TOSHIBA

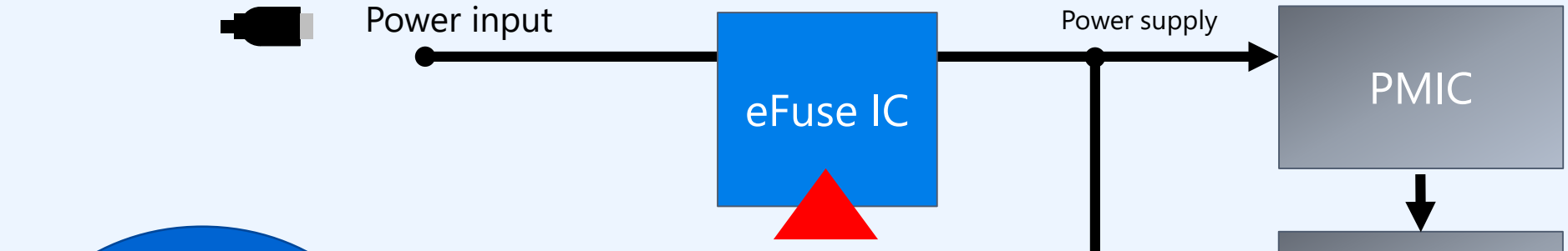
e-Learning

Basics of eFuse ICs

Toshiba Electronic Devices & Storage Corporation

What is the semi-conductor fuse eFuse IC?

Reusable fuse IC made of semiconductor.



Abundant Function

- Short-circuit protection
- Overcurrent protection
- Overvoltage(clamp) protection
- Inrush current suppression function (Slew Rate control function)
- Reverse current blocking (Option)
- Thermal shutdown
- IEC62368-1(G9)

The eFuse IC has a high-performance, high-precision protection function built into one package, which is not found in conventional fuses.
It can be used repeatedly, reducing maintenance costs and recovery time for repairs.

What is the semi-conductor fuse eFuse IC?

This is the product lineup list.
We plan to expand our lineup of products with a wide range of input voltage and packages in the future.

Product name	Input voltage Range	Limiting current range	Overvoltage Protection	Slew Rate Control	EN control	Return operation	Flag Function	Auto Discharge	Package
TCKE805NA	4.4V~18V	0.5A~5.0A Adjustable	6.04V OVC	Adjustable	Active High	Auto trie	None	Y	WSON10B 3x3mm
TCKE805NL	4.4V~18V	0.5A~5.0A Adjustable	6.04V OVC	Adjustable	Active High	Latch	None	Y	WSON10B 3x3mm
TCKE812NA	4.4V~18V	0.5A~5.0A Adjustable	15.1V OVC	Adjustable	Active High	Auto trie	None	Y	WSON10B 3x3mm
TCKE812NL	4.4V~18V	0.5A~5.0A Adjustable	15.1V OVC	Adjustable	Active High	Latch	None	Y	WSON10B 3x3mm
TCKE800NA	4.4V~18V	0.5A~5.0A Adjustable	None	Adjustable	Active High	Auto trie	None	Y	WSON10B 3x3mm
TCKE800NL	4.4V~18V	0.5A~5.0A Adjustable	None	Adjustable	Active High	Latch	None	Y	WSON10B 3x3mm
TCKE712BNL	4.4V~13.2V	0.51A~3.65A Adjustable	Adjustable	Adjustable	Active High	Latch	Yes	N	WSON10 3x3mm

