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# Product Standards

Part No.	AN8013SH
Package Code No.	SSOP010-P-0225A

Analogue LSI Business Unit  
Semiconductor Company  
Matsushita Electric Industrial Co., Ltd.

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# AN8013SH

## Single-channel step-up or step-down DC-DC converter control IC

### ■ Overview

AN8013SH is a single-channel DC-DC converter control IC using the PWM method.

This IC implements DC-DC converter that provide a single arbitrary output voltage that is either a stepped-up or stepped-down level. It features a wide operating supply voltage range, low power, and a built-in overcurrent protection circuit to protect the switching transistor from damage or destruction. The AN8013SH is provided in a 0.5 mm pitch 10-pin surface mounting package and is optimal for use in miniature high-efficiency portable power supplies.

### ■ Features

- Wide operating supply voltage range (3.6 V to 34 V)
- Small consumption current (2.4 mA typical)
- Supports control over a wide output frequency range: 20kHz to 500 kHz.
- Built-in pulse-by pulse overcurrent protection circuit (Detection voltage:  $V_{CC} - 100$  mV)
- Built-in timer latch short-circuit protection circuit (charge current : 1.3  $\mu$ A typical)
- Incorporating an under-voltage lock-out circuit (U.V.L.O)
- Built-in reference voltage circuit (Error amplifier reference input: 0.75 V (allowance:  $\pm 4\%$ ))
- Output block is open-collector (darlington) type.
- High absolute maximum rating of output current (100 mA)
- Duty ratio with small sample-to-sample variations ( $55\% \pm 5\%$ )

### ■ Applications

- Switching mode power supply units (in portable equipment and other applications)

### ■ Package

- 10 pin Plastic Shrink Small Outline Package (SSOP Type)

### ■ Type

- Silicon Monolithic Bipolar IC

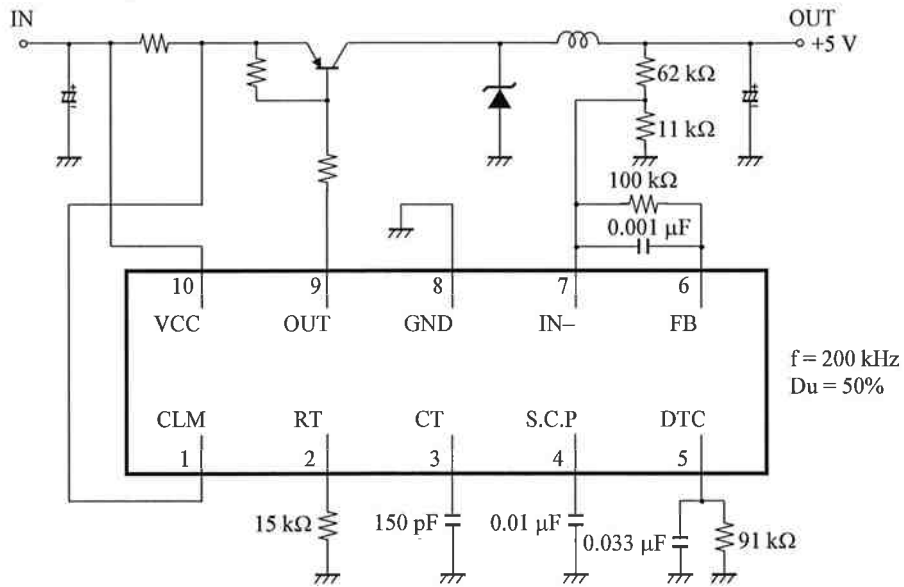
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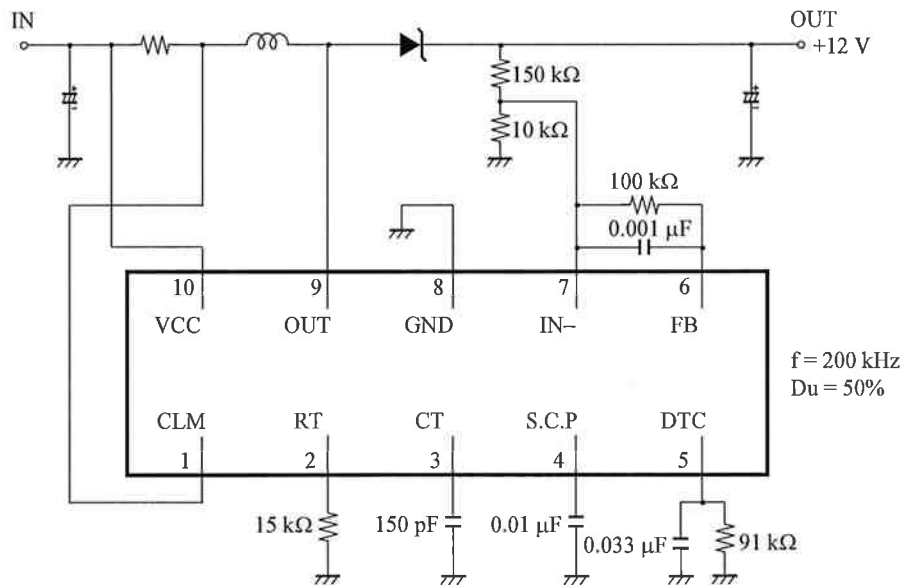
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■ Application Circuit Example

1. Step-down



2. Step-up



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■ Pin Descriptions

Pin No.	Pin name	Type	Description
1	CLM	Input	Overcurrent protection input
2	RT	—	Oscillator frequency setup resistor connection
3	CT	—	Oscillator frequency setup capacitor connection
4	S.C.P	—	Capacitor connection for delay short-circuit protection
5	DTC	Input	Dead time control pin
6	FB	Output	Output of error amplifier
7	IN-	Input	Inverted input for error amplifier
8	GND	Ground	Ground pin
9	OUT	Output	Open collector output
10	VCC	Power supply	Supply voltage application

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### ■ Absolute Maximum Ratings

A No.	Parameter	Symbol	Rating	Unit	Notes
1	Supply voltage	$V_{CC}$	35	V	*1
2	Supply current	$I_{CC}$	—	mA	—
3	Power dissipation	$P_D$	115	mW	*2
4	Operating ambient temperature	$T_{opr}$	-30 to +85	°C	*3
5	Storage temperature	$T_{stg}$	-55 to +125	°C	*3
6	CLM pin allowable applied voltage	$V_{CLM}$	35	V	—
7	Error amplifier allowable input voltage	$V_I$	-0.3 to 2.5	V	—
8	DTC pin allowable applied voltage	$V_{DTC}$	2.5	V	—
9	OUT pin allowable applied voltage	$V_{OUT}$	35	V	—
10	Output current	$I_O$	100	mA	—

Notes) \*1 : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

\*2 : The power dissipation shown is the value at  $T_a = 85^\circ\text{C}$  for the independent (unmounted) IC package.

