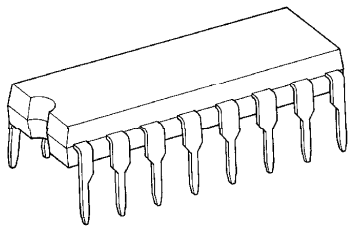
TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

TC9235P, TC9235F

ELECTRONIC VOLUME

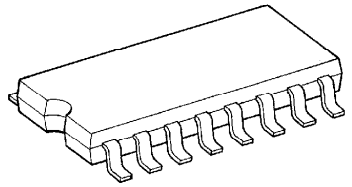
The TC9235P and TC9235F are an optimum CMOS IC which has been designed for electronization of volume control of audio equipment, etc.

TC9235P



DIP16-P-300-2.54A

TC9235F



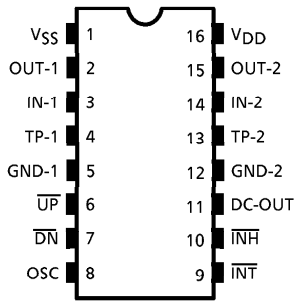
SOP16-P-300-1.27

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

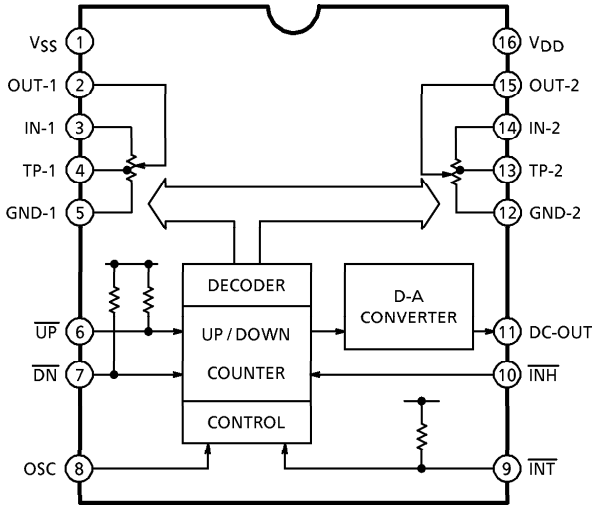
FEATURES

- 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 CONNECTION



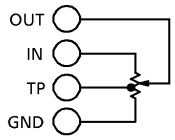
BLOCK DIAGRAM



980508EBA2

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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	Volume circuit 	—
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	$\overline{UP}$	Volume up input pin	Volume up, down control 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.	Built-in pull-up resistor
7	$\overline{DN}$	Volume down input pin		
8	OSC	Oscillation pin	Oscillation pin. Oscillator circuit consist of C·R connection. Oscillation is executed while key is pushed.	—
9	$\overline{INT}$	Initializing pin	Input pin for setting initial volume level volume level set to 46dB by "L" input.	Built-in pull-up resistor
10	$\overline{INH}$	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.	—

980508EBA2'

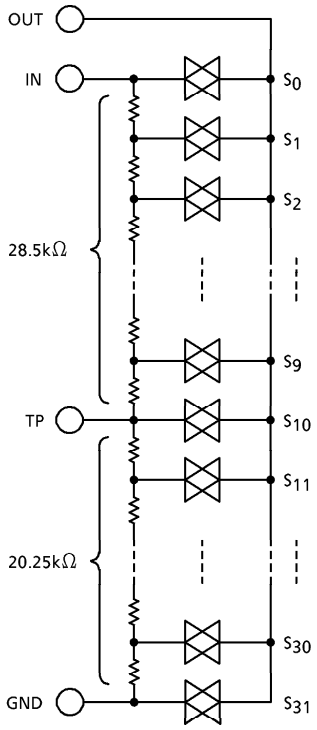
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- The information contained herein is subject to change without notice.

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.)

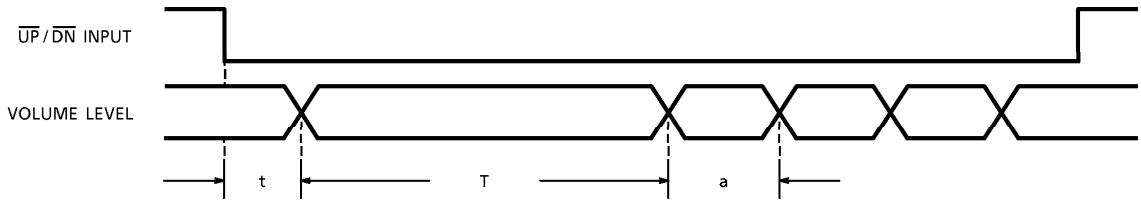
STEP	ATTENUATION	STEP	ATTENUATION
0	0 (dB)	16	32 (dB)
1	2	17	34
2	4	18	36
3	6	19	38
4	8	20	40
5	10	21	42
6	12	*22	46
7	14	23	50
8	16	24	54
9	18	25	58
10	20	26	62
11	22	27	66
12	24	28	70
13	26	29	74
14	28	30	78
15	30	31	∞