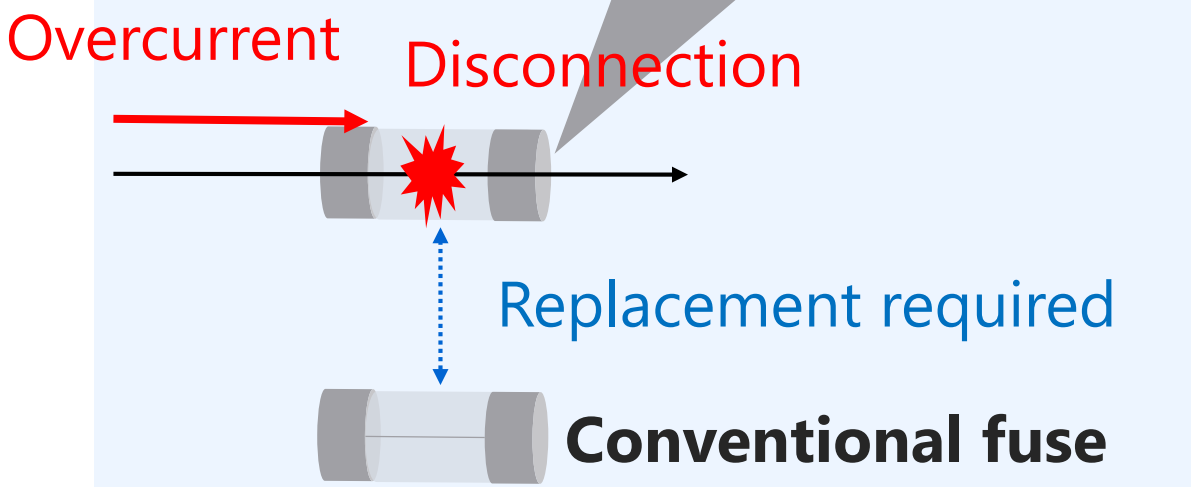
Auto retry : Automatically eFuse IC recovers after TSD (Thermal shutdown).
Latched : After TSD, eFuse IC recovers by setting the control signal to High again.

Advantages of Semiconductor-fuse eFuse IC (1)

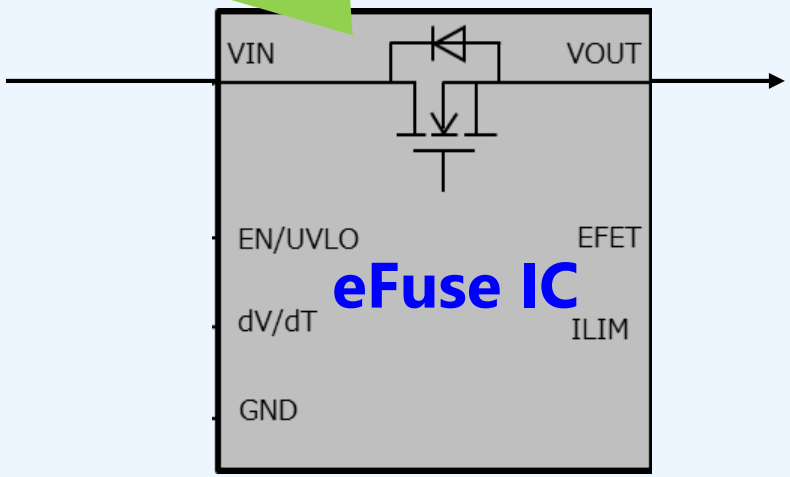
eFuse IC can be used repeatedly

Features

Thermal cutting
Breakage at one time



Can be used repeatedly in semiconductor control



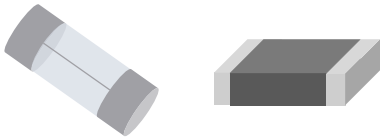
Conventional glass tube fuses and chip fuses have a structure that stops the current by melting the internal metal with heat when an overcurrent occurs and then breaking the wire.
Therefore, it will be broken at one time, and parts replacement, etc. must be carried out in order to operate it again.
On the other hand, eFuse IC shown on the right can be used repeatedly because the current is detected with high accuracy by the internal overcurrent circuitry to stop the internal MOSFET from being turned off.

Advantages of Semiconductor-fuse eFuse IC (2)

Compared with conventional fuses, eFuse IC has superior protective performance

Glass tube Fuse

Tip Fuse

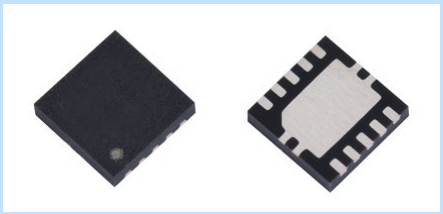


Blown by a single error

Poly Fuse

With repeatable use
Excessive current accuracy is poor.