When using this IC, refer to the  $P_D$ - $T_a$  diagram of the package standard page 4 and use under the condition not exceeding the allowable value.

\*3 : Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for  $T_a = 25^\circ\text{C}$ .

### ■ Operating supply voltage range

Parameter	Symbol	Range	Unit	Notes
Supply voltage range	$V_{CC}$	3.6 to 34	V	*

Note) \*: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

### ■ Recommended Operating Conditions

Parameter	Symbol	Min	Max	Unit	Notes
Supply voltage (0 to 3.6 V) rise time	$t_{r(VCC)}$	10	—	$\mu\text{s}$	*
Collector output voltage	$V_{OUT}$	—	34	V	*
Collector output current	$I_{OUT}$	—	50	mA	*
Timing capacitance	$C_T$	100	1 800	pF	*
Timing resistance	$R_T$	5.1	15	$\text{k}\Omega$	*
Output frequency	$f_{OUT}$	20	500	kHz	*
Time constant setting capacitance for short-circuit protection	$C_{SCP}$	1 000	—	pF	*

Note) \*: Do not apply current or voltage from external source to any pin not listed above.

In the circuit current, (+) means the current flowing into IC and (-) means the current flowing out of IC.

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■ Electrical Characteristics at  $V_{CC} = 12\text{ V}$ ,  $C_T = 150\text{ pF}$ ,  $R_T = 15\text{ k}\Omega$

Note)  $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$  unless otherwise specified.

B No.	Parameter	Symbol	Test circuits	Conditions	Limits			Unit	Notes
					Min	Typ	Max		
<b>U.V.L.O. Block</b>									
1	U.V.L.O. start voltage	$V_{UON}$	1	—	2.9	3.2	3.5	V	
2	Hysteresis width	$V_{HYS}$	1	—	60	—	400	mV	
<b>Error Amplifier Block</b>									
3	Input threshold voltage	$V_{TH}$	2	Voltage follower	0.72	0.75	0.78	V	
4	Line regulation	$V_{dv}$	2	Voltage follower $V_{CC} = 3.6\text{ V to }34\text{ V}$	—	2	8	mV	
5	Input current	$I_B$	3	—	-500	-35	—	nA	
6	High-level output voltage	$V_{EH}$	3	—	2.0	—	—	V	
7	Low-level output voltage	$V_{EL}$	3	—	—	—	0.3	V	
<b>PWM Comparator Block</b>									
8	High-level input threshold voltage	$V_{DT-H}$	4	Duty ratio 100%	1.2	—	—	V	
9	Low-level input threshold voltage	$V_{DT-L}$	4	Duty ratio 0%	—	—	0.6	V	
10	Input current	$I_{DTC}$	4	—	-12	-11	-10	$\mu\text{A}$	
<b>Output Block</b>									
11	Output frequency	$f_{OUT}$	5	—	185	205	225	kHz	
12	Output duty ratio	$D_U$	5	$R_{DTC} = 91\text{ k}\Omega$	50	55	60	%	
13	Output saturation voltage	$V_{(SAT)}$	4	$I_O = 50\text{ mA}$	—	0.9	1.2	V	
14	Output leak current	$I_{OLE}$	4	$V_{CC} = 34\text{ V}$ Duty ratio 0%	—	—	10	$\mu\text{A}$	
<b>Short-circuit Protection Block</b>									
15	Input threshold voltage	$V_{THPC}$	6	—	0.7	0.75	0.8	V	
16	Input standby voltage	$V_{STBY}$	6	—	—	—	120	mV	
17	Input latch voltage	$V_{IN}$	6	—	—	—	120	mV	
18	Charging current	$I_{CHG}$	6	—	-1.6	-1.3	-1.0	$\mu\text{A}$	
<b>Overcurrent Protection Block</b>									
19	Threshold voltage	$V_{CLM}$	7	—	$V_{CC} - 120$	$V_{CC} - 100$	$V_{CC} - 80$	mV	
<b>The Whole Circuit</b>									
20	Total current consumption1	$I_{CC1}$	8	—	—	2.4	3.5	mA	

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■ Electrical Characteristics (Reference values for design) at  $V_{CC} = 12\text{ V}$ ,  $C_T = 150\text{ pF}$ ,  $R_T = 15\text{ k}\Omega$

Note)  $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$  unless otherwise specified.

B No.	Parameter	Symbol	Test circuits	Conditions	Reference values			Unit	Notes
					Min	Typ	Max		
<b>Error Amplifier Block</b>									
21	Input threshold voltage temperature characteristics 1	$V_{dt1}$	2	Voltage follower $T_a = -30\text{ to }25^\circ\text{C}$	—	$\pm 1$	—	%	*1
22	Input threshold voltage temperature characteristics 2	$V_{dt2}$	2	Voltage follower $T_a = 25\text{ to }85^\circ\text{C}$	—	$\pm 1$	—	%	*1
23	Output sink current	$I_{SINK}$	3	$V_{FB} = 0.9\text{ V}$	—	8	—	mA	*1
24	Output source current	$I_{SOURCE}$	3	$V_{FB} = 0.9\text{ V}$	—	-120	—	$\mu\text{A}$	*1
25	Open-loop gain	AG	3	—	—	70	—	dB	*1
<b>Output Block</b>									
26	Maximum oscillation frequency	$f_{OUT(MAX)}$	5	$C_T = 120\text{ pF}$ , $R_T = 5.1\text{ k}\Omega$	—	500	—	kHz	*1
27	Frequency supply voltage characteristics	$f_{dv}$	5	$V_{CC} = 3.6\text{ V to }34\text{ V}$	—	$\pm 1$	—	%	*1
28	Frequency temperature characteristics 1	$f_{dt1}$	5	$T_a = -30\text{ to }25^\circ\text{C}$	—	$\pm 3$	—	%	*1
29	Frequency temperature characteristics 2	$f_{dt2}$	5	$T_a = 25\text{ to }85^\circ\text{C}$	—	$\pm 3$	—	%	*1
30	RT pin voltage	$V_{RT}$	4	—	—	0.59	—	V	*1
<b>Short-circuit Protection Block</b>									
31	Comparator threshold voltage	$V_{THL}$	6	—	—	1.90	—	V	*1
<b>Overcurrent Protection Block</b>									
32	Delay time	$t_{DLY}$	7	—	—	200	—	ns	*1
<b>The Whole Circuit</b>									
33	Total consumption current 2	$I_{CC2}$	8	$R_T = 5.1\text{ k}\Omega$	—	3.4	—	mA	*1

Note) \*1: The above characteristics are reference values for design of the IC and are not guaranteed by inspection.

