General-purpose Operational Amplifiers /Comparators

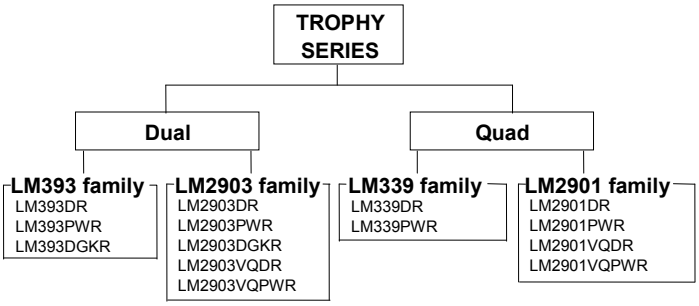
TROPHY SERIES
Comparators

LM393DR/PWR/DGKR,LM2903DR/PWR/DGKR/VQDR/VQPWR
LM339DR/PWR,LM2901DR/PWR/VQDR/VQPWR

No.10094EAT03

●Description

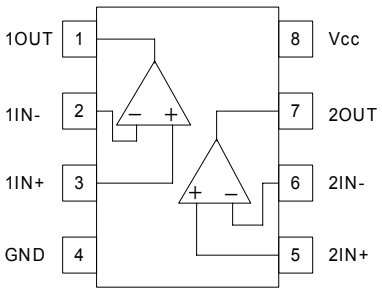
The Universal Standard family LM393 / LM339/ LM2903 / LM2901 monolithic ICs integrate two/four independent comparators on a single chip and feature high gain, low power consumption, and an operating voltage range from 2[V] to 36[V] (single power supply).

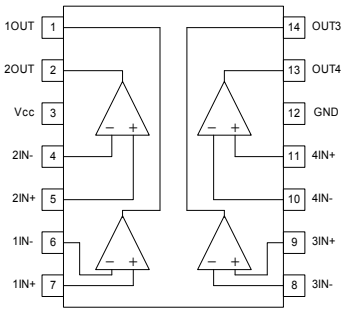


●Features

1) Operating temperature range
   Commercial Grade LM339/393 family : 0[℃] to + 70[℃]
   Extended Industrial Grade LM2903/2901 family : -40[℃] to +125[℃]
2) Open collector output
3) Single / dual power supply compatible
4) Low supply current
   0.8[mA] typ. (LM393/339/2903/2901 family)
5) Low input-bias current: 25[nA] typ.
6) Low input-offset voltage: 2[mV] typ.
7) Differential input voltage range equal to maximum rating
8) Low output saturation voltage
9) TTL,MOS,CMOS compatible output

●Pin Assignment





SOIC8	TSSOP8	MSOP8/VSSOP8
LM393DR	LM393PWR	LM393DGKR
LM2903DR	LM2903PWR	LM2903DGKR
LM2903VQDR	LM2903VQPWR	

SOIC14	TSSOP14
LM339DR	LM339PWR
LM2901DR	LM2901PWR
LM2901VQDR	LM2901VQPWR

●Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol	Ratings				Unit
		LM393 family	LM339 family	LM2903 family	LM2901 family	
Supply Voltage	Vcc-GND	+36				V
Input Differential Voltage	Vid	±36				V
Common-mode Input	Vicm	-0.3 to +36				V
Operating Temperature	Topr	0 to +70		-40 to +125		℃
Storage Temperature Range	Tstg	-65 to +150				℃
Maximum Junction Temperature	Tj	+150				℃

●Electric Characteristics

○LM393/339 family (Unless otherwise specified, Vcc=+5[V])