Can be used repeatedly
eFuse IC



Short Circuit Protection
Overcurrent protection
Overvoltage protection
Rush current suppression
Thermal shutdown
Reverse current blocking (option)

	Glass tube Fuse	Tip Fuse	Poly Fuse	Semiconductor fuse: eFuse IC
Repeatability	-	-	✓	✓ ✓ ✓
Overcurrent protection Speed and accuracy	-	-	-	✓ ✓ ✓
Other protection functions	-	-	-	✓ ✓ ✓
Effect of ambient temperature	-	-	-	✓ ✓ ✓
Single unit mounting area	-	✓ ✓	-	✓
Including protection circuit Total mounting area	-	-	-	✓ ✓ ✓
Cost of individual parts	✓	✓ ✓	-	✓
Function and maintenance Including total costs	-	-	-	✓ ✓ ✓

Advantages of Semiconductor-fuse eFuse IC (3)

Simplify to acquire IEC62368-1 certification with eFuse IC

~2022/12

IEC60950-1

Safety Standards for Information and Communications Equipment

IEC60065

Safety standards for AV equipment

2022/12～ Enforcement

IEC62368-1

New safety standards for information and communication equipment and AV equipment

New product safety standards developed based on the concepts of "Hazard-based Safety Engineering (HBSE)" that prevent injury to humans, IEC62368-1

IEC62368-1 test details

- Continuous operation test at maximum load
- Continuous operation test under output short circuit condition
- Continuous Output Short Circuit Test
- Continuous operation test under overcurrent protection status

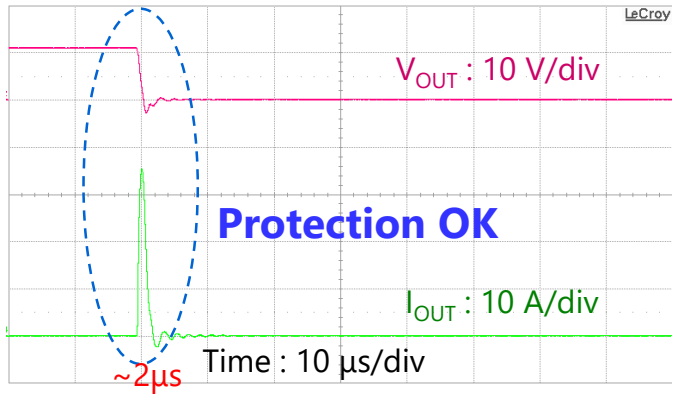
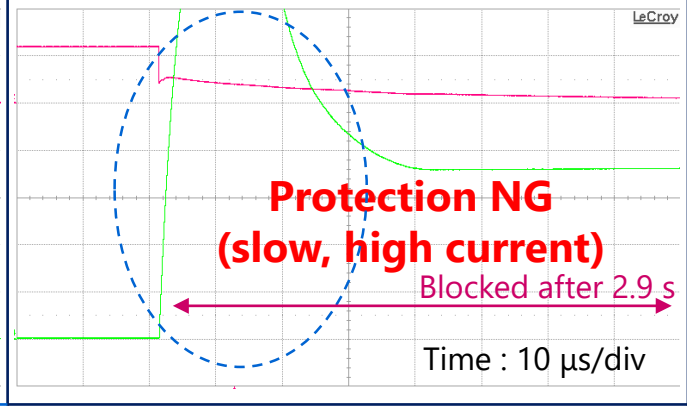
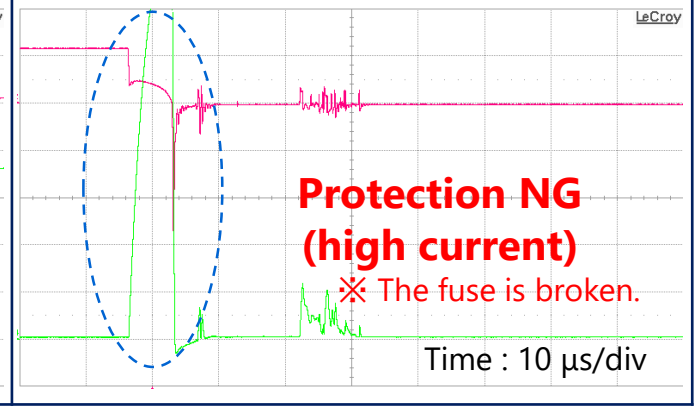
etc.

