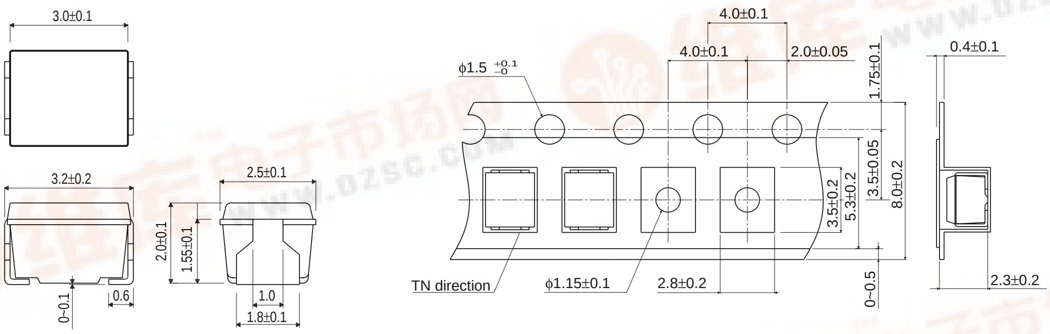
ICP-S Technical Manual

ICP-S

1. Overview

The ICP-S is an IC protector of surface mounting type developed as an element for the protection of ICs from output short-circuiting damage. The internal resistance of this lightweight, compact overcurrent protection element is low, as long as the steady-state current of the element does not exceed the rated DC or AC current. The ICP-S, however, turns off ICs instantly if the steady-state current reaches or exceeds the breaking current of the ICP-S.

2. External Dimensions (Unit: mm)



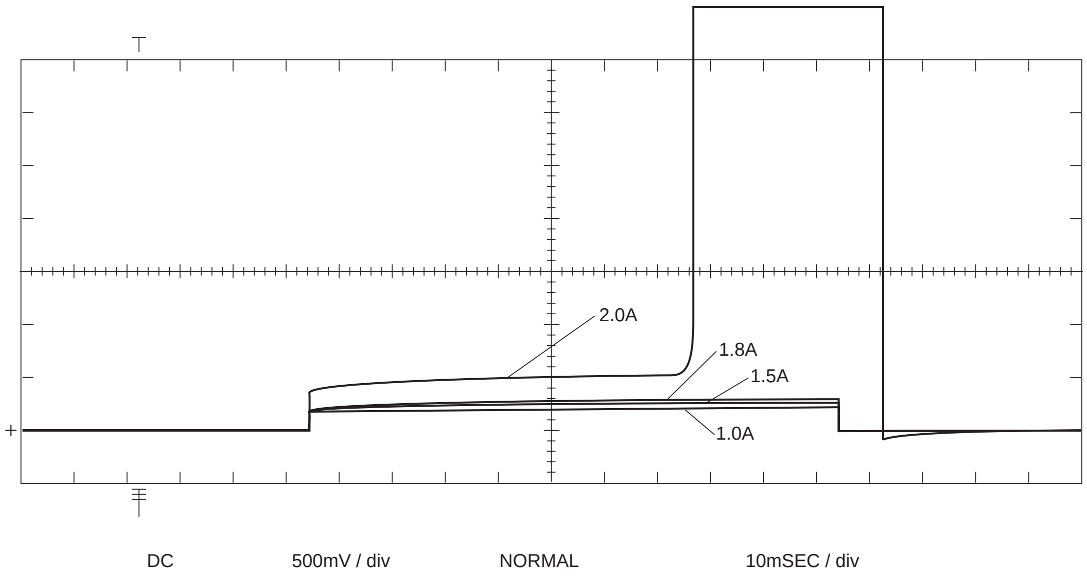
(Mark: TN)