Parameter	Symbol	Temperature range	Limits						Unit	condition	Fig. No.
			LM393 family			LM339 family					
			Min.	Typ.	Max.	Min.	Typ.	Max.			
Input Offset Voltage (*1)	VIO	25℃	–	2	7	–	2	7	mV	Vcc=5 to 30[V],VO=1.4[V] VIC=VIC(min)	2
		Full range	–	–	9	–	–	9			
Input Offset Current (*1)	IIO	25℃	–	5	50	–	5	50	nA	VO=1.4[V]	2
		Full range	–	–	250	–	–	150			
Input Bias Current (*1)	IIB	25℃	–	25	250	–	25	250	nA	VO=1.4[V]	2
		Full range	–	–	400	–	–	400			
Common-mode Input Voltage Range	VICR	25℃	–	–	Vcc-1.5	–	–	Vcc-1.5	V	–	2
		Full range	–	–	Vcc-2.0	–	–	Vcc-2.0			
Large Signal Differential Voltage Amplification	AVD	25℃	25	200	–	25	200	–	V/mA	Vcc=15[V] VO=1.4 to 11.4[V], RL≧15[kΩ],VRL=15[V]	2
High Level Output Current	IOH	25℃	–	0.1	–	–	0.1	–	nA	VID=1[V],VO=5[V]	3
		Full range	–	–	1	–	–	1	μA	VID=1[V],VO=30[V]	
Low Level Output Voltage	VOL	25℃	–	150	400	–	150	400	mV	VID=-1[V],IOL=4[mA]	3
		Full range	–	–	700	–	–	700			
Low Level Output Current	IOL	25℃	6	–	–	6	16	–	mA	VID=-1[V],VOL=1.5[V]	3
Supply Current	ICC	25℃	–	0.8	1	–	0.8	2	mA	RL=∞,Vcc=5V	3
		Full range	–	–	2.5	–	–	–		RL=∞,Vcc=30[V]	
Response Time	Tre	25℃	–	1.3	–	–	1.3	–	μs	RL=5.1[kΩ],VRL=5[V],CL=15pF VIN=100[mVp-p], overdrive=5[mV]	3
			–	0.3	–	–	0.3	–		RL=5.1[kΩ],VRL=5[V], CL=15pF VIN=TTL-Level input step Vref=1.4[V]	

(*1) Absolute value

○LM2903/2901 family(Unless otherwise specified, Vcc=+5[V])

Parameter	Symbol	Temperature range	Limits						Unit	Condition	Fig. No
			LM2903 family			LM2901 family					
			Min.	Typ.	Max.	Min.	Typ.	Max.			
Input Offset Voltage (*2)	VIO	25℃	—	2	7	—	2	7	mV	Vcc=5 to MAX),VO=1.4[V] VIC=VIC (min)	2
		Full range	—	—	15	—	—	15			
Input Offset Current (*2)	IIO	25℃	—	5	50	—	5	50	nA	VO=1.4[V]	2
		Full range	—	—	200	—	—	200			
Input Bias Current (*2)	IIB	25℃	—	25	250	—	25	250	nA	VO=1.4[V]	2
		Full range	—	—	500	—	—	500			
Common-mode Input Voltage Range	VICR	25℃	—	—	Vcc-1.5	—	—	Vcc-1.5	V	—	2
		Full range	—	—	Vcc-2.0	—	—	Vcc-2.0			
Large Signal Differential Voltage Amplification	AVD	25℃	25	100	—	25	100	—	V/mV	Vcc=15[V],VOUT=1.4 to 11.4[V], RL≧15[kΩ],VRL=15[V]	2
High Level Output Current	IOH	25℃	—	0.1	—	—	0.1	—	nA	VID=1[V], VOH=5[V]	3
		Full range	—	—	1	—	—	1	μA	VID=1[V], VOH=MAX	
Low Level Output Voltage LM2901(*3)	VOL	25℃	—	150	400	—	150	500	mV	3	
Low Level Output Voltage LM2901V(*3)		25℃	—	150	400	—	150	400			
		Full range	—	—	700	—	—	700			
Low Level Output Current	IOL	25℃	6	16	—	6	16	—	mA	VID=-1[V], VOL=1.5[V]	3
Supply Current	ICC	25℃	—	0.8	2	—	0.8	2	mA	RL=∞,Vcc=5V	3
			—	1	2.5	—	1	2.5		RL=∞,Vcc=MAX(*7)	
Response Time	Tre	25℃	—	1.3	—	—	1.3	—	μs	RL=5.1[Ω],VRL=5[V],CL=15pF VIN=100[mVp-p], Overdrive=5[mV]	3
			—	0.3	—	—	0.3	—		RL=5.1[kΩ],VRL=5[V], CL=15pF VIN=TTL-Level input step Vref=1.4[V]	