* 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



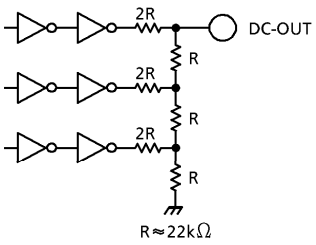
(f_{OSC} = 20Hz)

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

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 ≈22kΩ (typ.) is high, If input impedance of next setting level meter IC is low, set to Buffer.

- Equivalence circuit



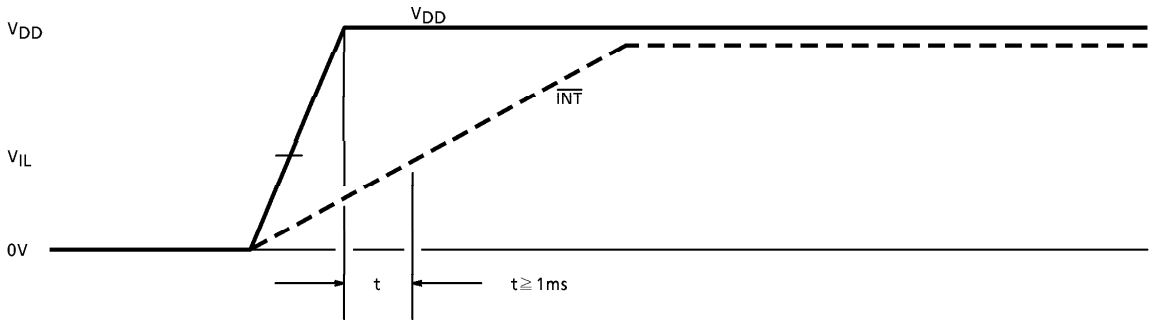
- Volume step and Output voltage

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

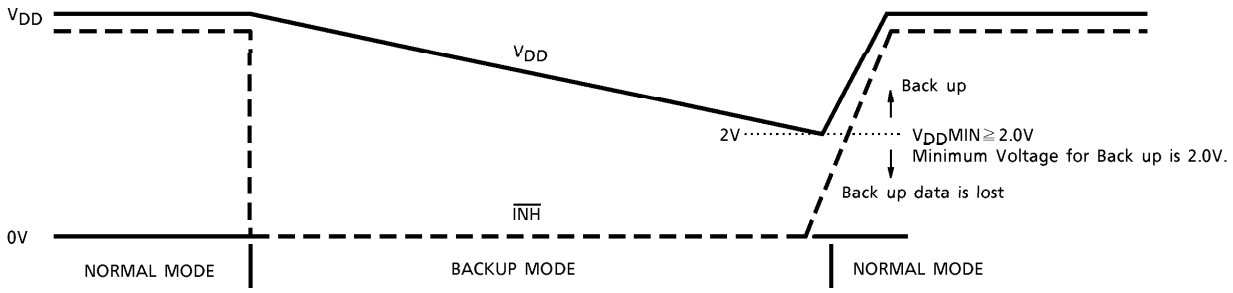
When power on, volume level is set to initial value (46dB) by setting $\overline{INT}$ pin to "L" level for a while.



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

(2) Backup operation

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



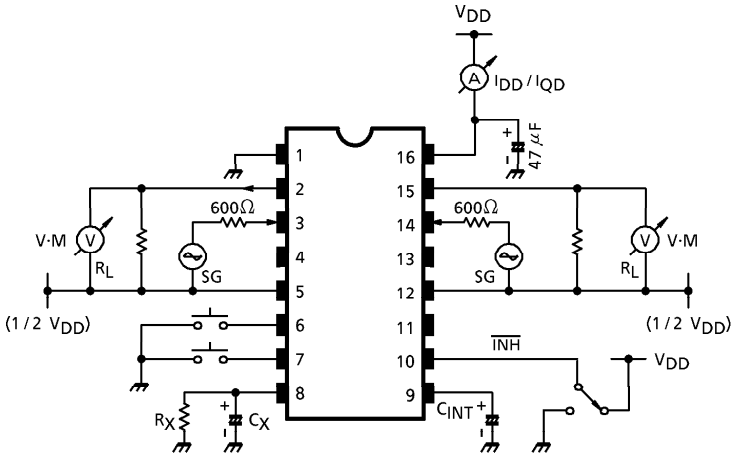
MAXIMUM RATINGS (Ta = 25°C)