By obtaining this standard,
To reduce the amount of work required to acquire certification as a set

Comparison of eFuse IC performance with conventional fuses

Only the eFuse IC cuts off the current path at high speed and does not allow a large current to flow.

Results of short circuit protection operation

	eFuse IC (TCKE812NL)	Polyfuse	Chip fuse
Rated current	3 (Setting)	3.1 (Rated)	3 (Rated)
Interruption time	2 µs	2.9 S	7µs
Protective operation review			

It was confirmed that a large current of 70A or more flowed momentarily in the poly fuse and chip fuse, and the chip fuse was broken.

Examples of applications where semiconductor fuses(eFuse ICs) are used

NBPC

SSD/HDD

Server

Printer

Video

Game

VR/AR

Smart speakers

Headset

Etc.
Many other I/O devices

Semiconductor fuses (eFuse ICs) are used in many applications.

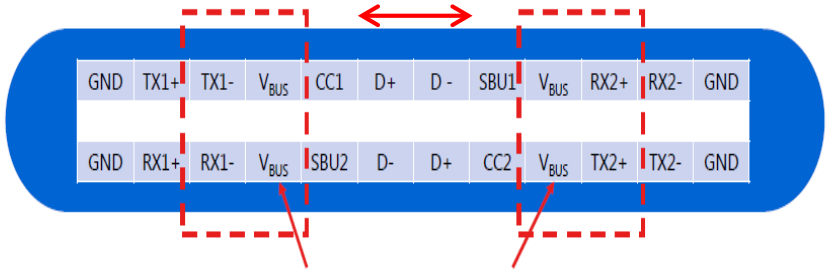
Examples of applications where semiconductor fuses(eFuse ICs) are used

Actual eFuse IC Usage Examples: USB Type-C Examples

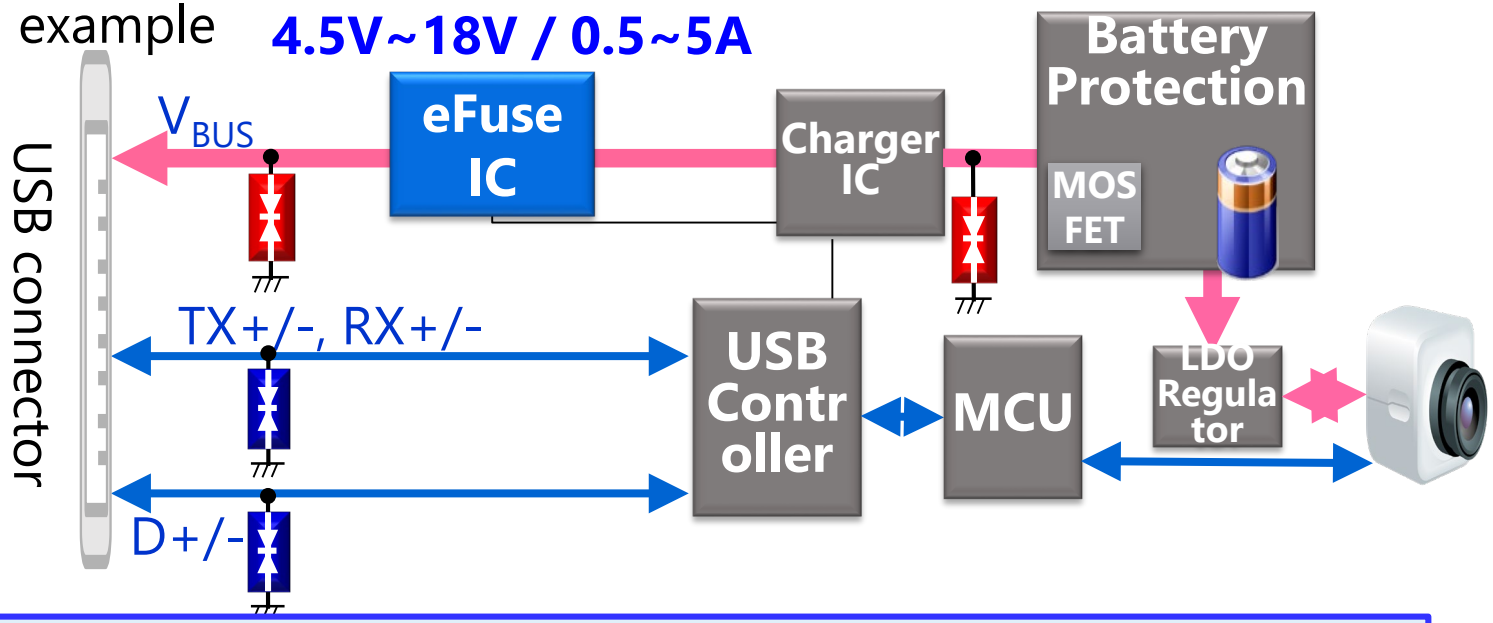
Short Circuit Protection of USB VBUS and IEC62368 Standards Compliant