If a problem does occur related to these characteristics, Matsushita will respond in good faith to user concerns.

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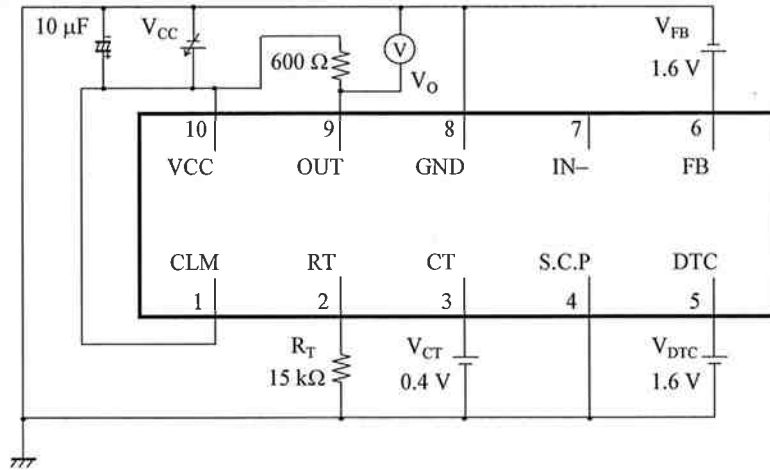
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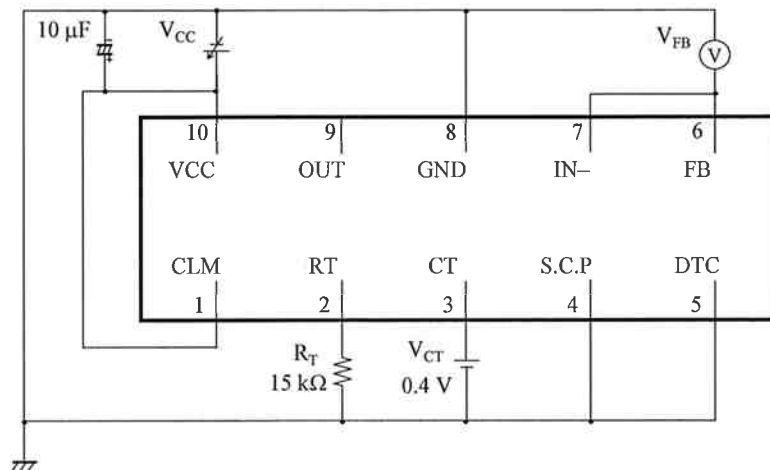
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■ Test Circuit Diagram

1. Test Circuit 1



2. Test Circuit 2



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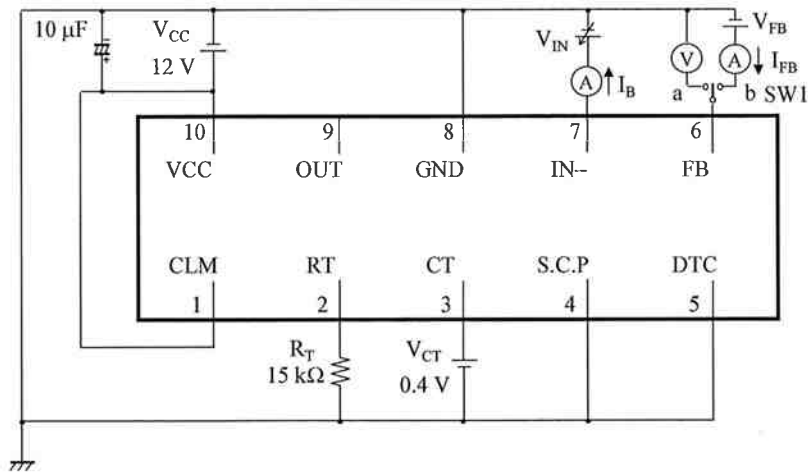
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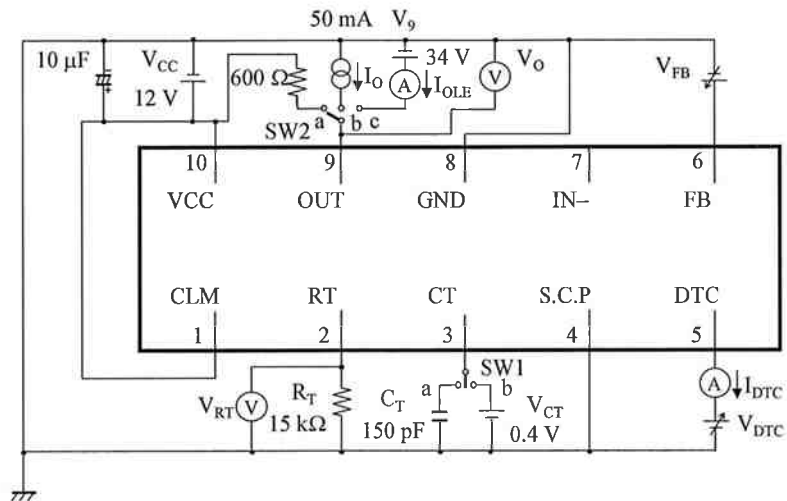
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3. Test Circuit 3



