

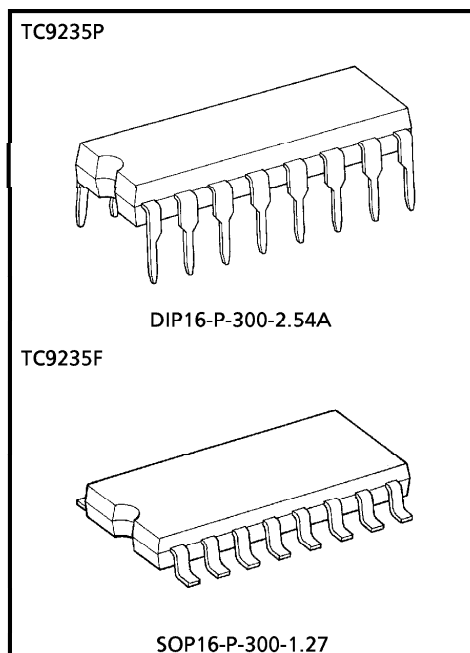
TC9235P, TC9235F

ELECTRONIC VOLUME

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

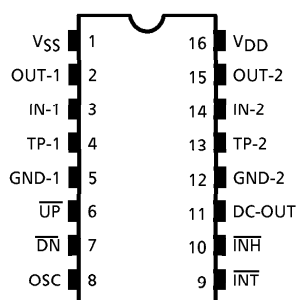
FEATURES

- 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.

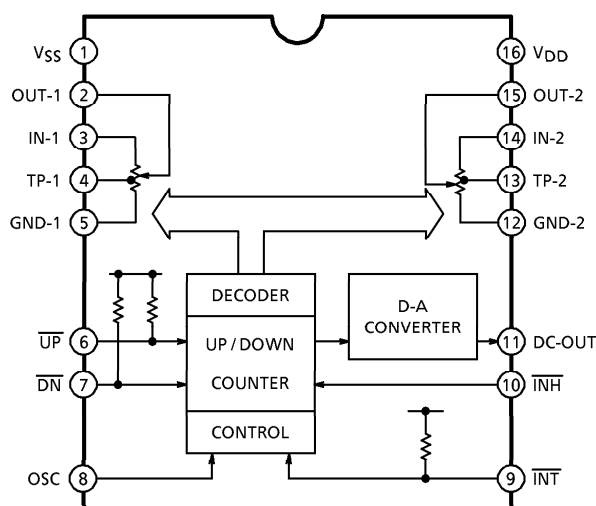


Weight
 DIP16-P-300-2.54A : 1.0g (Typ.)
 SOP16-P-300-1.27 : 0.16g (Typ.)

PIN CONNECTION



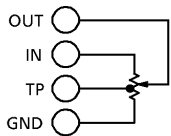
BLOCK DIAGRAM



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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	<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	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	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	INT	Initializing pin	Input pin for setting initial volume level volume level set to 46dB by "L" input.	Built-in pull-up resistor
10	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.	—

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OPERATION

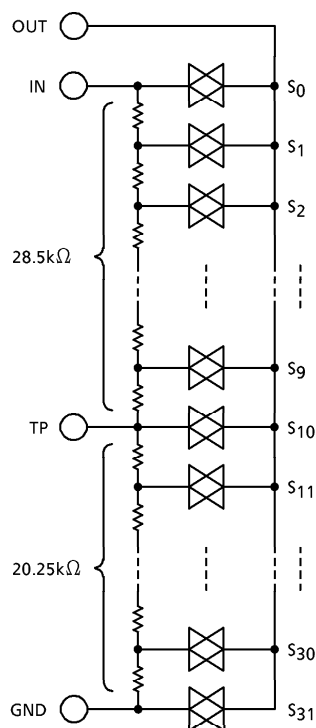
1. Volume circuit

Volume circuit consist of ladder resistor and analog switch.

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

Attenuation is as follows when resistor ($3.9k\Omega$) is connected between TP pin and GND pin.

- Equivalence circuit



- Volume step and attenuation
(Attenuation is as follows when resistor ($3.9k\Omega$) is connected between TP pin and GND pin.)