Pin spacing 0.5mm

USB Type-C Pin assignment



USB example

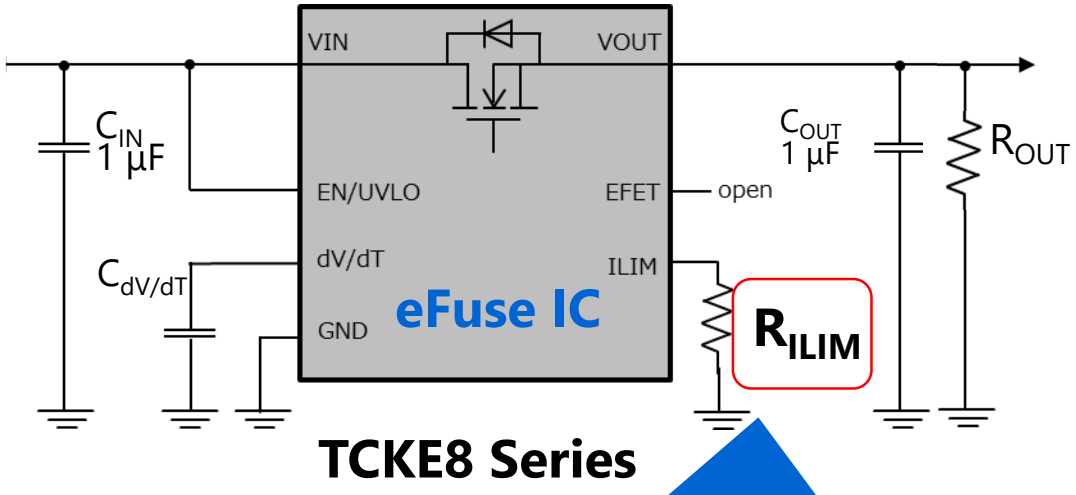


From Load SW and MOSFET to eFuse to comply with USB-terminal standards Switching is proceeding. It is important to use it in combination with ESD, etc.

Overcurrent protection function (OCP)

The overcurrent protection function prevents damage to the IC and load by suppressing power consumption in the event of an error. If the output current exceeds the limit current (ILIM) due to a load error or short circuit, the output voltage and output current also decrease, thereby limiting the power consumed by the ICs and the load.