4. Test Circuit 4



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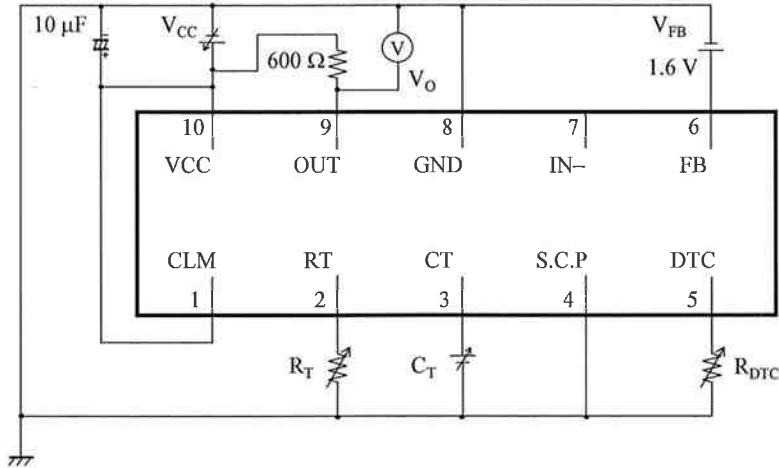
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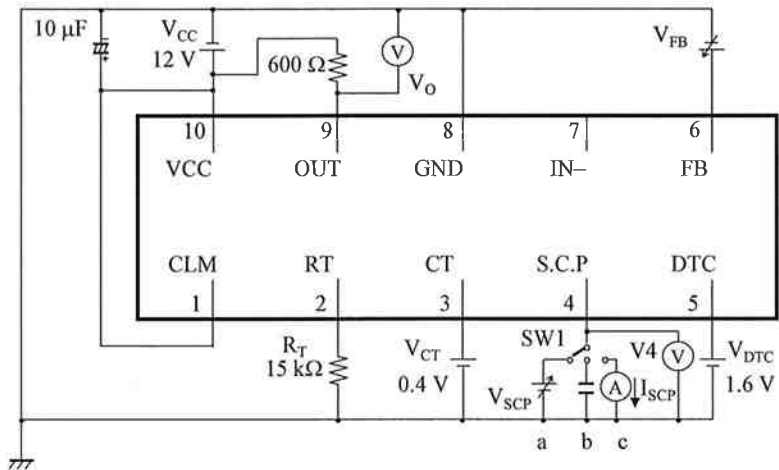
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■ Test Circuit Diagram (continued)

5. Test Circuit 5



6. Test Circuit 6



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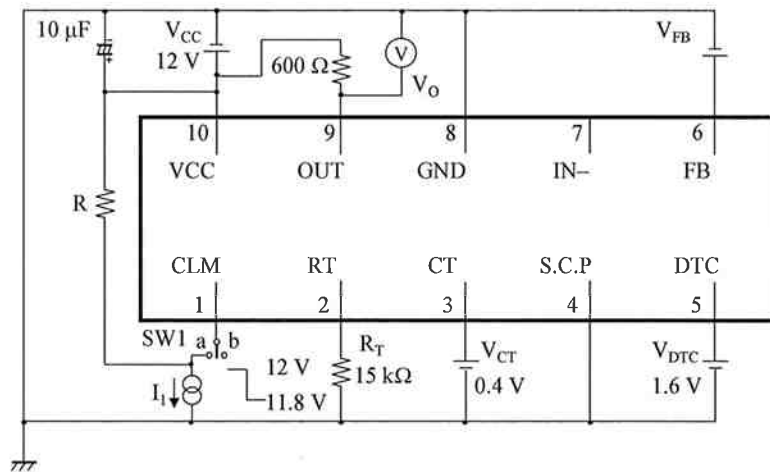
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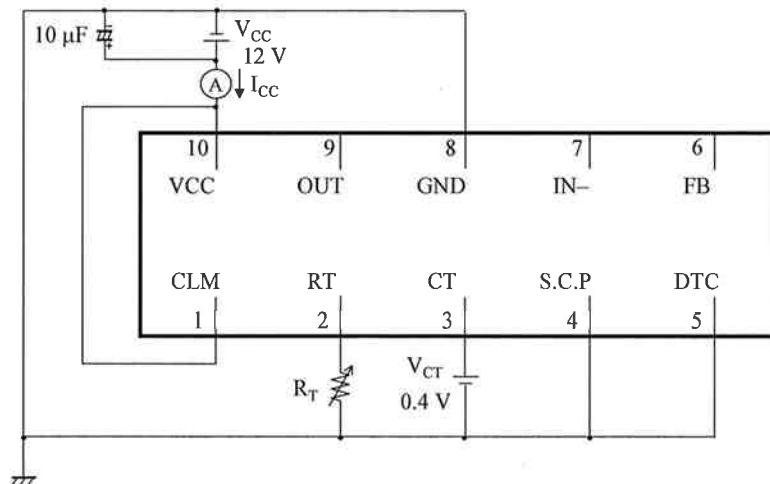
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■ Test Circuit Diagram (continued)

7. Test Circuit 7



8. Test Circuit 8



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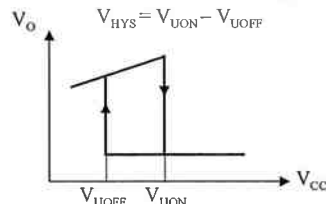
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## ■ Electrical Characteristics Test Procedures

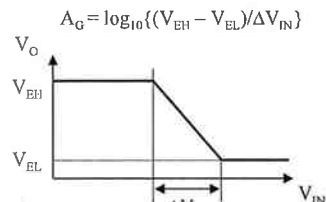
### 1. Test Circuit1

C No.	Parameter	Conditions	Measuring Method
1	U.V.L.O. start voltage	$V_{CT} = 0.3 \text{ V}$ , $V_{DTC} = 1.6 \text{ V}$ $V_{FB} = 1.6 \text{ V}$	Measure the $V_{CC}$ voltage when the $V_O$ changes from High to Low level while increasing the $V_{CC}$ voltage gradually.
2	Hysteresis width	$V_{CT} = 0.3 \text{ V}$ , $V_{DTC} = 1.6 \text{ V}$ $V_{FB} = 1.6 \text{ V}$	

### 2. Test Circuit2

C No.	Parameter	Conditions	Measuring Method
3	Input threshold voltage	$V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$	Measure the voltage of $V_{FB}$ .
4	Line regulation	$V_{CC} = 3.6 \text{ V to } 34 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$	Check the regulation of $V_{FB}$ .
21	Input threshold voltage temperature characteristics 1	$V_{CC} = 12 \text{ V}$ , $T_a = -30 \text{ to } 25^\circ\text{C}$	Check the regulation of $V_{FB}$ .
22	Input threshold voltage temperature characteristics 2	$V_{CC} = 12 \text{ V}$ , $T_a = 25 \text{ to } 85^\circ\text{C}$	Check the regulation of $V_{FB}$ .