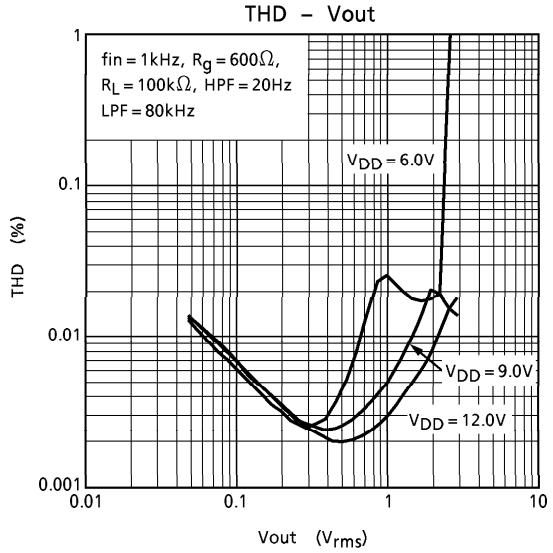
CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V_{DD}	−0.3~15	V
Input Voltage	V_{IN}	−0.3~V_{DD} +0.3	V
Power Dissipation	P_D	300	mW
Operating Temperature	T_{opr}	−40~85	°C
Storage Temperature	t_{stg}	−55~150	°C

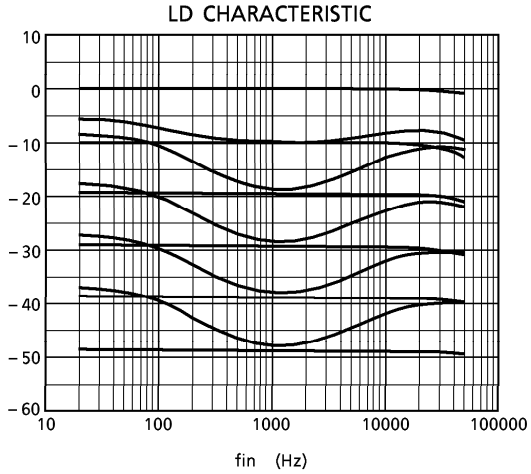
ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Ta = 25°C, V_{DD} = 9V)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	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} = 20Hz		—	0.3	1.0	mA
Backup Voltage		V_{QD}	—	$\overline{INH}$ = "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}	—	$\overline{INH}$ input pin	$V_{IH} = V_{DD}$	−1	—	1	μA
	"L" Level	I_{IL}			V_{IL} = 0V	−1	—	1	
Pull Up Resistor		R_{UP}	—	$\overline{UP}$, $\overline{DN}$, $\overline{INT}$ 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} = 1kHz, V_{IN} = 1V_{rms}, R_L = 100kΩ, R_g = 600Ω	0dB	—	0.01	—	%
Maximum Attenuation		ATT_{MAX}			∞dB	—	100	—	dB
Cross Talk		C·T			0dB	—	100	—	dB
Output Noise Voltage		V_N				—	2.0	—	μV_{rms}
OSC Frequency		f_{OSC}	1	C_X = 2.2μF, RX = 33kΩ		—	20	—	Hz