3. Features

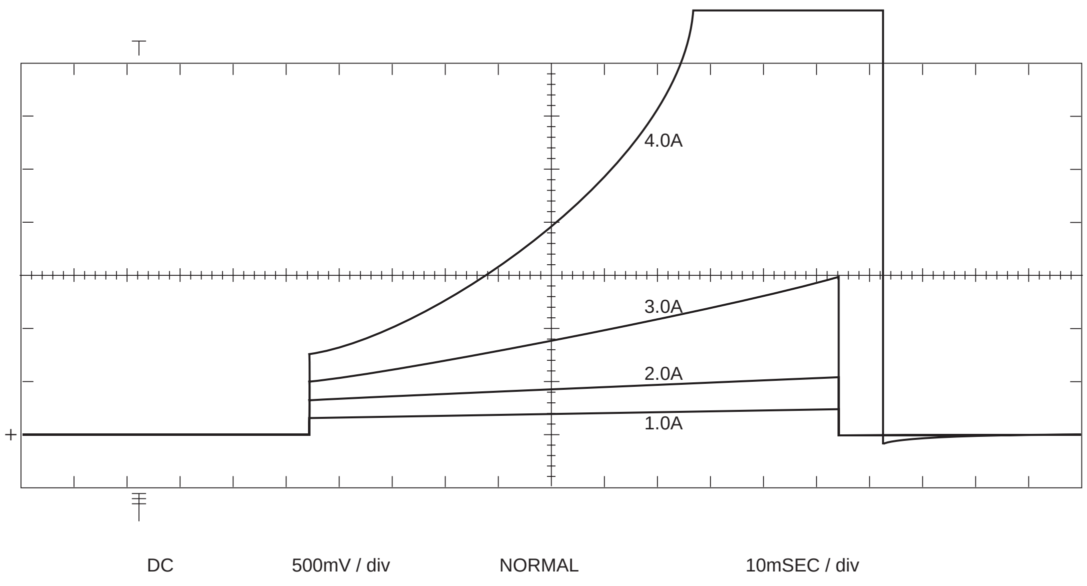
1) Instantly breaks currents with a low potential drop. (See 3-1 Potential Drop Comparison)
2) Compact surface-mounting model. (See 2. External Dimensions)
3) Unlike fuses, there is no steady-state current reduction with the rated current applied. No derating is necessary.
4) Minimal breaking point dispersion. (See the graph in 3-2 Breaking Current Dispersion Characteristics)
5) Excellent temperature characteristics (See the graphs in 3-3 Temperature Characteristics)
   - The fluctuation of the breaking current caused by temperature changes is minimal.
   - Wide operating temperature range: –55°C to +125°C
6) Excellent vibration resistance.
7) UL-approved product with certification No. 107856.
8) No deterioration or circuit breaking caused by static electricity.

3-1 Potential Drop Comparison (ICP-S VS Fuse)

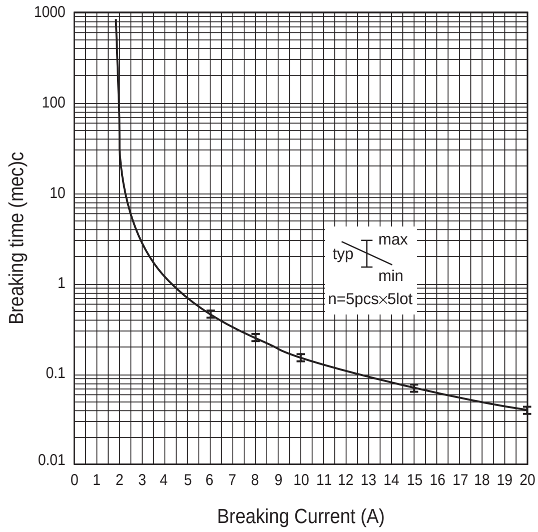
ICP-S1.0 (Rated Current: 1 A)



Fuse (Rated Current: 1 A)

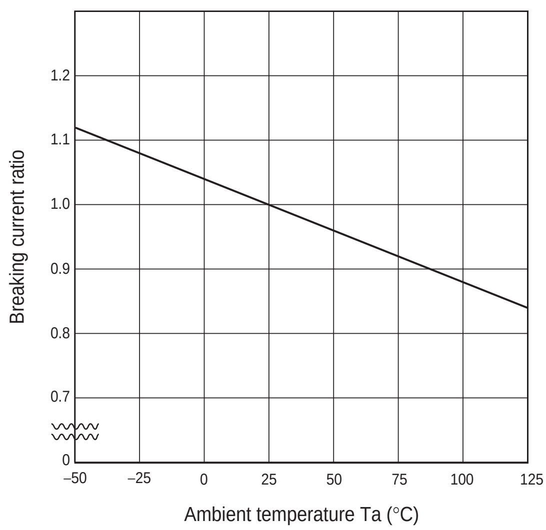


3-2 Breaking Current Dispersion Characteristics

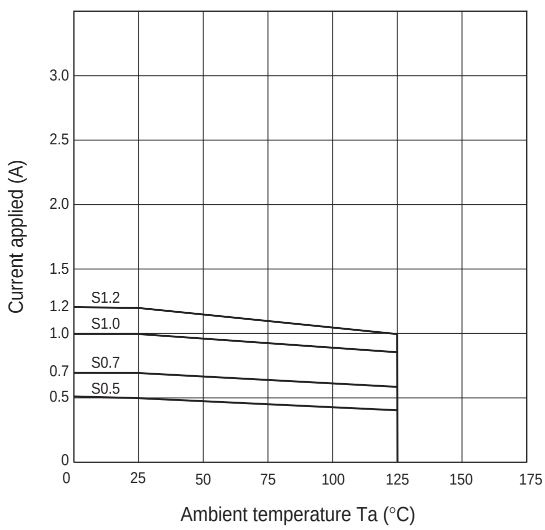


Breaking Time (Reference) Effective Value and Dispersion Data (ICP-S1.0)