(*2) Absolute value
(*3) Supply Voltage Maximum Value LM2901DR, LM2901PWR MAX=30[V], LM2901VQDR, LM2901VQPWR MAX=32[V]

●Circuit Diagram

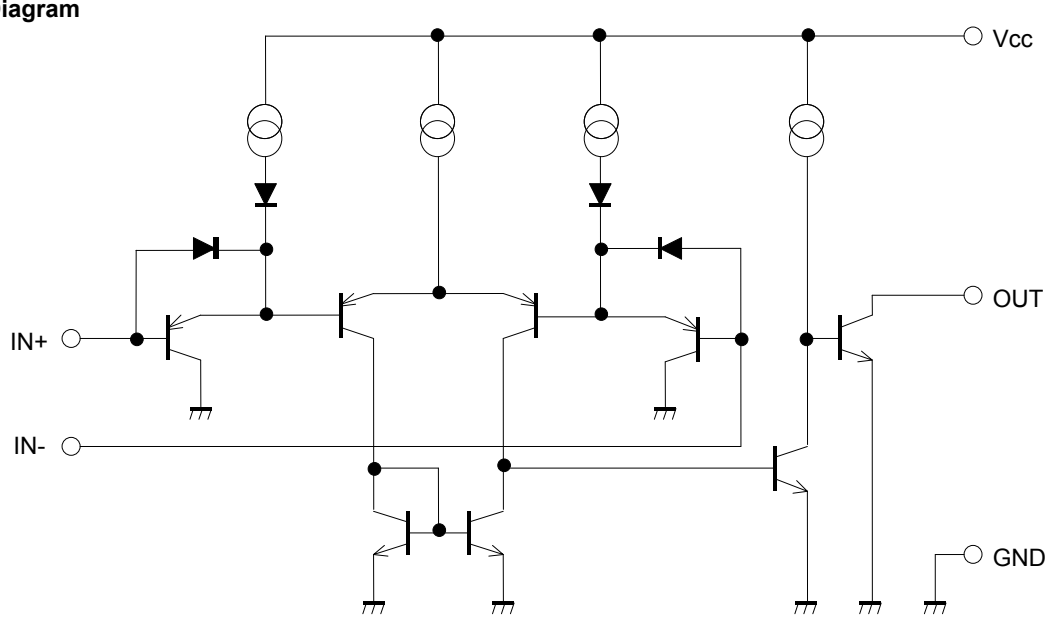


Fig.1 Circuit Diagram (each Comparator)

●Measurement circuit 1 NULL Method measurement condition

Vcc,GND,EK,VICR Unit：[V]

Parameter	VF	S1	S2	S3	LM393/LM339 family				LM2903/LM2901 family				Calculation
					Vcc	GND	EK	VICR	Vcc	GND	EK	VICR	
Input Offset Voltage	VF1	ON	ON	ON	5 to 30	0	-1.4	0	5 to 30	0	-1.4	0	1
Input Offset Current	VF2	OFF	OFF	ON	5	0	-1.4	0	5	0	-1.4	0	2
Input Bias Current	VF3	OFF	ON	ON	5	0	-1.4	0	5	0	-1.4	0	3
	VF4	ON	OFF		5	0	-1.4	0	5	0	-1.4	0	
Large Signal Voltage Gain	VF5	ON	ON	ON	15	0	-1.4	0	15	0	-1.4	0	4
	VF6				15	0	-11.4	0	15	0	-11.4	0	

