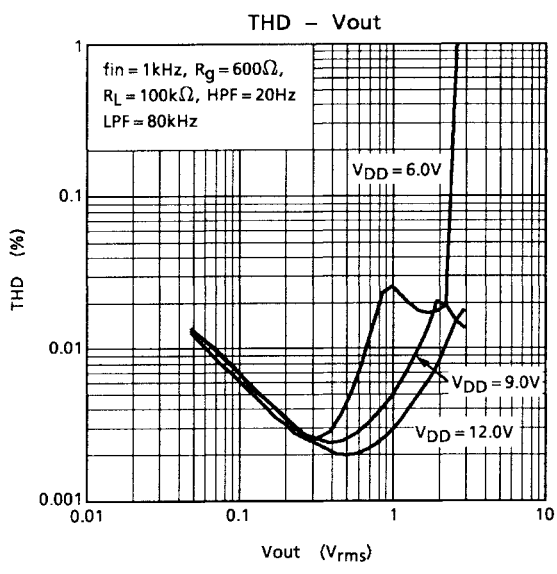
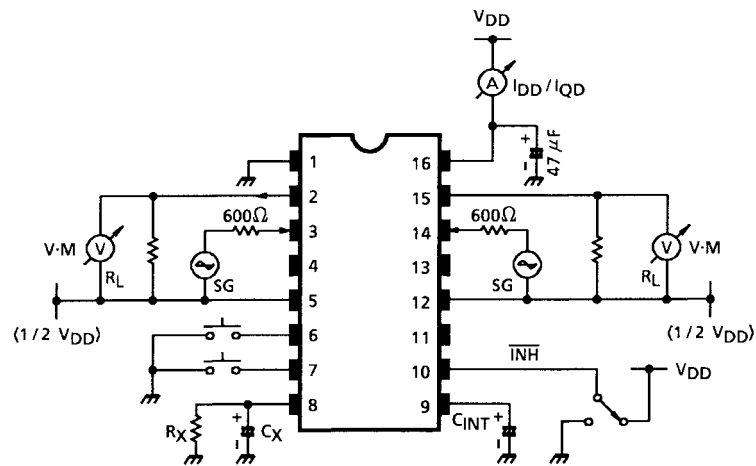
Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Supply voltage	V _{DD}	-0.3~15	V
Input voltage	V _{IN}	-0.3~V _{DD} + 0.3	V
Power dissipation	P _D	300	mW
Operating temperature	T _{opr}	-40~85	°C
Storage temperature	T _{stg}	-55~150	°C

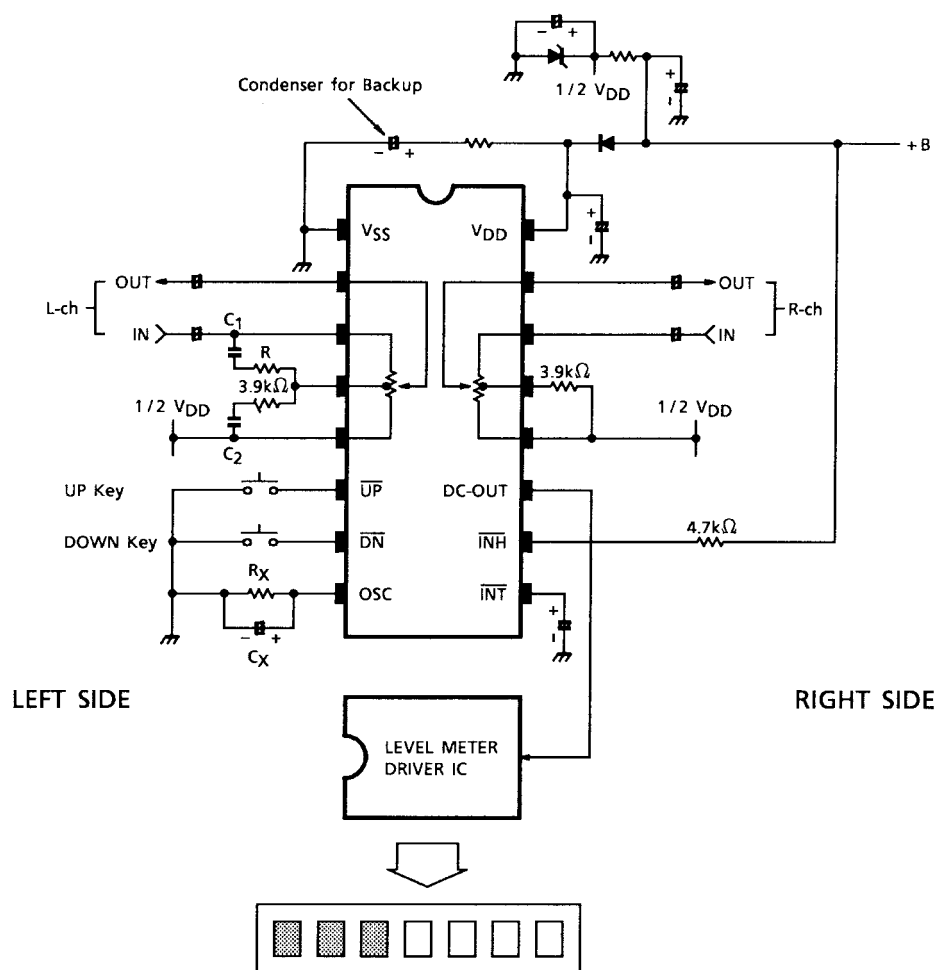
Electrical Characteristics (unless otherwise specified, Ta = 25°C, V_{DD} = 9 V)