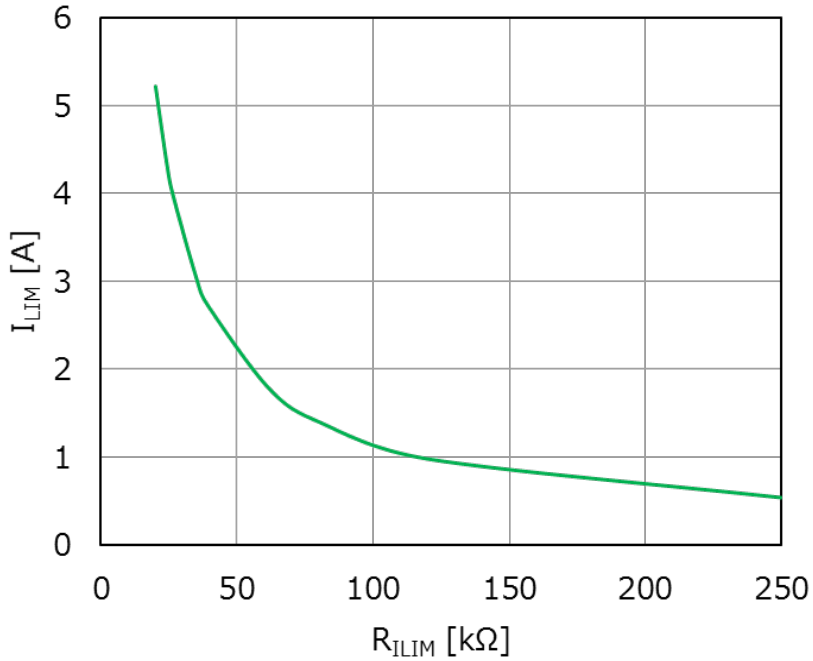
Basic circuit



TCKE8 Series

For the overcurrent limit with an external resistor (R_{ILIM}) can be set to 0.5 ~ 5A

Limited current ILIM-external resistor RILIM

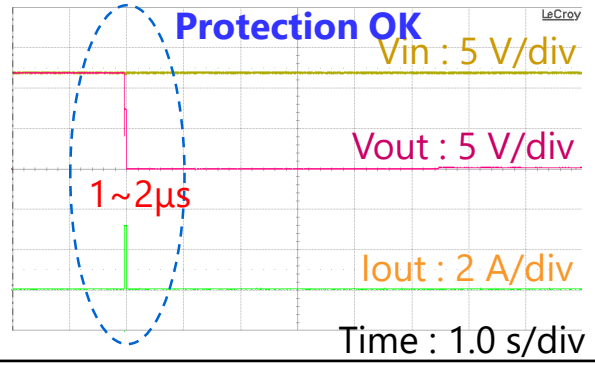
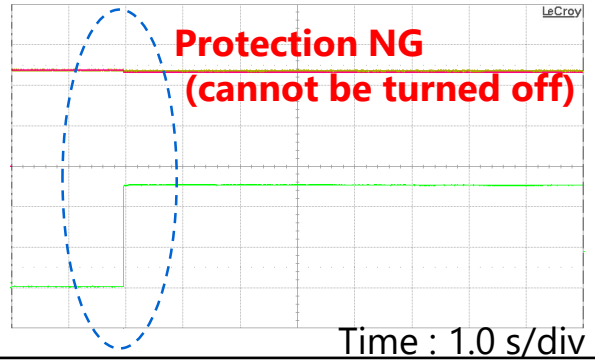
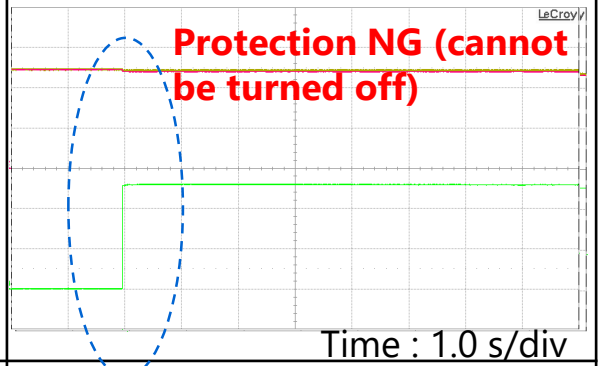
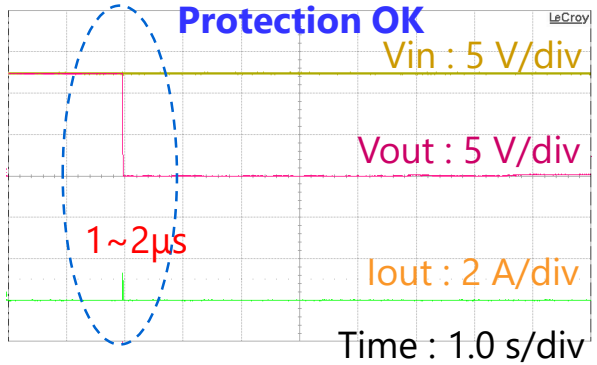
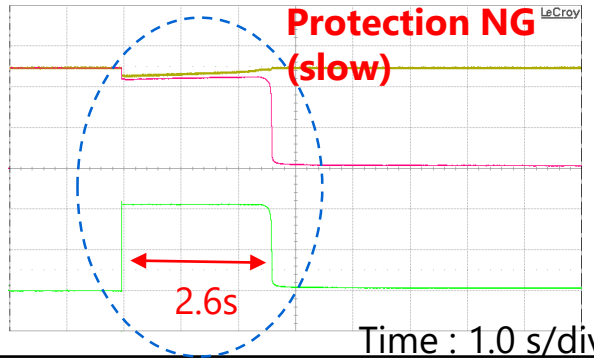
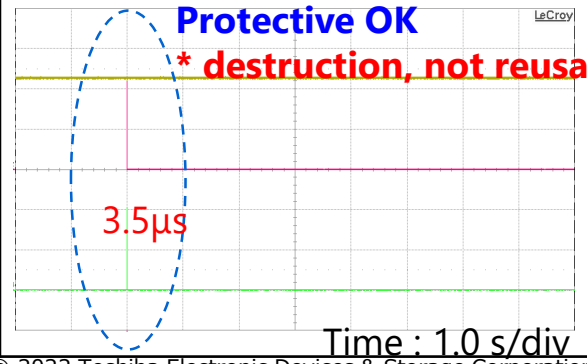