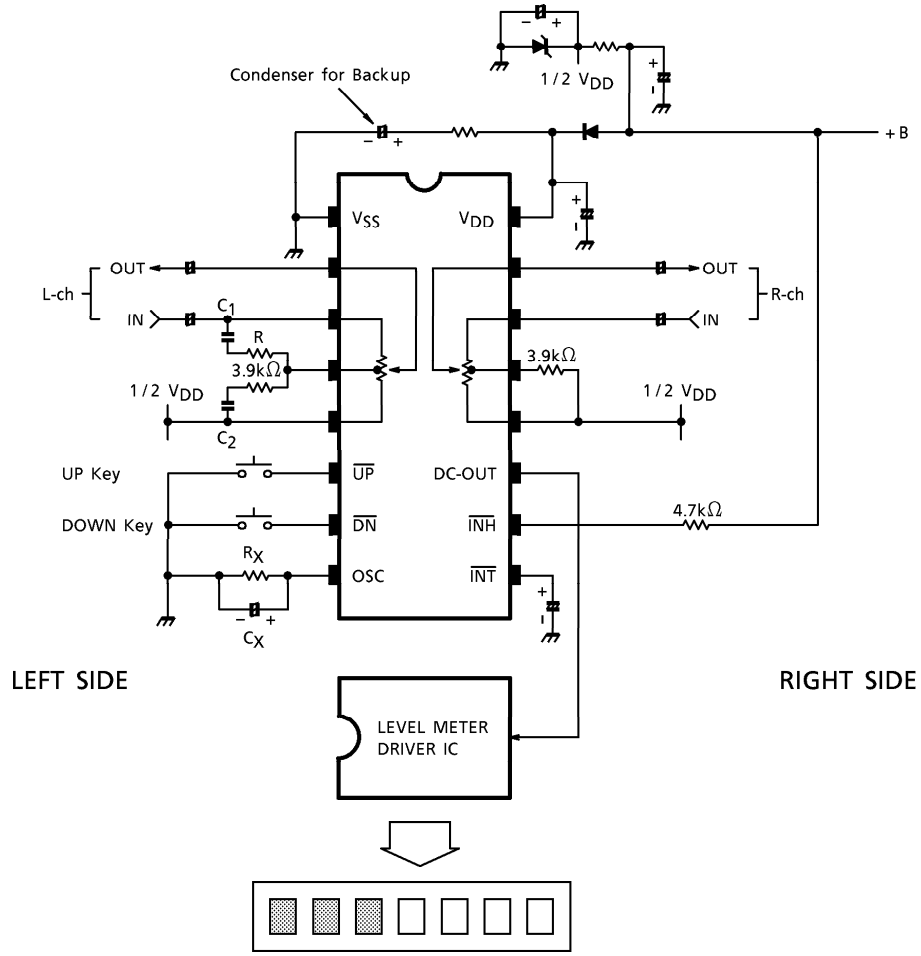
TEST CIRCUIT 1







EXAMPLE OF APPLICATION CIRCUIT

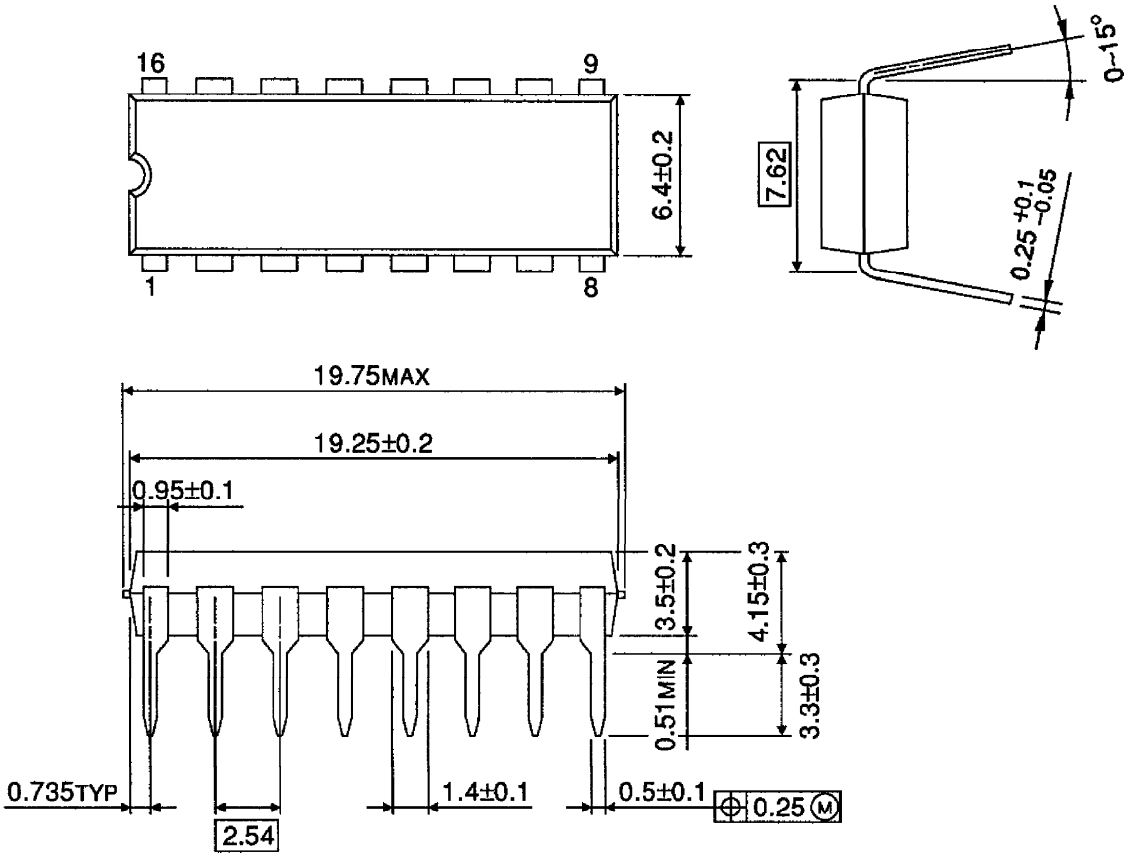


(Note) Loudness circuit is left side, only volume (without loudness) circuit is right side.