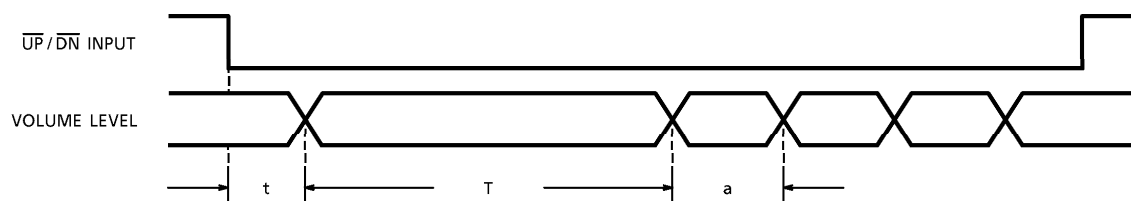
STEP	ATTENUATION	STEP	ATTENUATION
0	0 (dB)	16	32 (dB)
1	2	17	34
2	4	18	36
3	6	19	38
4	8	20	40
5	10	21	42
6	12	*22	46
7	14	23	50
8	16	24	54
9	18	25	58
10	20	26	62
11	22	27	66
12	24	28	70
13	26	29	74
14	28	30	78
15	30	31	∞

* 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



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

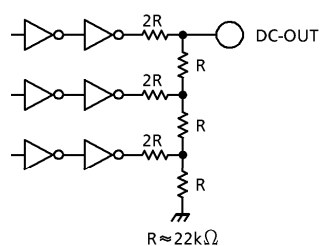
3. DC output circuit for volume level

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

• Equivalence circuit



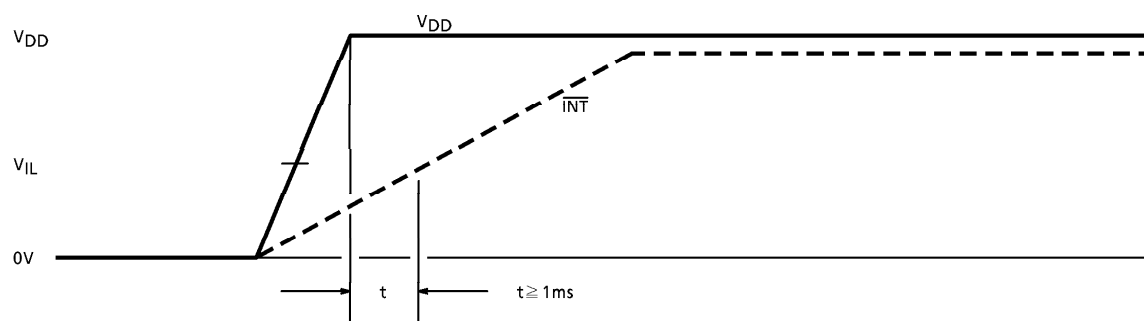
• Volume step and Output voltage

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

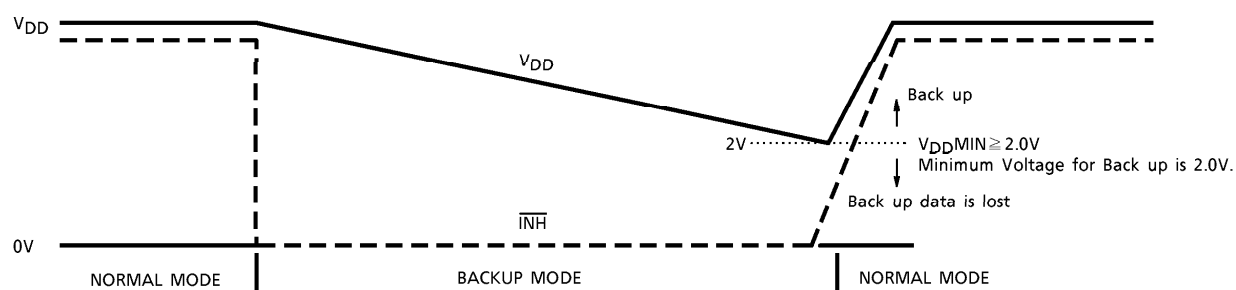
When power on, volume level is set to initial value (46dB) by setting $\overline{\text{INT}}$ pin to "L" level for a while.