Overcurrent limit calculation formula
$I_{LIM}(A)=0.13+101800/R_{ILIM}(\Omega)$

Overcurrent protection function (OCP)

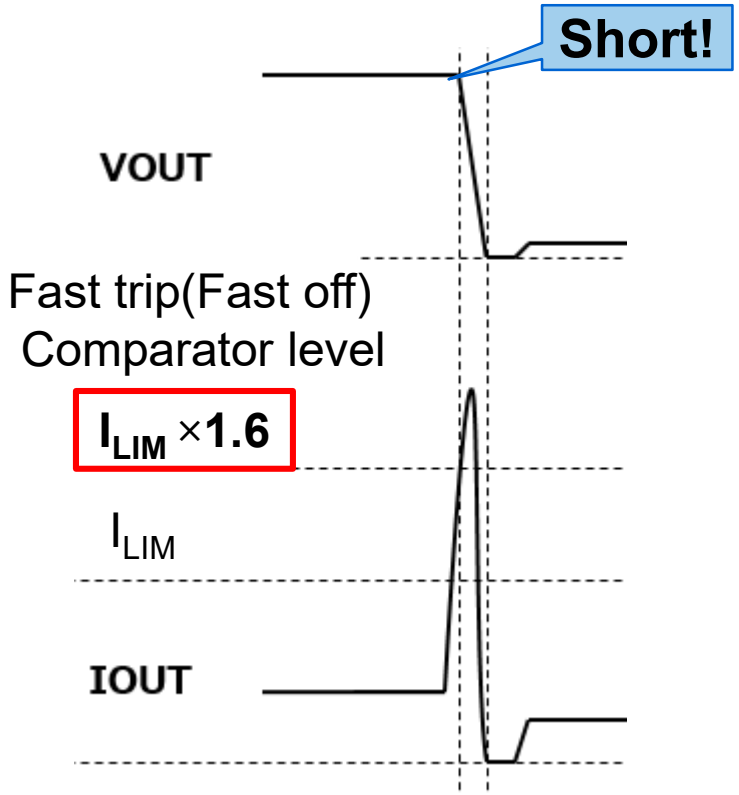
●Comparison of eFuse IC performance with conventional fuses

eFuse IC performs protective operation at high speed and with high accuracy.