3-3 Temperature Characteristics

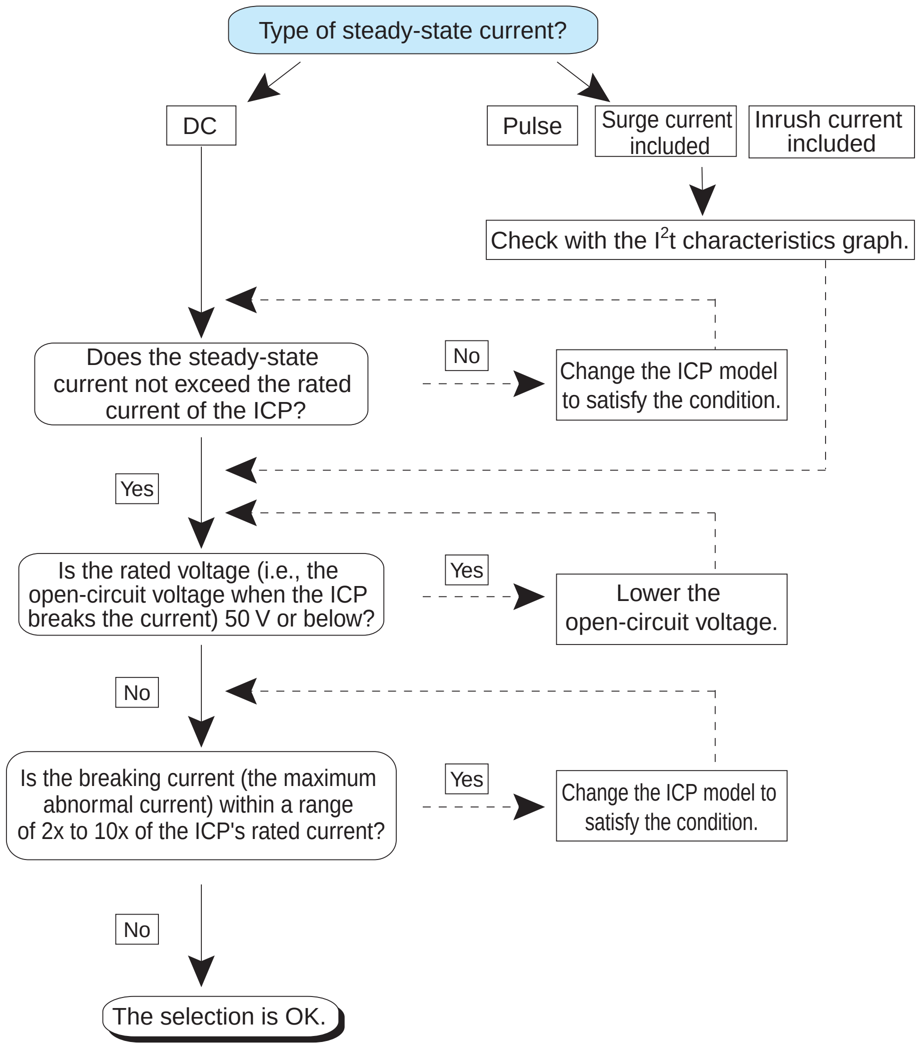


Breaking Current vs.
Ambient Temperature Characteristics (ICP-S)



Rated Current Derating Curve (ICP-S)

4. Selection Flowchart



List of ICP-S Models

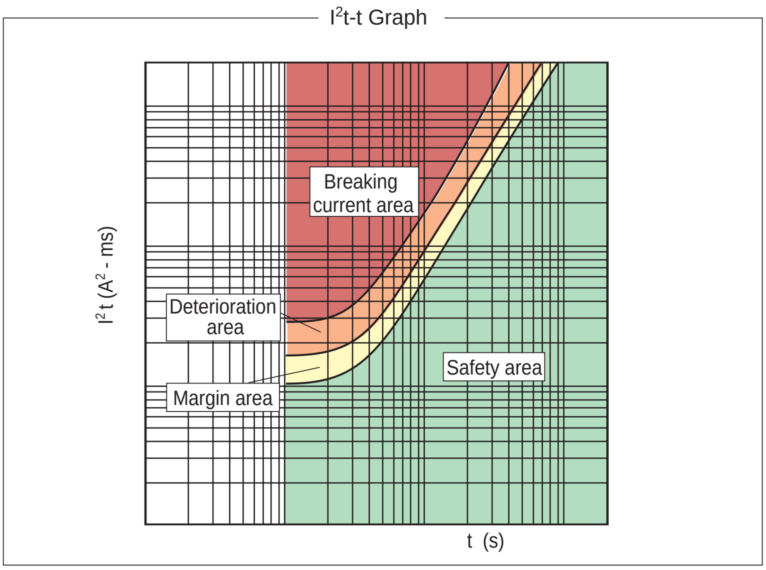
TYPE	Rated current (A)	Breaking current (A)
ICP-S0.5	0.5	1.0 to 5.0
ICP-S0.7	0.7	1.4 to 7.0
ICP-S1.0	1.0	2.0 to 10.0
ICP-S1.2	1.2	2.4 to 12.0

The I^2t-t characteristic graph (i.e., the Joule integral sheet) provides necessary data used to check how the life of the ICP-S is influenced by heat cycling or mechanical fatigue caused by repetitive current pulses.