－Calculation－

1.Input offset voltage (VIO)

$$Vio = \frac{|VF1|}{1+ Rf/Rs} \ [V]$$

2.Input offset current (IIO)

$$Iio = \frac{|VF2 - VF1|}{Ri(1+ Rf / Rs)} \ [A]$$

3.Input bias current (IIb)

$$Ib = \frac{|VF4 - VF3|}{2\times Ri(1+ Rf / Rs)} \ [A]$$

4.Large signal differential voltage gain (AVD)

$$AV = 20\times Log \frac{10\times (1+ Rf/Rs)}{|VF6 - VF5|} \ [dB]$$

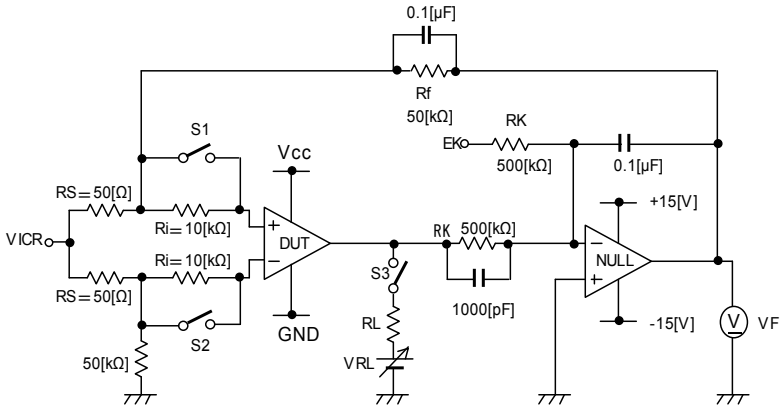


Fig.2 Measurement Circuit1 (each Comparator)

●**Measurement Circuit2 Switch Condition**

SW No.		SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7
Supply Current	—	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Low Level Output Current	VOL=1.5[V]	OFF	ON	ON	OFF	ON	ON	OFF
Low Level Output Current	IOL=4[mA]	OFF	ON	ON	OFF	OFF	OFF	ON
High Level Output Current	VOH=36[V]	OFF	ON	ON	OFF	OFF	OFF	ON
Response Time	RL=5.1[kΩ] VRL=5[V]	ON	OFF	ON	ON	OFF	ON	OFF

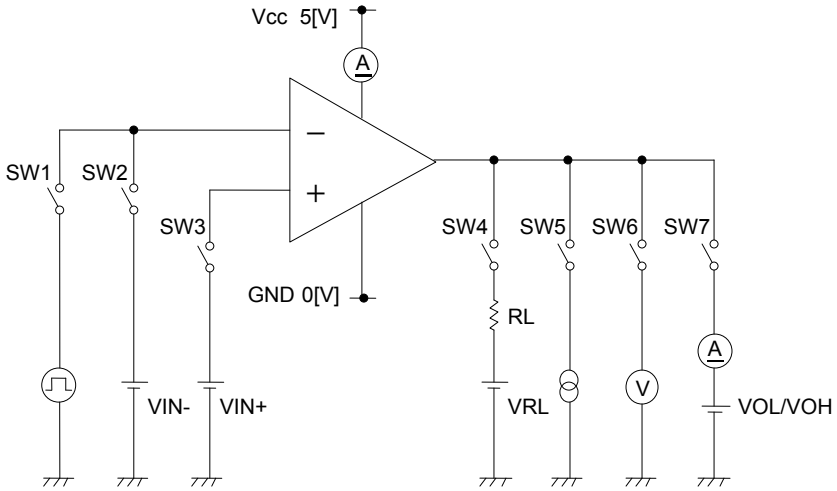


Fig.3 Measurement Circuit2 (each channel)