Characteristics		Symbol	Test Circuit	Test Condition		Min	Typ.	Max	Unit
Operating supply voltage		V _{DD}	—	Ta = −40~85°C		4.5	9.0	12	V
Operating supply current		I _{DD}	1	No load, f _{OSC} = 20 Hz		—	0.3	1.0	mA
Backup voltage		V _{QD}	—	$\overline{\text{INH}} = \text{“L”}$		2.0	~	12	V
Backup current		I _{QD}	1			—	0.01	1.0	μA
Input voltage	“H” level	V _{IH}	—	All input pin		V _{DD} × 0.7	~	V _{DD}	V
	“L” level	V _{IL}				0	~	V _{DD} × 0.3	
Input current	“H” level	I _{IH}	—	$\overline{\text{INH}}$ input pin	V _{IH} = V _{DD}	−1	—	1	μA
	“L” level	I _{IL}			V _{IL} = 0 V	−1	—	1	
Pull up resistor		R _{UP}	—	$\overline{\text{UP}}$, $\overline{\text{DN}}$, $\overline{\text{INT}}$ input pin		23	47	71	kΩ
Volume resistor		R _{VR}	—	Between IN → GND resistor		31	44	58	kΩ
Analog switch ON resistor		R _{ON}	—	Analog switch ON resistor		—	500	800	Ω
Attenuation error		ΔATT	—	—		—	0	±2.0	dB
Balance between left and right		ΔR _{VR}	—	Volume resistor error between left and right		—	0	±3.0	%
Total harmonic distortion		THD	1	f _{IN} = 1 kHz	0dB	—	0.01	—	%
Maximum attenuation		ATT _{MAX}		V _{IN} = 1 V _{rms}	∞dB	—	100	—	dB
Cross talk		C·T		R _L = 100 kΩ	0dB	—	100	—	dB
Output noise voltage		V _N		R _g = 600 Ω		—	2.0	—	μV _{rms}
OSC frequency		f _{OSC}	1	C _X = 2.2 μF, R _X = 33 kΩ		—	20	—	Hz

Test Circuit 1



Example of Application Circuit



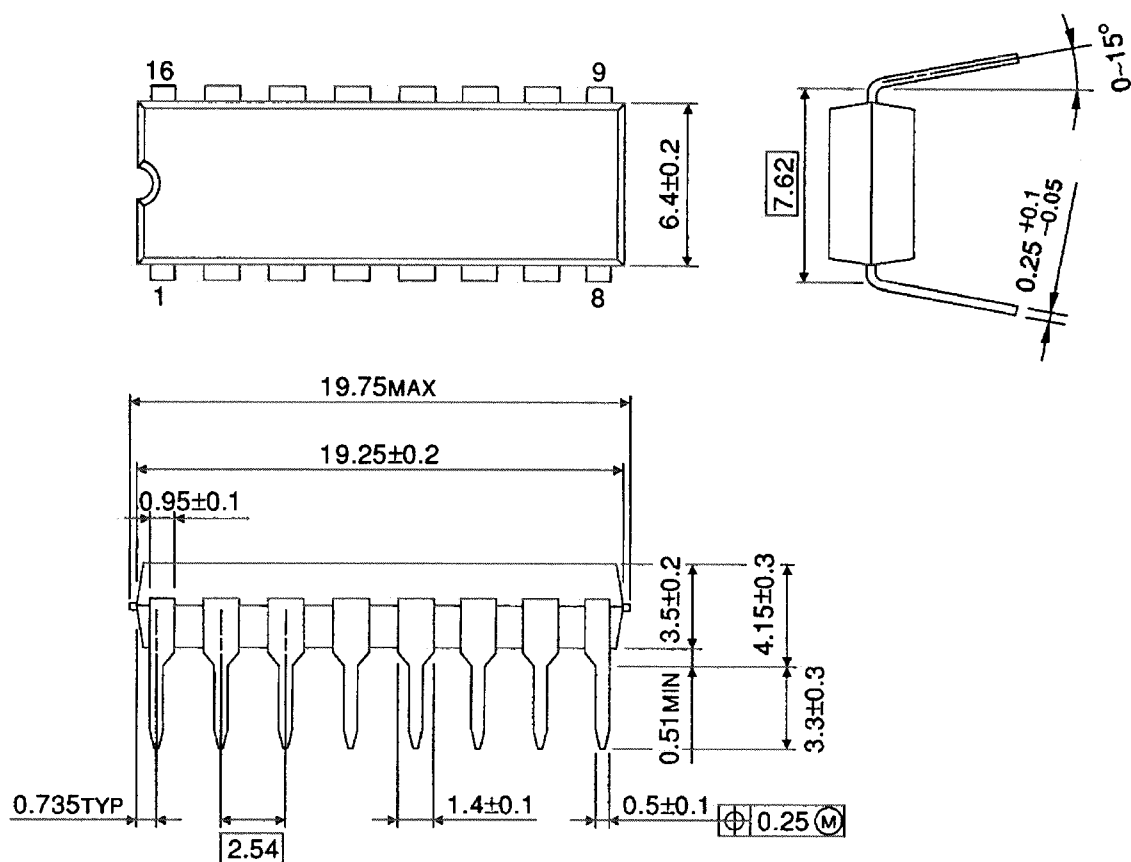
Note 2: Loudness circuit is left side, only volume (without loudness) circuit is right side.