5. Checks with I^2t-tCharacteristic Graph

If the steady-state current includes a pulse, surge, or inrush-current, use the I^2t graph and check that the ICP will not deteriorate regardless of the mode of the current or the ICP will not break the steady-state current while the ICP is in operation.

I^2t-t Graph



Breaking current area: The ICP breaks the current in this area.

Deterioration area: Although the ICP does not break the current instantaneously, the ICP may break the current as a result of ICP deterioration.

Marginal area: The area where the risk of ICP deterioration is low. Basically avoid using this area.

Safety area: The ICP will not deteriorate or break the current.

Precautions

• Even though the Joule integral value of the current wave form designed at your end is within the safety area, it is recommended that you confirm the steady-state current for the safety of the components

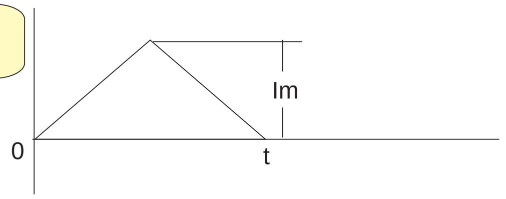
Refer to the next section, calculate the I^2t value, and check the position of the I2t value in the graph. If the value is in the safety area, it is okay to use the selected ICP model. If the value is, however, beyond the safety area, use an ICP model with higher ratings.

• Note: The inspection and selection of the ICP according to the Joule integral value is absolutely based on the results of the approximation of the current wave form.
Be sure to inspect all the current wave forms of your application, or otherwise the safety of the application will not be fully ensured.
• Consider a safety margin with the dispersion of component characteristics taken into calculation when inspecting and selecting the ICP, if it is impossible to check the worst current wave form.

6. I^2t Calculation of a Variety of Wave forms

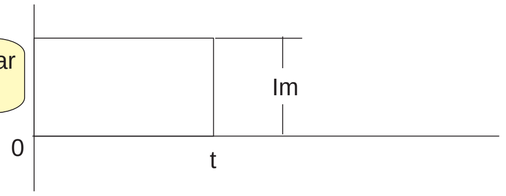
If the steady-state current includes a pulse, surge, or inrush current, calculate the I^2t of the wave form of the current. The following graphs and formulas show how to calculate a variety of wave forms.

1) Triangular wave form



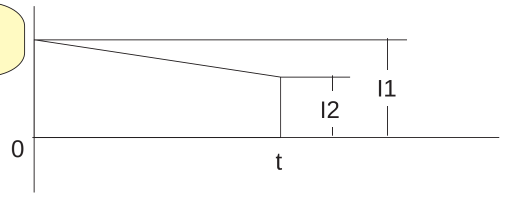
$$I^2t = \frac{1}{3} Im^2t$$

2) Rectangular wave form



$$I^2t = Im^2t$$

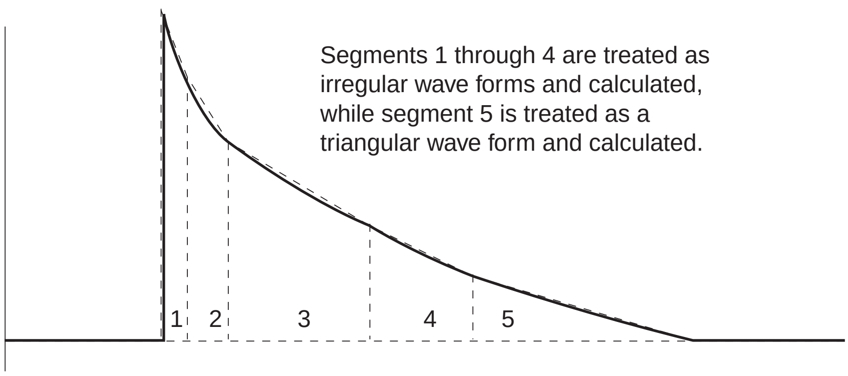
3) Irregular wave form



$$I^2t = I_1I_2t + \frac{1}{3}(I_1 - I_2)^2t$$

4) Charged or discharged wave form

- The charged wave form is segmented as shown below. The Joule heat generated during each segmented period is plotted onto a Joule integral sheet.



7. ICP-S Test Example

7-1 Example 1

Current mode: DC

Model: ICP-S1.0

Wave form:
DC 1A
2A
5A

Test:

The current values of all segmented periods are plotted respectively as shown in attached graph 1.

1 A: The steady-state current is in the safety area where the ICP-S will not deteriorate or break the current.

2 A: The ICP-S will break the steady-state current in the breaking current area in approximately 100 ms.

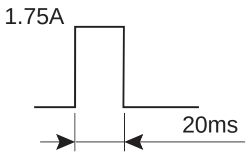
5 A: The ICP-S will break the steady-state current in the breaking current area in approximately 0.7 ms.

7-2 Example 2

Current mode: A single pulse

Model: ICP-S1.0

Wave form: A current of 1.75 A flows for a period of 20 ms.