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



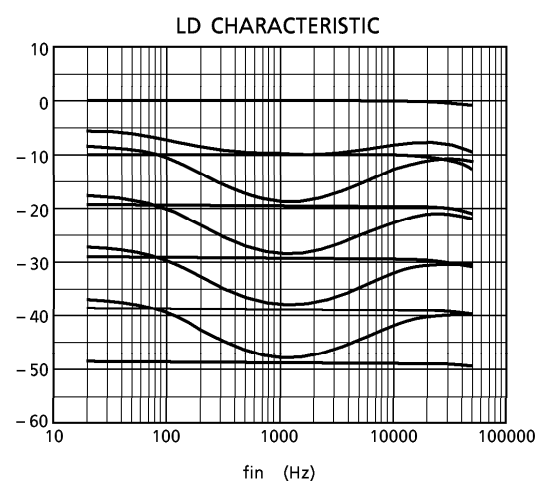
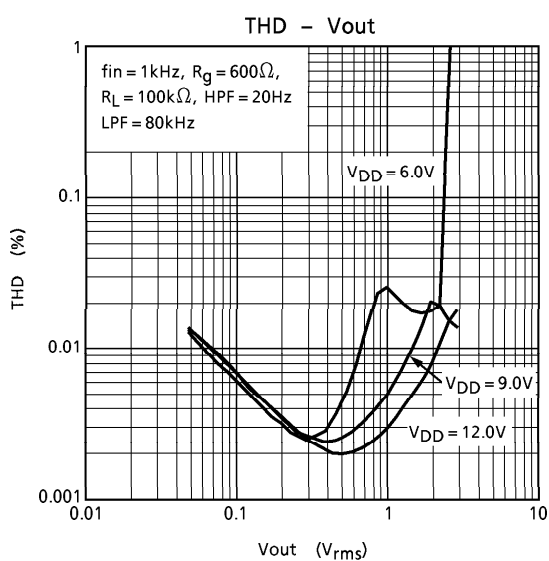
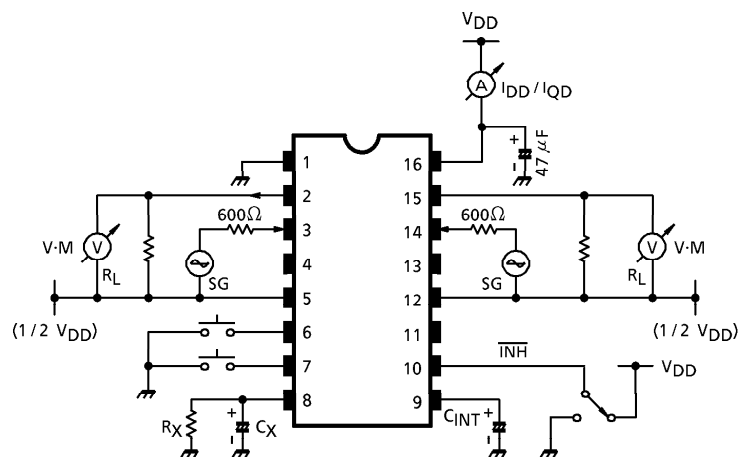
MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V _{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