### 3. Test Circuit3

C No.	Parameter	Conditions	Measuring Method
5	Input current	$SW1 = a$ , $V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$ $V_{IN} = 0.8 \text{ V}$	Measure the current of $I_B$ .
6	High-level output voltage	$SW1 = a$ , $V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$ $V_{IN} = 0.7 \text{ V}$	Measure the voltage of $V_O$ .
7	Low-level output voltage	$SW1 = a$ , $V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$ $V_{IN} = 0.8 \text{ V}$	Measure the voltage of $V_O$ .
23	Output sink current	$SW1 = b$ , $V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$ $V_{IN} = 0.8 \text{ V}$ , $V_{FB} = 0.9 \text{ V}$	Measure the current of $I_{FB}$ .
24	Output source current	$SW1 = b$ , $V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$ $V_{IN} = 0.7 \text{ V}$ , $V_{FB} = 0.9 \text{ V}$	Measure the current of $I_{FB}$ .
25	Open-loop gain	$SW1 = a$ , $V_{CC} = 12 \text{ V}$ , $V_{CT} = 0.4 \text{ V}$	

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■ Electrical Characteristics Test Procedures (continued)

4. Test Circuit4

C No.	Parameter	Conditions	Measuring Method
8	High-level input threshold voltage	SW1 = a, SW2 = a, V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V	Measure the voltage of V <sub>DTC</sub> when the output duty ratio = 100%.
9	Low-level input threshold voltage	SW1 = a, SW2 = a, V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V	Measure the voltage of V <sub>DTC</sub> when the output duty ratio = 0%.
10	Input current	SW1 = b, SW2 = a, V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, V <sub>DTC</sub> = 0.2 V	Measure the current of I <sub>DTC</sub> .
13	Output saturation voltage	SW1 = b, SW2 = b, V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, V <sub>DTC</sub> = 1.6 V	Measure the voltage of V <sub>O</sub> .
14	Output leak current	SW1 = b, SW2 = c, V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 0 V, V <sub>DTC</sub> = 0.2 V	Measure the current of I <sub>OLE</sub> .
30	RT pin voltage	SW1 = b, SW2 = a, V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 0 V, V <sub>DTC</sub> = 1.6 V	Measure the voltage of V <sub>RT</sub> .

5. Test Circuit5

C No.	Parameter	Conditions	Measuring Method
11	Output frequency	V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, R <sub>T</sub> = 15 kΩ, C <sub>T</sub> = 150 pF, R <sub>DTC</sub> = 91 kΩ	$f_{OUT} = \frac{1}{T}$ (kHz)
12	Output duty ratio	V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, R <sub>T</sub> = 15 kΩ, C <sub>T</sub> = 150 pF, R <sub>DTC</sub> = 91 kΩ	$D_U = \frac{t_{ON}}{T} \times 100 (\%)$
26	Maximum oscillation frequency	V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, R <sub>T</sub> = 15 kΩ, C <sub>T</sub> = 120 pF, R <sub>DTC</sub> = 33 kΩ	$f_{OUT} = \frac{1}{T}$ (kHz)
27	Frequency supply voltage characteristics	V <sub>CC</sub> = 3.6 V → 34 V, V <sub>FB</sub> = 1.6 V, R <sub>T</sub> = 15 kΩ, C <sub>T</sub> = 150 pF, R <sub>DTC</sub> = 91 kΩ	Check the regulation of f <sub>OUT</sub> .
28	Frequency temperature characteristics 1	V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, R <sub>T</sub> = 15 kΩ, C <sub>T</sub> = 150 pF, R <sub>DTC</sub> = 91 kΩ, T <sub>a</sub> = -30 to 25°C	Check the regulation of f <sub>OUT</sub> .
29	Frequency temperature characteristics 2	V <sub>CC</sub> = 12 V, V <sub>FB</sub> = 1.6 V, R <sub>T</sub> = 15 kΩ, C <sub>T</sub> = 150 pF, R <sub>DTC</sub> = 91 kΩ, T <sub>a</sub> = 25 to 85°C	Check the regulation of f <sub>OUT</sub> .

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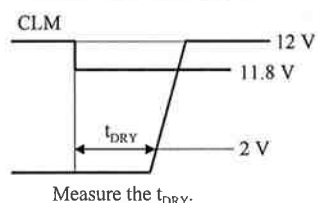
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■ Electrical Characteristics Test Procedures (continued)

6. Test Circuit6

C No.	Parameter	Conditions	Measuring Method
15	Input threshold voltage	SW1 = a, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$ , $V_{FB} = 1.6\text{ V}$	Measure the $V_{SCP}$ voltage when $V_O$ changes from low to high level while increasing the $V_{SCP}$ voltage gradually.
16	Input standby voltage	SW1 = b, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$ , $V_{FB} = 1.6\text{ V}$	Measure the voltage of $V_4$ .
17	Input latch voltage	SW1 = b, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$ , $V_{FB} = 2.0\text{ V}$	Measure the voltage of $V_4$ .
18	Charging current	SW1 = c, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$ , $V_{FB} = 2.0\text{ V}$	Measure the current of $I_{SCP}$ .
31	Comparator threshold voltage	SW1 = b, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$	Measure the $V_{FB}$ voltage when the $V_6$ changes from low to high level while increasing the $V_{FB}$ voltage gradually from 1.6 V.

7. Test Circuit7

C No.	Parameter	Conditions	Measuring Method
19	Threshold voltage	SW1 = a, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$ , $V_{FB} = 1.6\text{ V}$	Measure the $I_1$ current when the $V_O$ changes from low to high level while increasing the $I_1$ current gradually. $V_{CLM} = I_1 \cdot R$
32	Delay time	SW1 = b, $V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $V_{DTC} = 1.6\text{ V}$ , $V_{FB} = 1.6\text{ V}$	 <p>Measure the <math>t_{DRY}</math>.</p>

8. Test Circuit8

C No.	Parameter	Conditions	Measuring Method
20	Total consumption current 1	$V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $R_T = 15\text{ k}\Omega$	Measure the current of $I_{CC}$ .
33	Total consumption current 2	$V_{CC} = 12\text{ V}$ , $V_{CT} = 0.4\text{ V}$ $R_T = 5.1\text{ k}\Omega$	Measure the current of $I_{CC}$ .