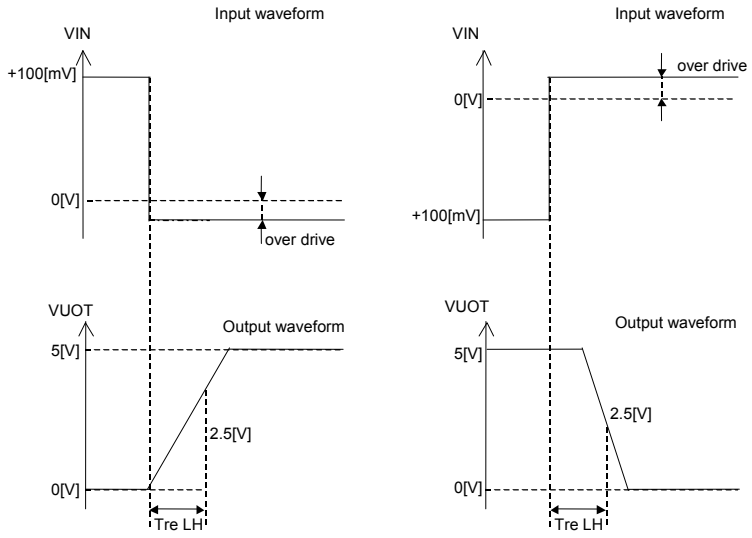


Fig.4 Response Time

●Description of Electrical Characteristics

Described below are descriptions of the relevant electrical terms.
Please note that item names, symbols, and their meanings may differ from those on another manufacturer's documents.

1. Absolute maximum ratings

The absolute maximum ratings are values that should never be exceeded, since doing so may result in deterioration of electrical characteristics or damage to the part itself as well as peripheral components.

1.1 Power supply voltage (Vcc/GND)

Expresses the maximum voltage that can be supplied between the positive and negative power supply terminals without causing deterioration of the electrical characteristics or destruction of the internal circuitry.

1.2 Differential input voltage (VID)

Indicates the maximum voltage that can be supplied between the non-inverting and inverting terminals without damaging the IC.

1.3 Input common-mode voltage range (VICR)

Signifies the maximum voltage that can be supplied to non-inverting and inverting terminals without causing deterioration of the electrical characteristics or damage to the IC itself. Normal operation is not guaranteed within the input common-mode voltage range of the maximum ratings – use within the input common-mode voltage range of the electric characteristics instead.

1.4 Operating temperature range and storage temperature range (Topr,Tstg)

The operating temperature range indicates the temperature range within which the IC can operate. The higher the ambient temperature, the lower the power consumption of the IC. The storage temperature range denotes the range of temperatures the IC can be stored under without causing excessive deterioration of the electrical characteristics.

1.5 Power dissipation (Pd)

Indicates the power that can be consumed by a particular mounted board at ambient temperature (25°C). For packaged products, Pd is determined by maximum junction temperature and the thermal resistance.

2. Electrical characteristics

2.1 Input offset voltage (VIO)

Signifies the voltage difference between the non-inverting and inverting terminals. It can be thought of as the input voltage difference required for setting the output voltage to 0V.

2.2 Input offset current (IIO)

Indicates the difference of the input bias current between the non-inverting and inverting terminals.

2.3 Input bias current (IIB)

Denotes the current that flows into or out of the input terminal, it is defined by the average of the input bias current at the non-inverting terminal and the input bias current at the inverting terminal.

2.4 Input common-mode voltage range (VICR)

Indicates the input voltage range under which the IC operates normally.

2.5 Large signal differential voltage gain (AVD)

The amplifying rate (gain) of the output voltage against the voltage difference between the non-inverting and inverting terminals, it is (normally) the amplifying rate (gain) with respect to DC voltage.
AVD = (output voltage fluctuation) / (input offset fluctuation)

2.6 Supply current (ICC)

Indicates the current of the IC itself that flows under specific conditions and during no-load steady state.

2.7 Low level output current (IOL)

Denotes the maximum current that can be output under specific output conditions.

2.8 Low level output voltage (VOL)

Signifies the voltage range that can be output under specific output conditions.

2.9 High level output current (IOH)

Indicates the current that flows into the IC under specific input and output conditions.

2.10 Response time (tre)

The interval between the application of input and output conditions.