$C_1 = 1500pF$ $C_2 = 0.1\mu F$ $R = 8.2k\Omega$

OUTLINE DRAWING

DIP16-P-300-2.54A

Unit : mm

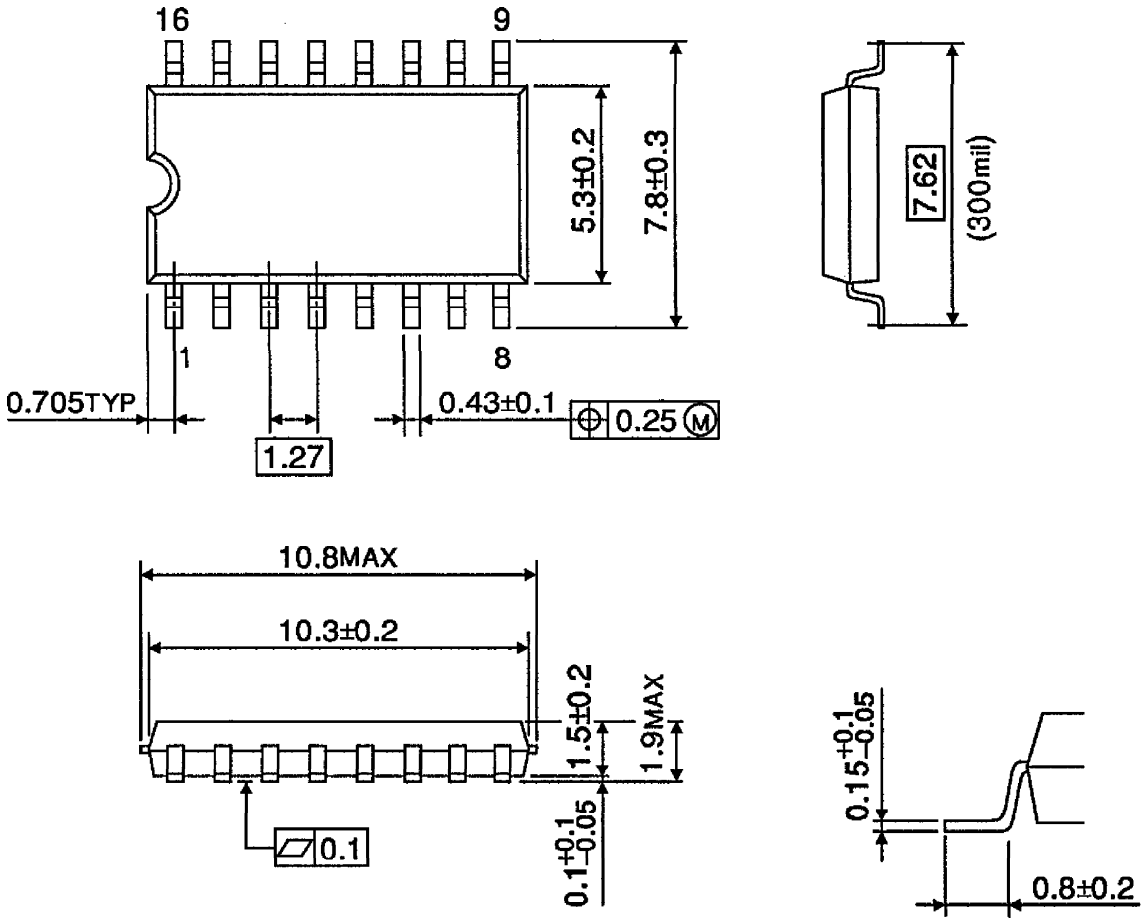


Weight : 1.0g (Typ.)

OUTLINE DRAWING

SOP16-P-300-1.27

Unit : mm



Weight : 0.16g (Typ.)