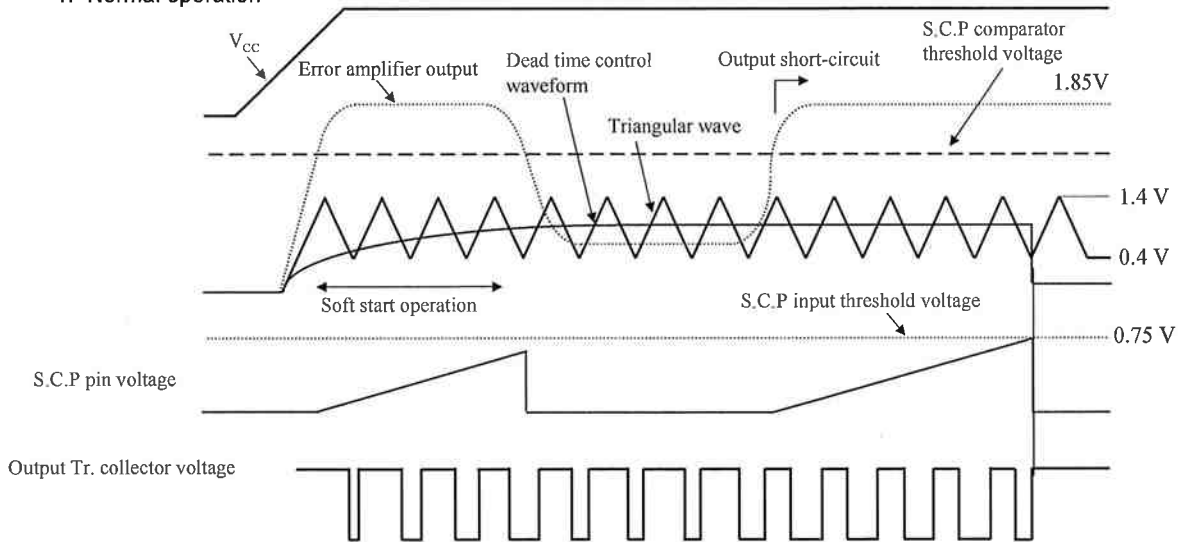
2006-08-24		
Established	Revised	



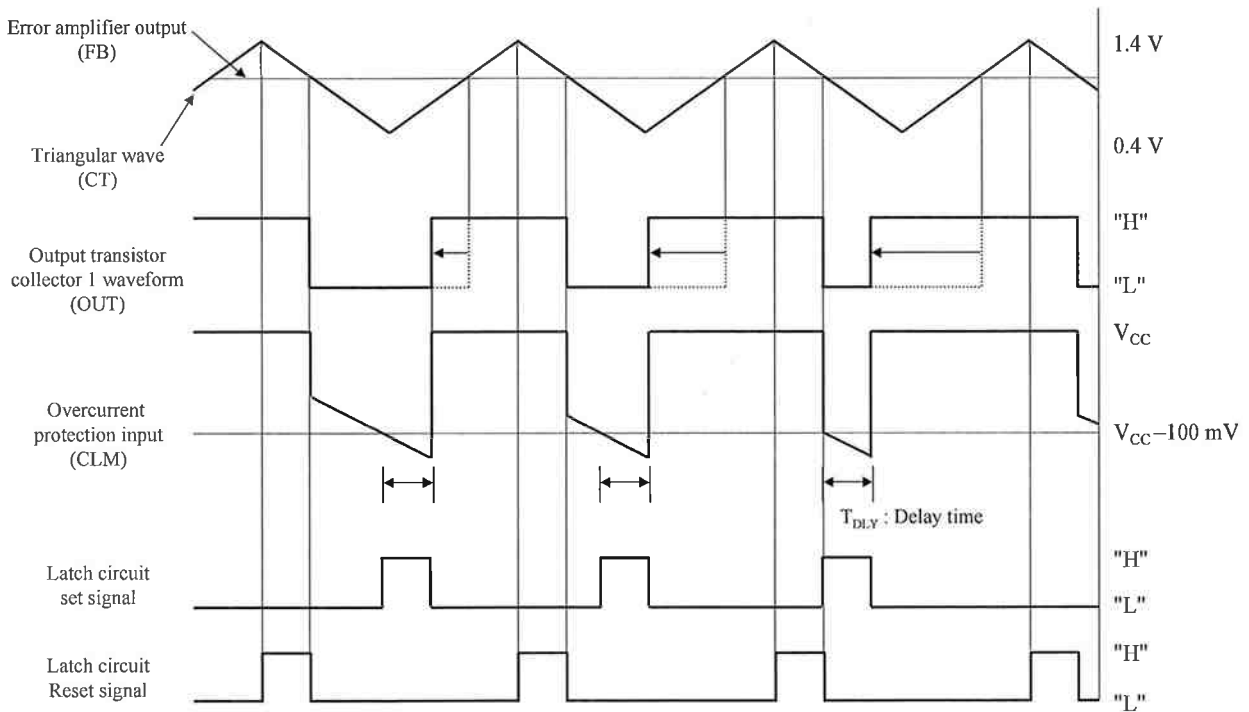
■ Technical Data

• Timing chart

1. Normal operation



2. Overcurrent protection operation



2006-08-24		
Established	Revised	

210801301706070

Semiconductor Company, Matsushita Electric Industrial Co., Ltd.