Results: The steady-state current is in the critical area. If the single pulse is repeated intermittently, the ICP-S will deteriorate or break the current in the end.

Test:

With pulse current: $I^2t = 1.75^2 \times 20$

$= 61\ (A^2 \cdot ms)$ at 20ms (See graph 2)

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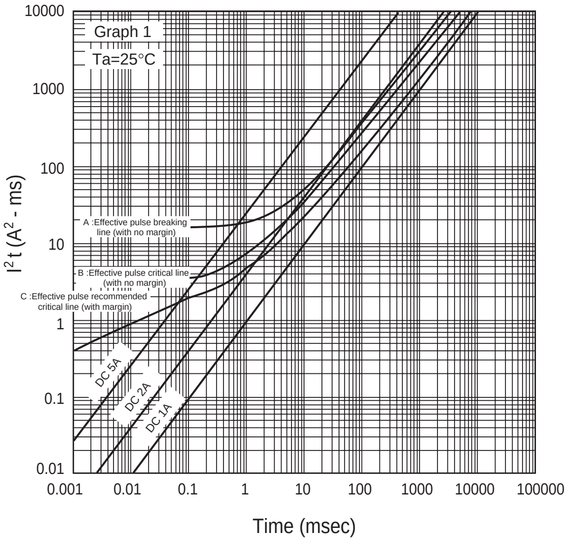
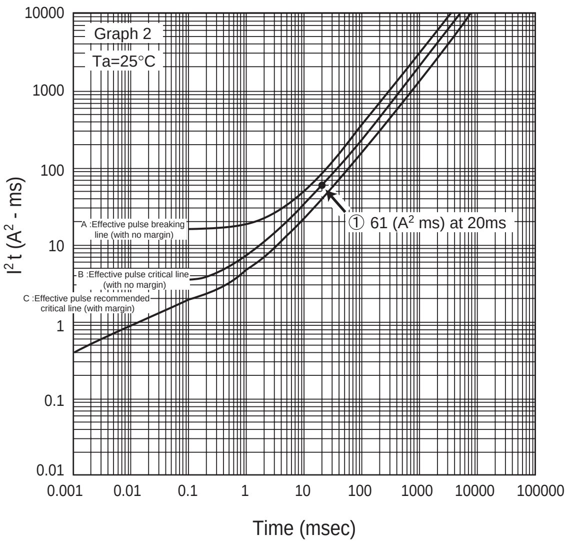


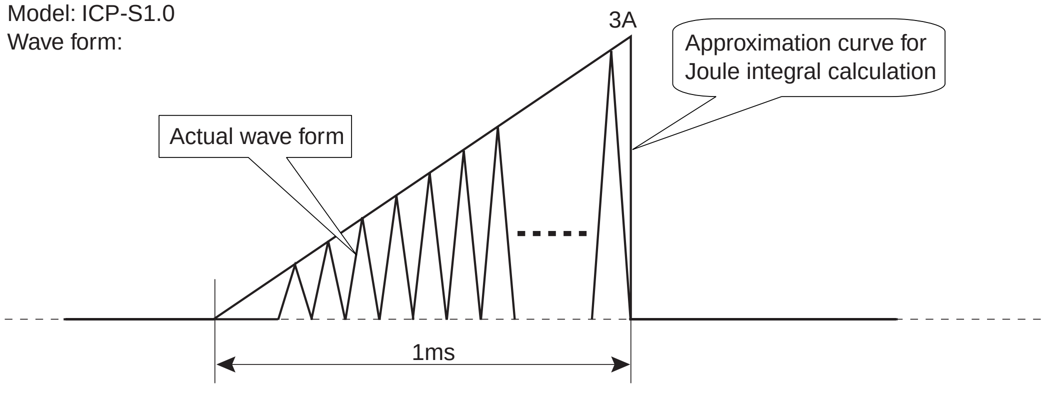
I^2 t-t Characteristic Curve (ICP-S1.0)



I^2 t-t Characteristic Curve (ICP-S1.0)

Joule Integral Calculation of Irregularly Increasing or Decreasing Current

Current mode: Irregular triangular wave form
Model: ICP-S1.0
Wave form:

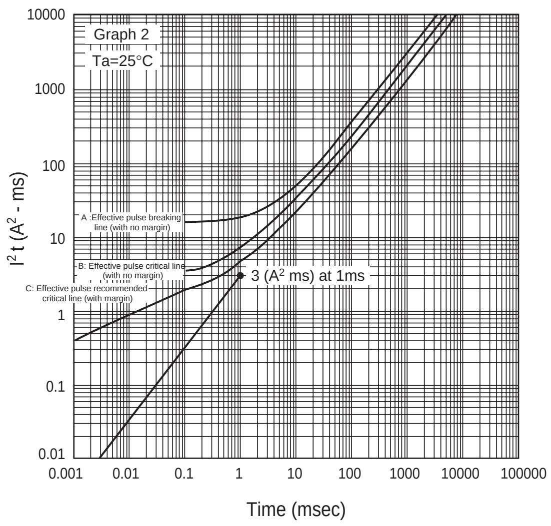


Wave form approximation: The above wave form is approximated by electrically calculating the Joule integral of each segment of the current wave form. In consideration of the heat cycling and mechanical fatigue of the ICP-S, however, a practical Joule integral value is calculated from an approximation curve obtained by connecting the peak of each current wave form.