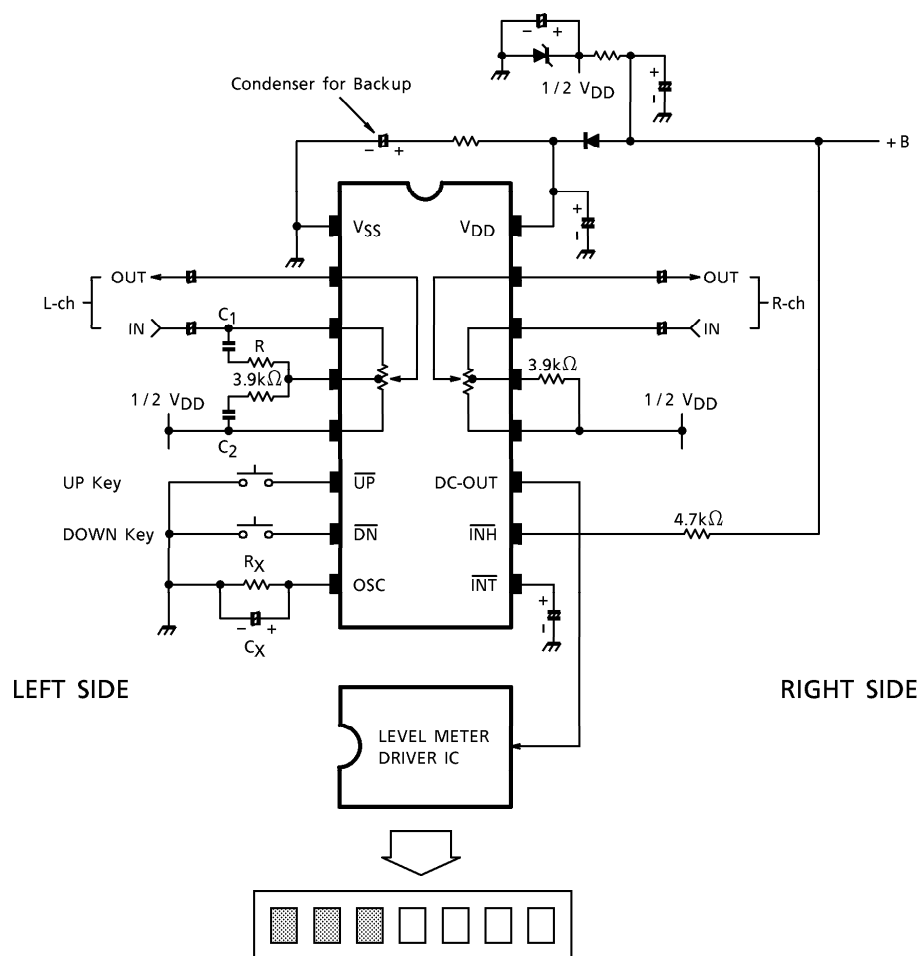
ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Ta = 25°C, V_{DD} = 9V)

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}	—	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}	—	INH input pin	V _{IH} = V _{DD}	- 1	—	1	μA
	"L" Level	I _{IL}			V _{IL} = 0V	- 1	—	1	
Pull Up Resistor		R _{UP}	—	UP, DN, 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, R _X = 33kΩ		—	20	—	Hz