# PACKAGE STANDARDS

Package Code

SSOP010-P-0225A

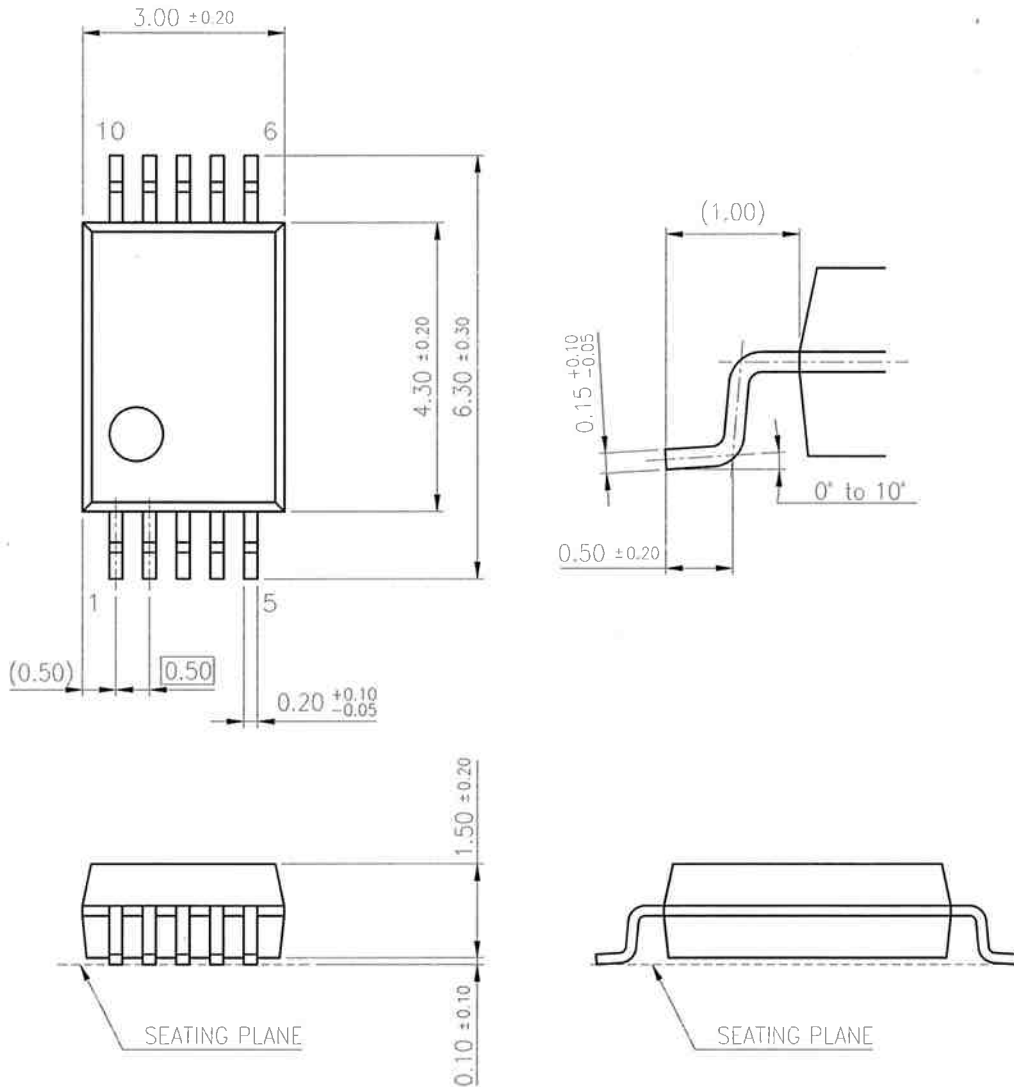
Semiconductor Company  
Matsushita Electric Industrial Co., Ltd.

Established by	Applied by	Checked by	Prepared by
K.Komichi	H.Yoshida	M.Okajima	M.Itoh

	<b>PACKAGE STANDARDS</b> SSOP010-P-0225A		
		Total Pages	Page
		6	2

1. Outline Drawing

Unit:mm



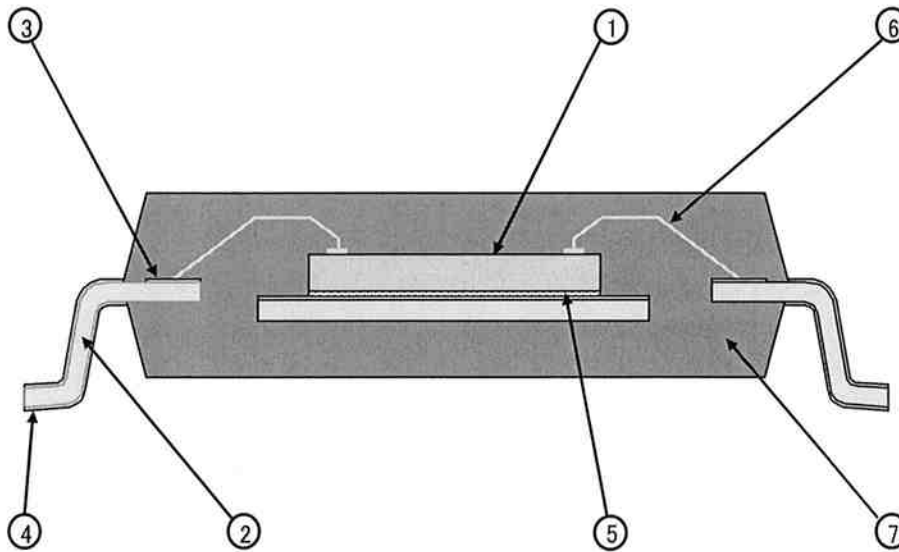
Weight	: 43 mg
Body Material	: Epoxy Resin
Lead Material	: Cu Alloy
Lead Finish Method	: SnBi Plating

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	<b>PACKAGE STANDARDS</b> <b>SSOP010-P-0225A</b>		
		Total Pages	Page
		6	3

2. Package Structure (Technical Report)

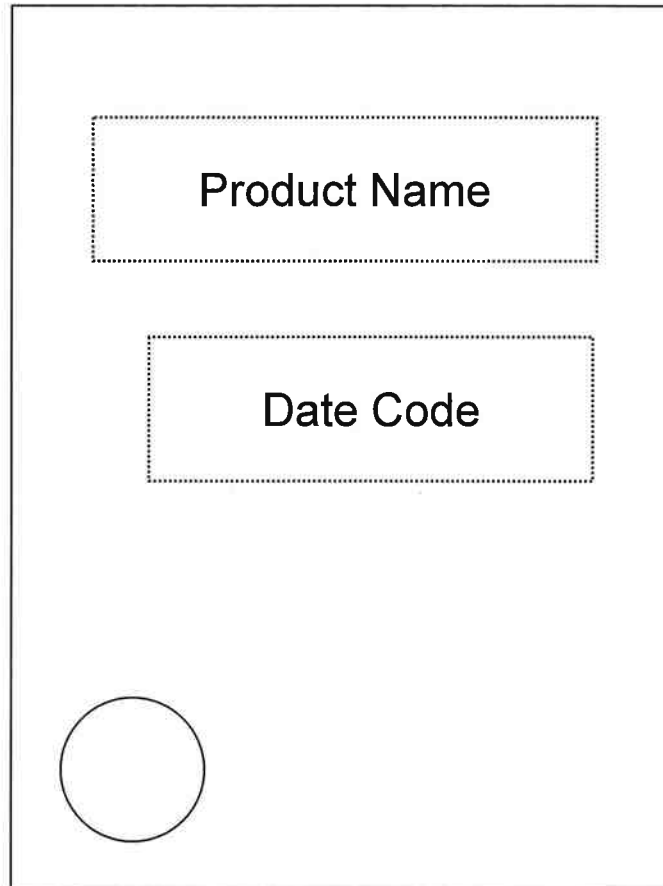
Chip Material	Si	①	
Leadframe material	Cu alloy	②	
Inner lead surface	Ag plating	③	
Outer lead surface	SnBi plating	④	
Chip mount	Method	Resin adhesive method	⑤
	Material	Adhesive material	
Wirebond	Method	Thermo-compression bonding	⑥
	Material	Au	
Molding	Method	Multiplunger molding	⑦
	Material	Epoxy resin	