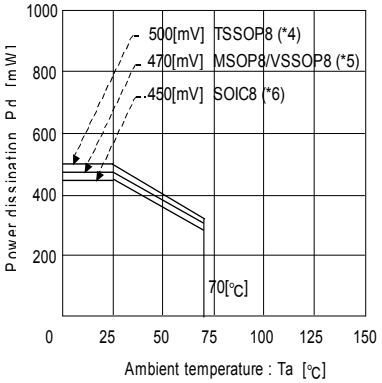
2.11 Common-mode rejection ratio (CMRR)

Denotes the ratio of fluctuation of the input offset voltage when the in-phase input voltage is changed (DC fluctuation).
CMRR = (change of input common-mode voltage) / (input offset fluctuation)

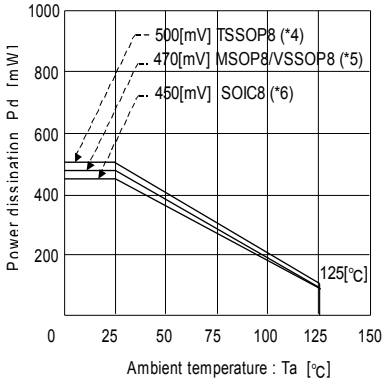
2.12 Power supply rejection ratio (PSRR)

Signifies the ratio of fluctuation of the input offset voltage when the supply voltage is changed (DC fluctuation).
PSRR = (change in power supply voltage) / (input offset fluctuation)

●Derating Curves



LM393DR/PWR/DGKR



LM2903DR/PWR/DGKR/VQDR/VQPWR

Power Dissipation

Package	Pd[W]	θja [℃/W]
SOIC8 (*6)	450	3.6
TSSOP8 (*4)	500	4.0
MSOP8/VSSOP8	470	3.76

θja = (Tj-Ta)/Pd[℃/W]

Fig.5 Derating Curves

●Precautions

1) Unused circuits
When there are unused circuits it is recommended that they be connected as in Fig. 6, setting the non-inverting input terminalto a potential within the in-phase input voltage range (VICR).

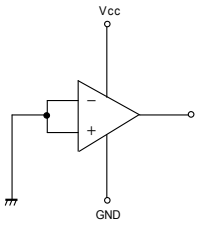


Fig.6 Disable circuit example

2) Input terminal voltage
Applying GND + 36V to the input terminal is possible without causing deterioration of the electrical characteristics or destruction, irrespective of the supply voltage. However, this does not ensure normal circuit operation.
Please note that the circuit operates normally only when the input voltage is within the common mode input voltage range of the electric characteristics.

3) Power supply (single / dual)
The op-amp operates when the specified voltage supplied is between Vcc and GND. Therefore, the single supply op-amp can be used as a dual supply op-amp as well.

4) Power dissipation Pd
Using the unit in excess of the rated power dissipation may cause deterioration in electrical characteristics due to a rise in chip temperature, including reduced current capability. Therefore, please take into consideration the power dissipation (Pd) under actual operating conditions and apply a sufficient margin in thermal design. Refer to the thermal derating curves for more information.

5) Short-circuit between pins and erroneous mounting
Incorrect mounting may damage the IC. In addition, the presence of foreign particles between the outputs, the output and the power supply, or the output and GND may result in IC destruction.

6) Terminal short-circuits
When the output and Vcc terminals are shorted, excessive output current may flow, resulting in undue heat generation and, subsequently, destruction.

7) Operation in a strong electromagnetic field
Operation in a strong electromagnetic field may cause malfunctions.

8) Radiation
This IC is not designed to withstand radiation.

9) IC handing
Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuations in the electrical characteristics due to piezoelectric (piezo) effects.

10) Board inspection
Connecting a capacitor to a pin with low impedance may stress the IC. Therefore, discharging the capacitor after every process is recommended. In addition, when attaching and detaching the jig during the inspection phase, ensure that the power is turned OFF before inspection and removal. Furthermore, please take measures against ESD in the assembly process as well as during transportation and storage.