Test: Obtain the approximated value by substituting the values into the formula (triangular wave form $I^2t = 1/3 \cdot Im^2 \cdot t$).

$$I^2t = 1/3 \times 3^2 A \times 1ms = 3\ (A^2 \cdot ms)$$

Plotting test:

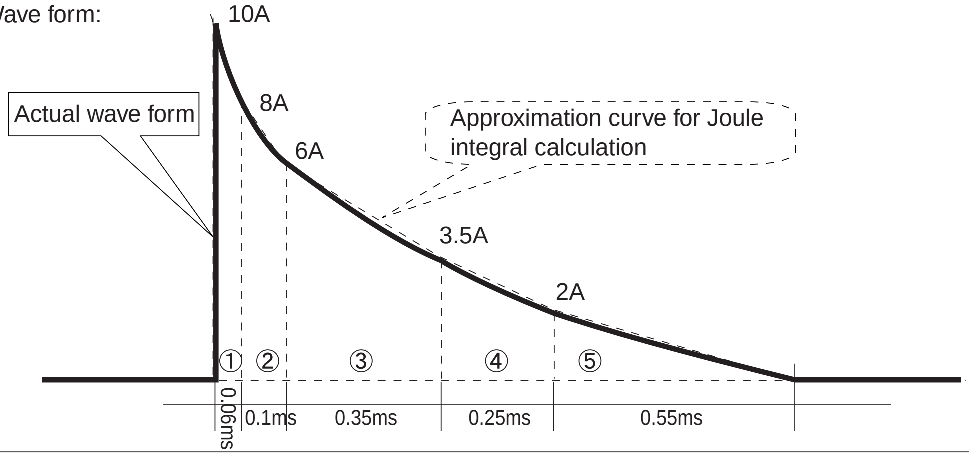


I^2t-t Characteristic Curve (ICP-S1.0)

Test results: The steady-state current does not exceed line C. Therefore, it is considered that the ICP-S will not deteriorate or break the current.

Joule Integral Calculation of Irregularly Increasing or Decreasing Current

Current mode: Irregular wave form + triangular wave form
Model: ICP-S1.2
Wave form:

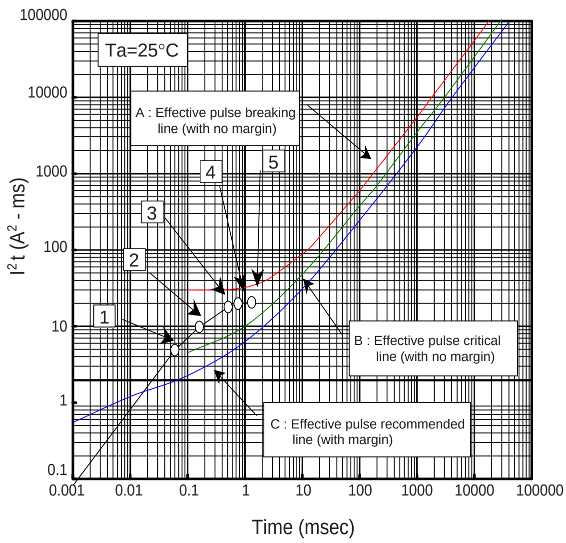


Wave form approximation: The above wave form (electric charge wave form) is approximated as an irregular wave form to calculate the Joule integral of the wave form.

Test:

Item No.	Peak current Im (A)	Segmented period t (ms)	Joule integral Formula Coefficient × Im² × t A² · ms)		Accumu-lation (A² · ms)	Lapsed time (ms)
1	10	0.06	$10 \times 8 \times 0.06 + 1/3 \times (10-8)^2 \times 0.06 =$	4.88	4.88	0.06
2	8	0.1	$8 \times 6 \times 0.1 + 1/3 \times (8-6)^2 \times 0.1 =$	4.93	9.81	0.16
3	6	0.35	$6 \times 3.5 \times 0.35 + 1/3 \times (6-3.5)^2 \times 0.35 =$	8.07	17.88	0.51
4	3.5	0.25	$3.5 \times 2 \times 0.25 + 1/3 \times (3.5-2)^2 \times 0.25 =$	1.93	19.81	0.76
5	2	0.55	$1/3 \times (2)^2 \times 0.55 =$	0.73	20.54	1.31

Plotting test:

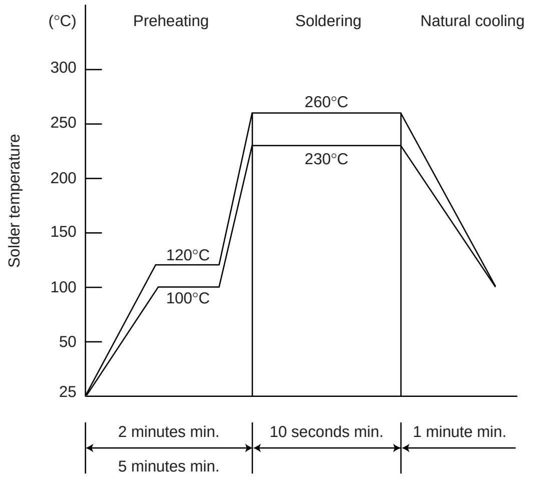


I^2 t-t Characteristic Curve (ICP-S1.2)

Test results: The steady-state current is between lines B and A. Therefore, it is considered that the ICP-S will deteriorate or break the current due to the repetitive pulses.

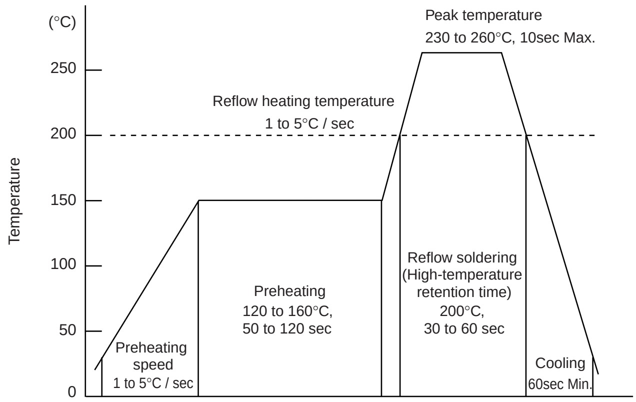
8. Application Circuit Example

8-1 Recommended Flow Soldering Conditions



Manual soldering conditions
Soldering iron temperature: 350°C max.
Soldering time: 3 seconds max.

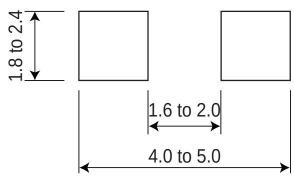
8-2 Recommended Reflow Soldering Conditions



* Number of reflow times: 2 TIMES Max.

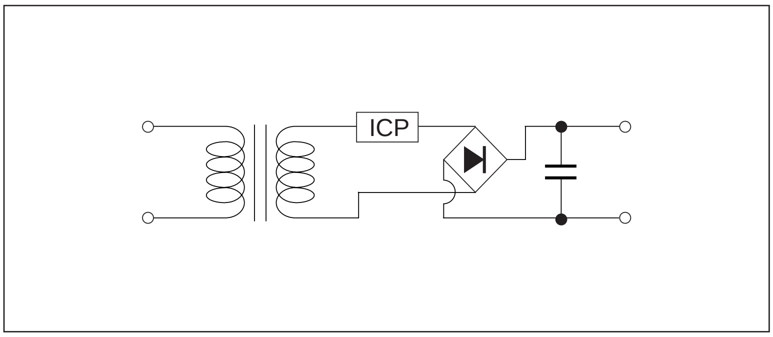
A peak temperature of at least 230°C is recommended. If the peak temperature is less than 230°C, it is recommended to make some adjustments, such as the retention of the peak temperature and soldering time longer and an increase in the thickness of solder paste.