TEST CIRCUIT 1



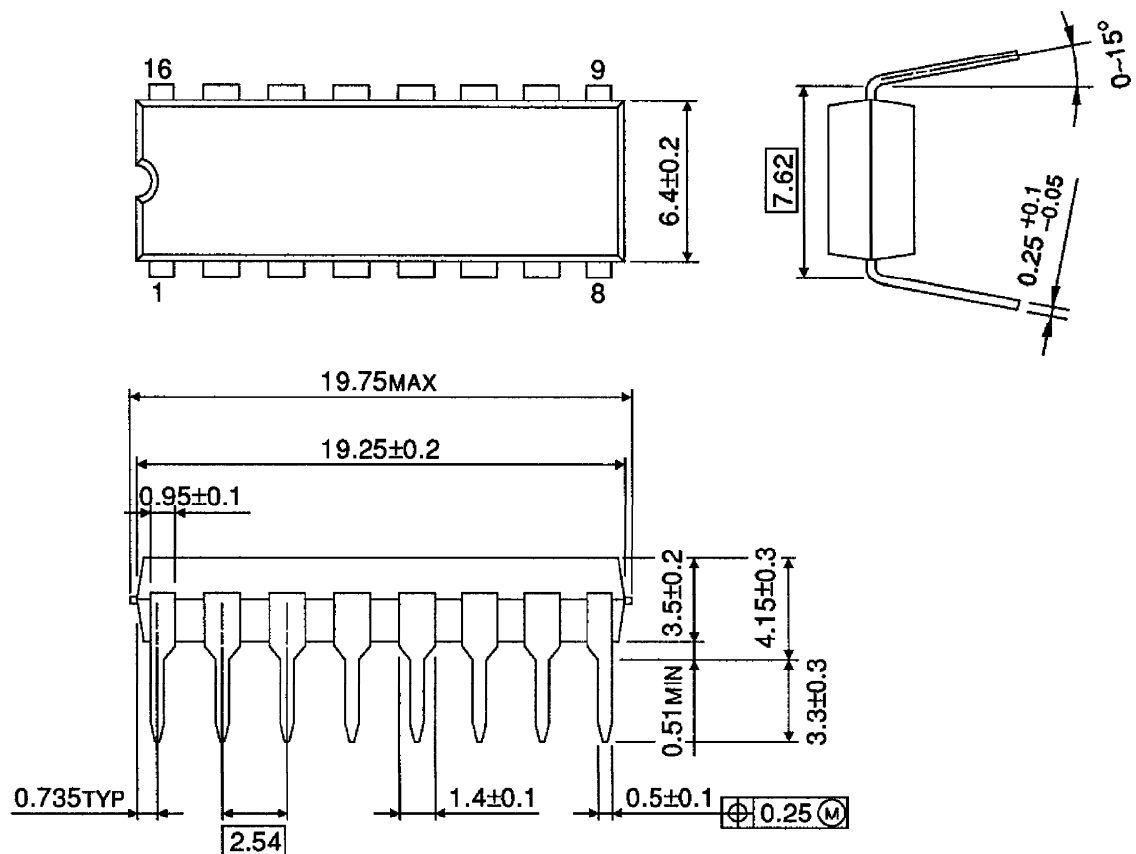
EXAMPLE OF APPLICATION CIRCUIT



(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

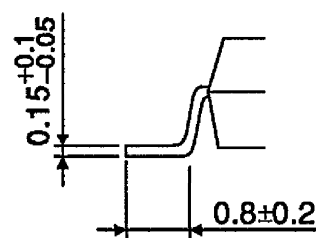
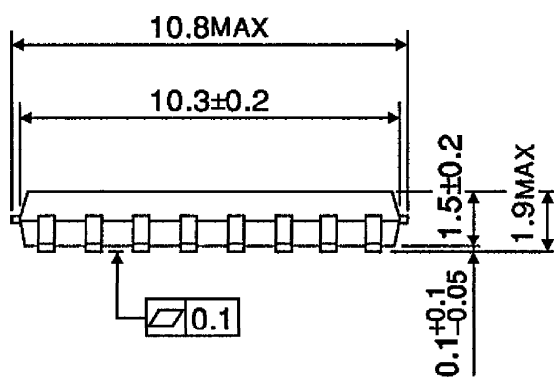
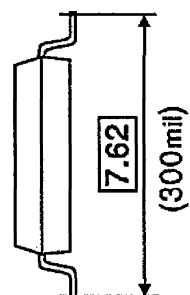
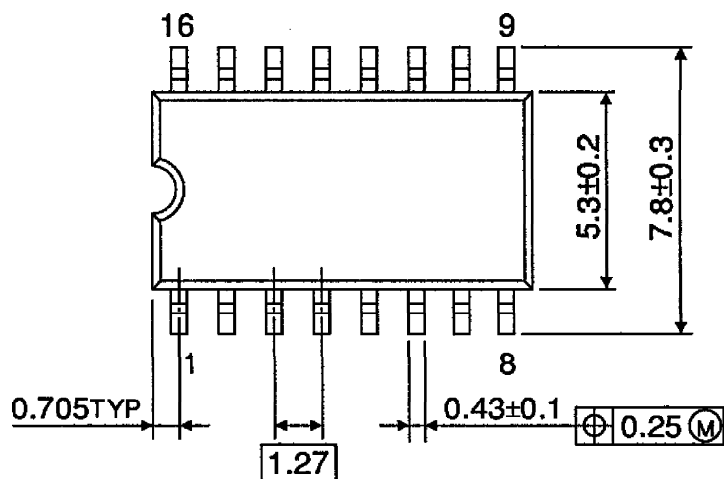
Unit : mm



Weight : 1.0g (Typ.)

OUTLINE DRAWING
SOP16-P-300-1.27

Unit : mm



Weight : 0.16g (Typ.)