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	<b>PACKAGE STANDARDS</b> <b>SSOP010-P-0225A</b>		
		Total Pages	Page
		6	4

3. Mark Drawing

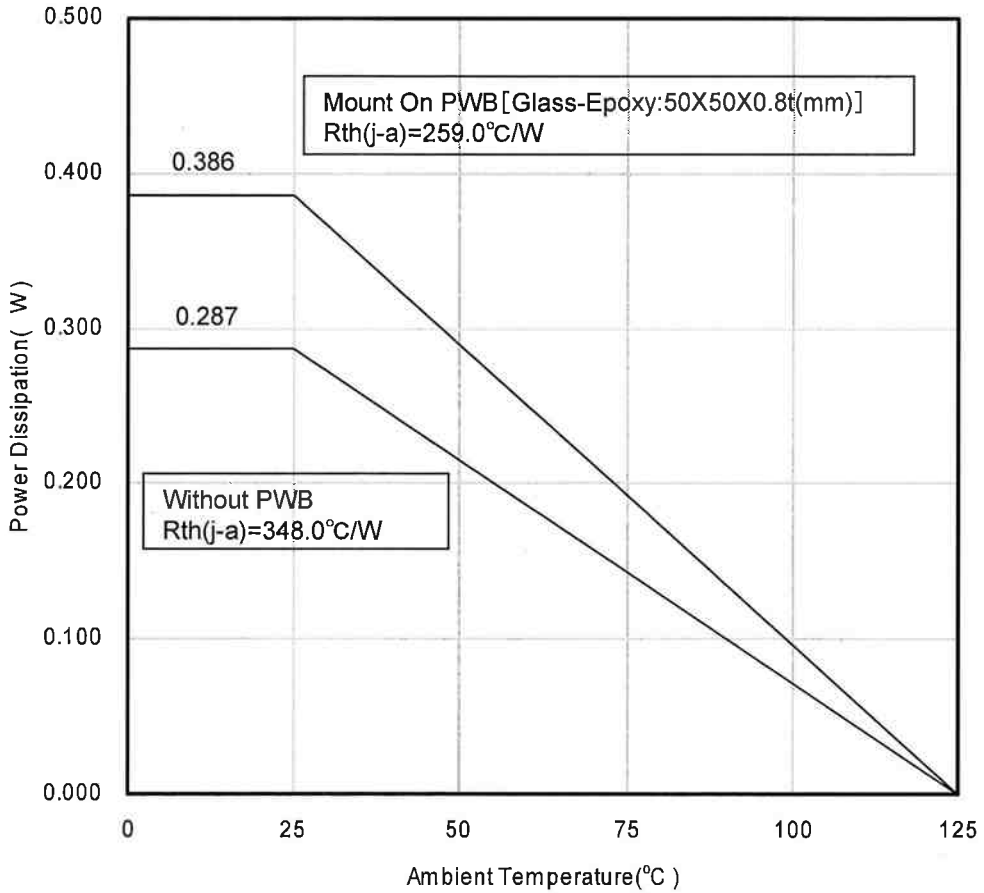


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	<b>PACKAGE STANDARDS</b> <b>SSOP010-P-0225A</b>		
		Total Pages	Page
		6	5

4. Power Dissipation (Technical Report)



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### 5. Power Dissipation (Supplementary Explanation)

**[Experiment environment]**

Power Dissipation (Technical Report) is a result in the experiment environment of SEMI standard conformity. (Ambient air temperature (Ta) is 25 degrees C)

**[Supplementary information of PWB to be used for measurement]**

The supplement of PWB information for Power Dissipation data (Technical Report) are shown below.

Indication	Total Layer	Resin Material
Glass-Epoxy	1-layer	FR-4
4-layer	4-layer	FR-4

**[Notes about Power Dissipation (Thermal Resistance) ]**

Power Dissipation values (Thermal Resistance) depend on the conditions of the surroundings, such as specification of PWB and a mounting condition , and a ambient temperature. (Power Dissipation (Thermal Resistance) is not a fixed value.)

The Power Dissipation value (Technical Report) is the experiment result in specific conditions (evaluation environment of SEMI standard conformity) ,and keep in mind that Power Dissipation values (Thermal resistance) depend on circumference conditions and also change.

**[Definition of each temperature and thermal resistance]**

Ta : Ambient air temperature

※The temperature of the air is defined at the position where the convection, radiation, etc. don't affect the temperature value, and it's separated from the heating elements.

Tc : It's the temperature near the center of a package surface. The package surface is defined at the opposite side if the PWB.

Tj : Semiconductor element surface temperature (Junction temperature.)

Rth(j-c) : The thermal resistance (difference of temperature of per 1 Watts) between a semiconductor element junction part and the package surface

Rth(c-a) : The thermal resistance (difference of temperature of per 1 Watts) between the package surface and the ambient air

Rth(j-a) : The thermal resistance (difference of temperature of per 1 Watts) between a semiconductor element junction part and the ambient air

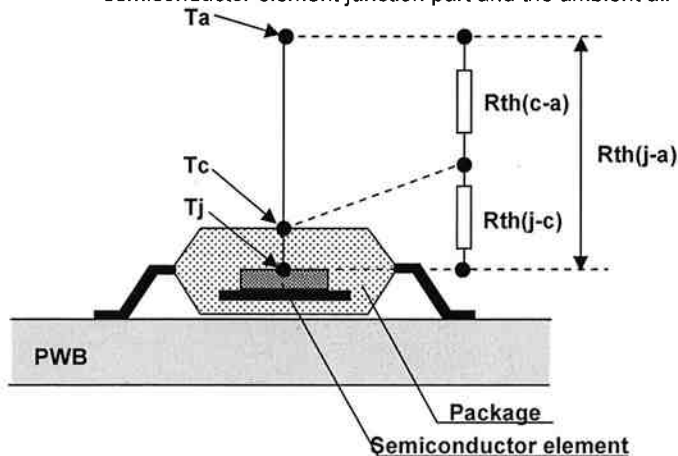


Fig1. Definition image

**[Definition formula]**

$$Tj = \{Rth(j-c) + Rth(c-a)\} \times P + Ta$$

$$= Rth(j-a) \times P + Ta$$

$$Rth(j-c) = \frac{Tj - Tc}{P} \quad (^\circ C/W)$$

$$Rth(c-a) = \frac{Tc - Ta}{P} \quad (^\circ C/W)$$

$$Rth(j-a) = \frac{Tj - Ta}{P} \quad (^\circ C/W)$$

$$= Rth(j-c) + Rth(c-a)$$

P: power(W)

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