8-3 Recommended Copper Pattern on PCB

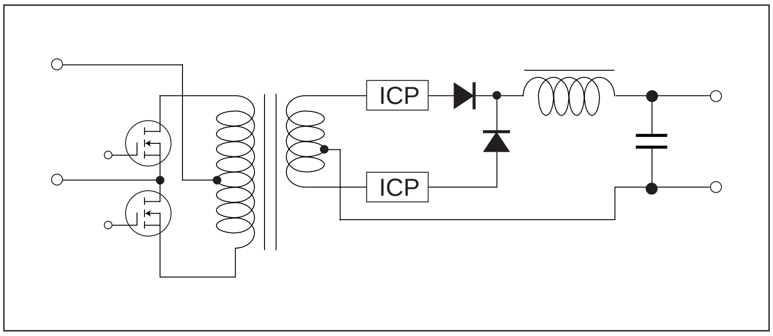


9. Application Circuit Examples

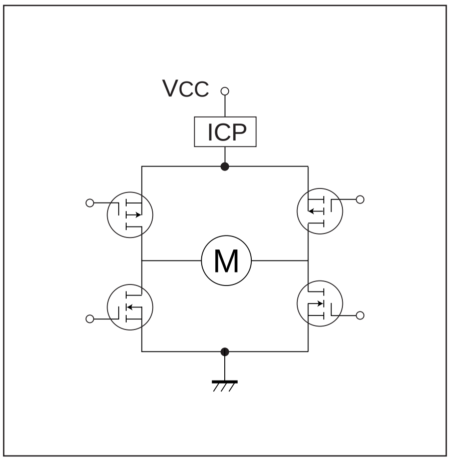
9-1 Power Supply Circuit



9-2 DC-DC Converter

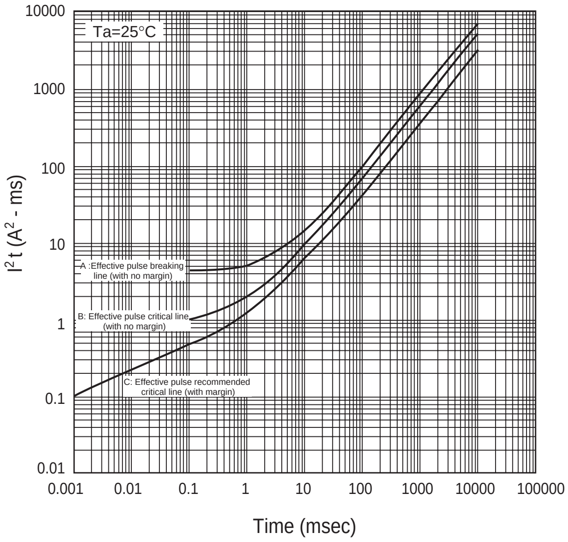


9-3 Motor Control

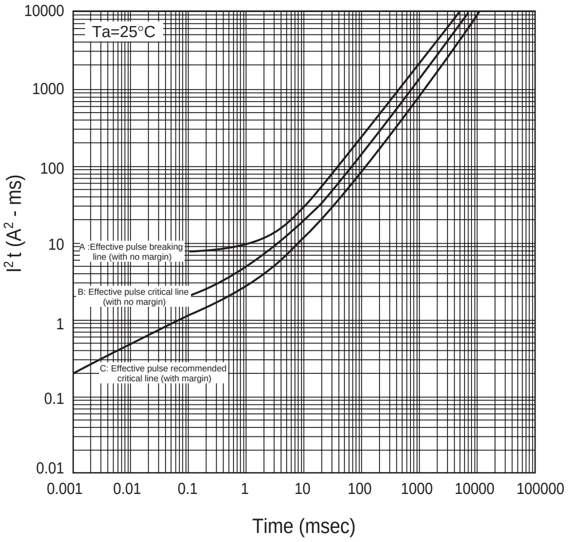


10. Precautions

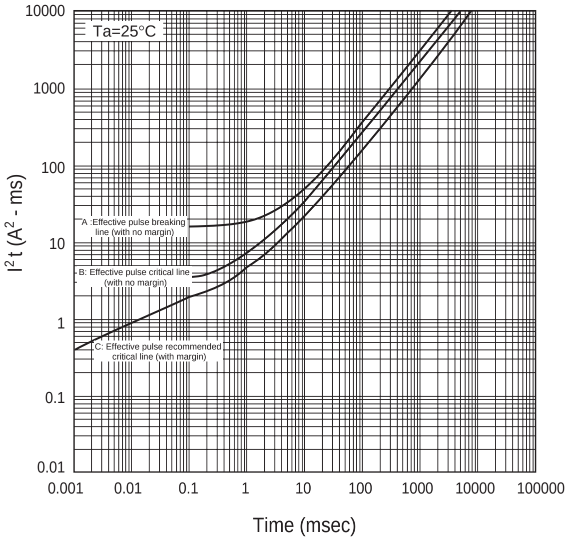
1. Set the breaking current two to ten times as high as the rated current.
   Use the ICP-S so that the open-circuit voltage between the terminals after the ICP-S breaks the current will be a maximum of 50 V. Unless the ICP-S is used under these conditions, the mold may be damaged or internal resistance may remain after the ICP-S breaks the current.
2. Do not use the ICP-S for the primary side of commercial power supply, or otherwise the mold may be damaged by arcing after the ICP-S breaks the current.



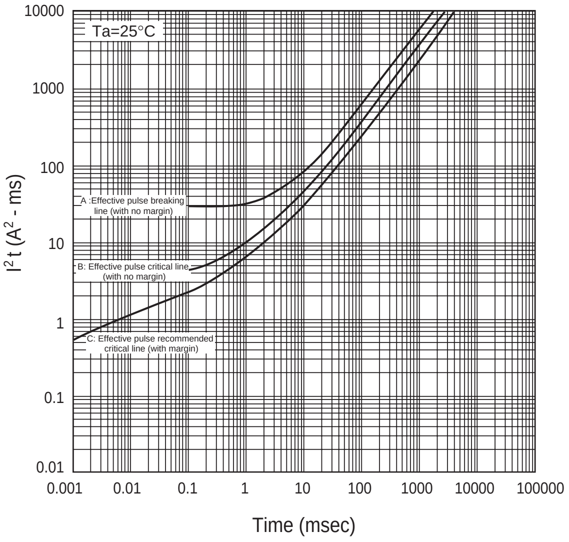
I^2 t-t Characteristic Curve (ICP-S0.5)



I^2 t-t Characteristic Curve (ICP-S0.7)



I^2 t-t Characteristic Curve (ICP-S1.0)



I^2 t-t Characteristic Curve (ICP-S1.2)

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