●Ordering part number

L	M	2	9	0	3	V	Q	D	R

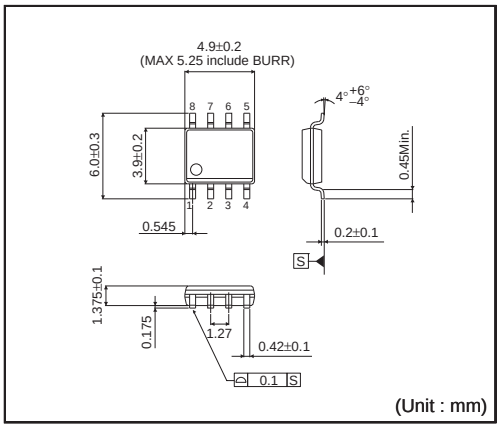
Family name
LM393
LM339
LM2901
LM2903

Operating Voltage
VQ : Tested to 32V
None : Tested to 30V

Package type
D : SOIC
PW : TSSOP
DGK : MSOP/VSSOP

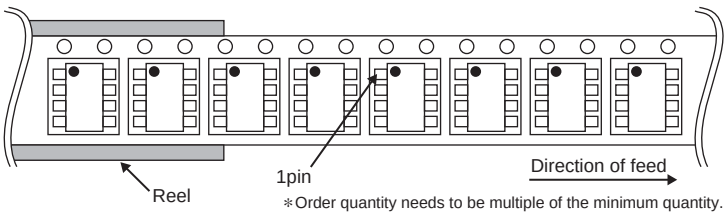
R : Real

SOIC8



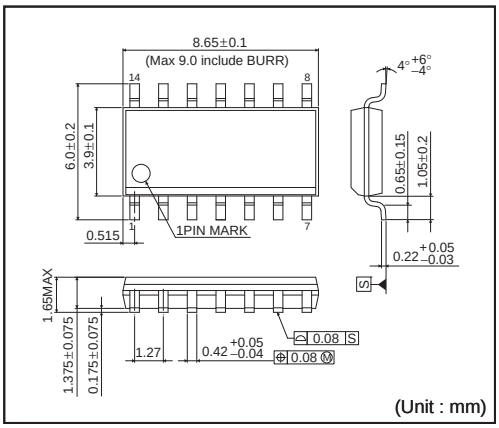
<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

SOIC14



<Tape and Reel information>

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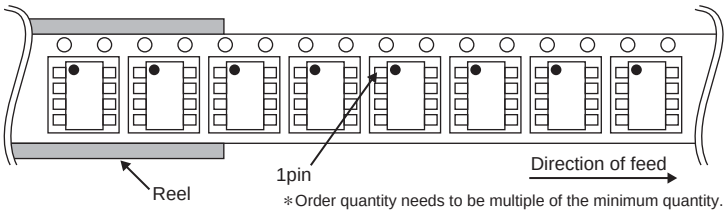

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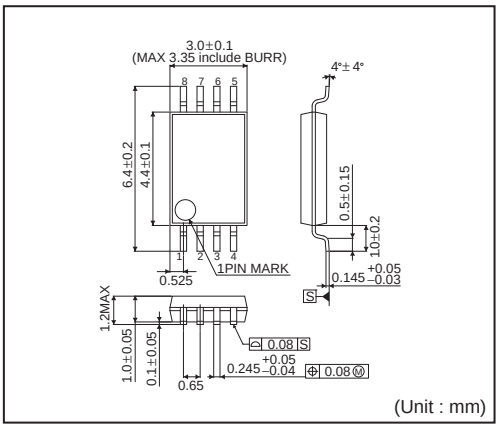
TSSOP8