$C_1 = 1500 \text{ pF}$ $C_2 = 0.1 \text{ } \mu\text{F}$ $R = 8.2 \text{ k}\Omega$

Package Dimensions

DIP16-P-300-2.54A

Unit : mm

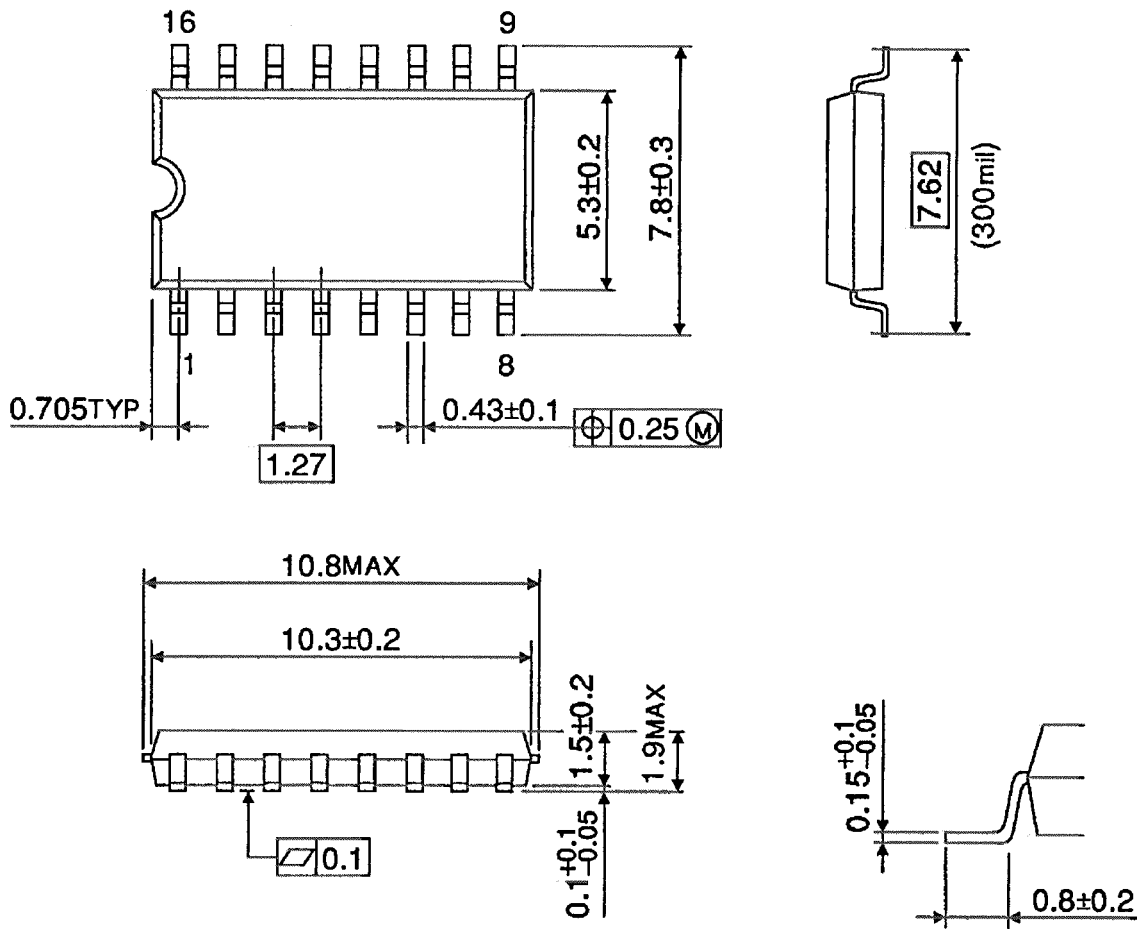


Weight: 1.0 g (typ.)

Package Dimensions

SOP16-P-300-1.27

Unit : mm



Weight: 0.16 g (typ.)

RESTRICTIONS ON PRODUCT USE

030619EBA

- The information contained herein is subject to change without notice.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA for any infringements of patents or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of TOSHIBA or others.
- TOSHIBA is continually working to improve the quality and 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 comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products 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 TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- TOSHIBA products should not be embedded to the downstream products which are prohibited to be produced and sold, under any law and regulations.