<Tape and Reel information>

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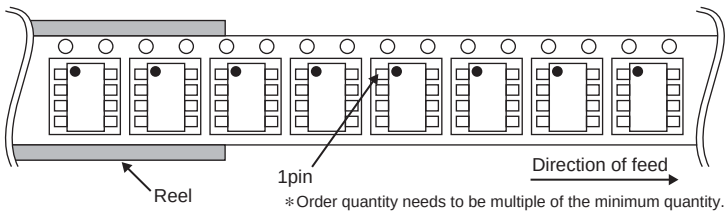
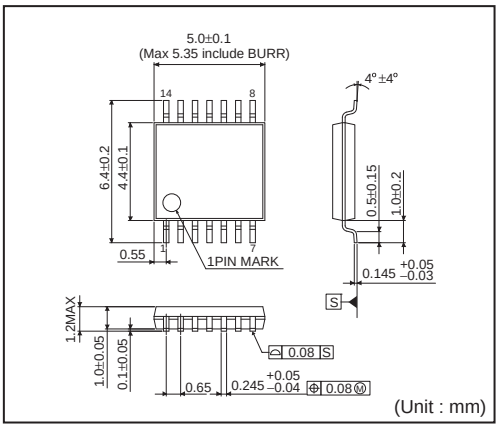
Quantity	2500pcs
Direction of feed	(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



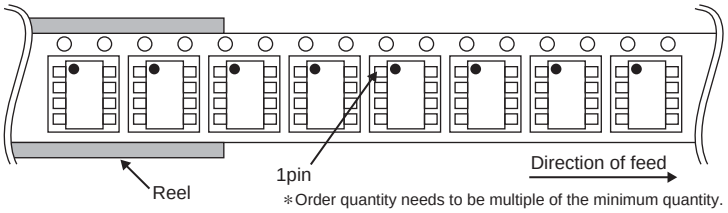
∗Order quantity needs to be multiple of the minimum quantity.

TSSOP14



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



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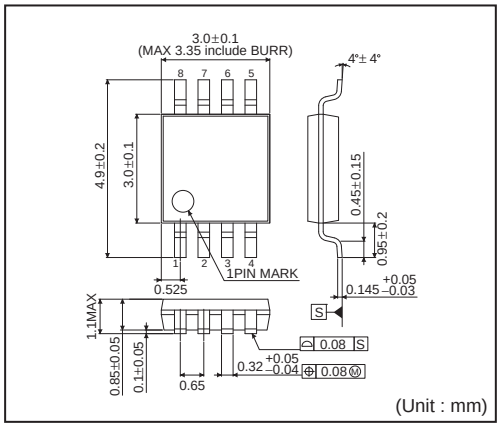
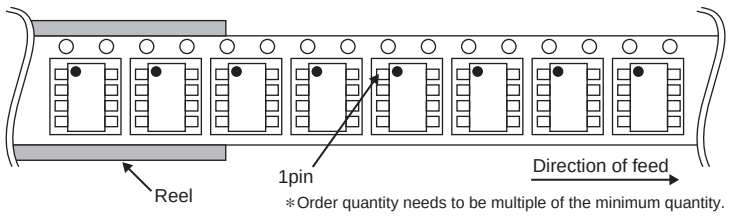
MSOP / VSSOP8



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

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Please be sure to implement in your equipment using the Products safety measures to guard against the possibility of physical injury, fire or any other damage caused in the event of the failure of any Product, such as derating, redundancy, fire control and fail-safe designs. ROHM shall bear no responsibility whatsoever for your use of any Product outside of the prescribed scope or not in accordance with the instruction manual.

The Products are not designed or manufactured to be used with any equipment, device or system which requires an extremely high level of reliability the failure or malfunction of which may result in a direct threat to human life or create a risk of human injury (such as a medical instrument, transportation equipment, aerospace machinery, nuclear-reactor controller, fuel-controller or other safety device). ROHM shall bear no responsibility in any way for use of any of the Products for the above special purposes. If a Product is intended to be used for any such special purpose, please contact a ROHM sales representative before purchasing.

If you intend to export or ship overseas any Product or technology specified herein that may be controlled under the Foreign Exchange and the Foreign Trade Law, you will be required to obtain a license or permit under the Law.

ROHM SEMICONDUCTOR

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