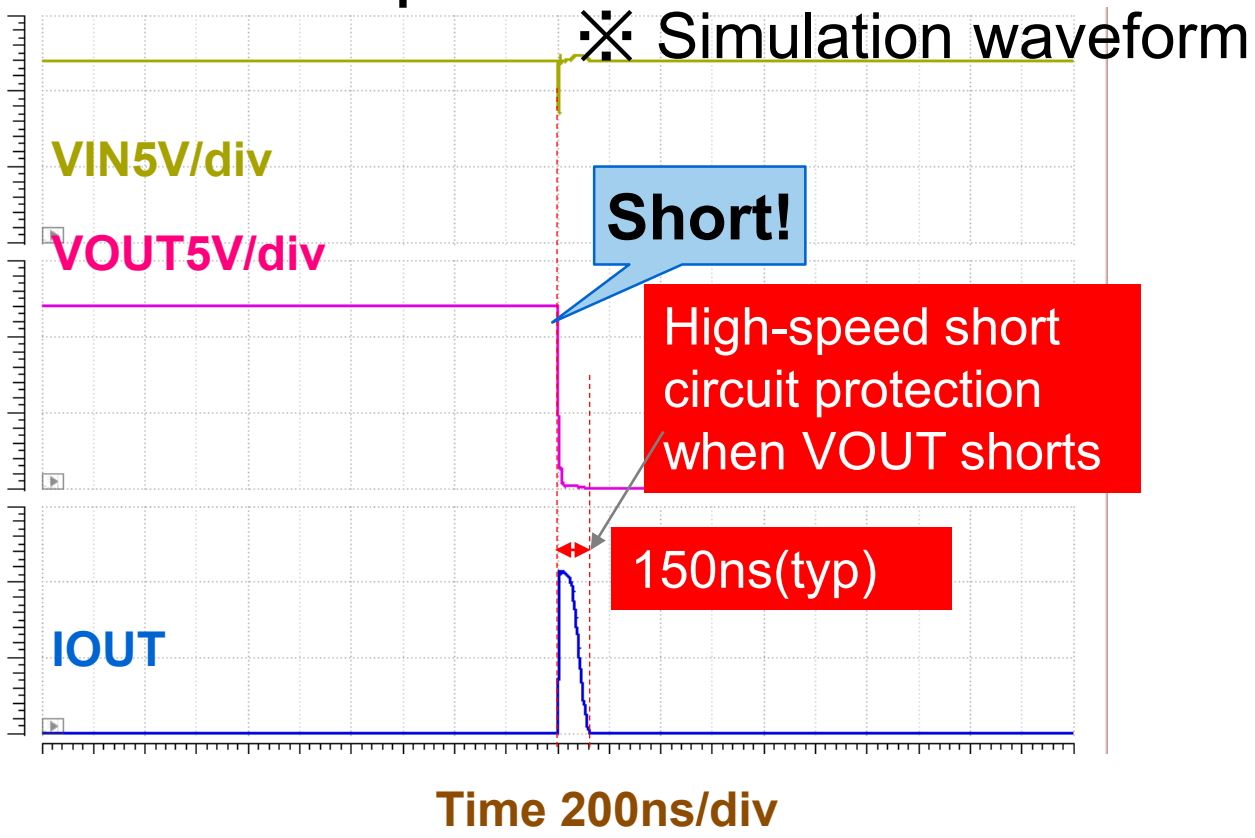
	eFuse IC (TCKE812NL)	Polyfuse	Chip fuse
Rated current	3 A (setting)	3 (Rated)	3.1 (Rated)
Overcurrent Protection operation (at 5A current)			
Overcurrent Protective operation (at 10A current)			

Short circuit protection function

The short circuit protection function prevents excessive current from flowing by stopping operation when the power supply line or load is short-circuited due to some kind of abnormality. In TCKE800 / 805/812 series, if the output current is 1.6 times the current limit (ILIM) for a very short period of time, the output is judged to be short-circuited and this function operates.



Short circuit protection waveform



Because of the faster off-time, damage and destruction of the subsequent IC can be reduced

Overvoltage protection function (overvoltage clamp)

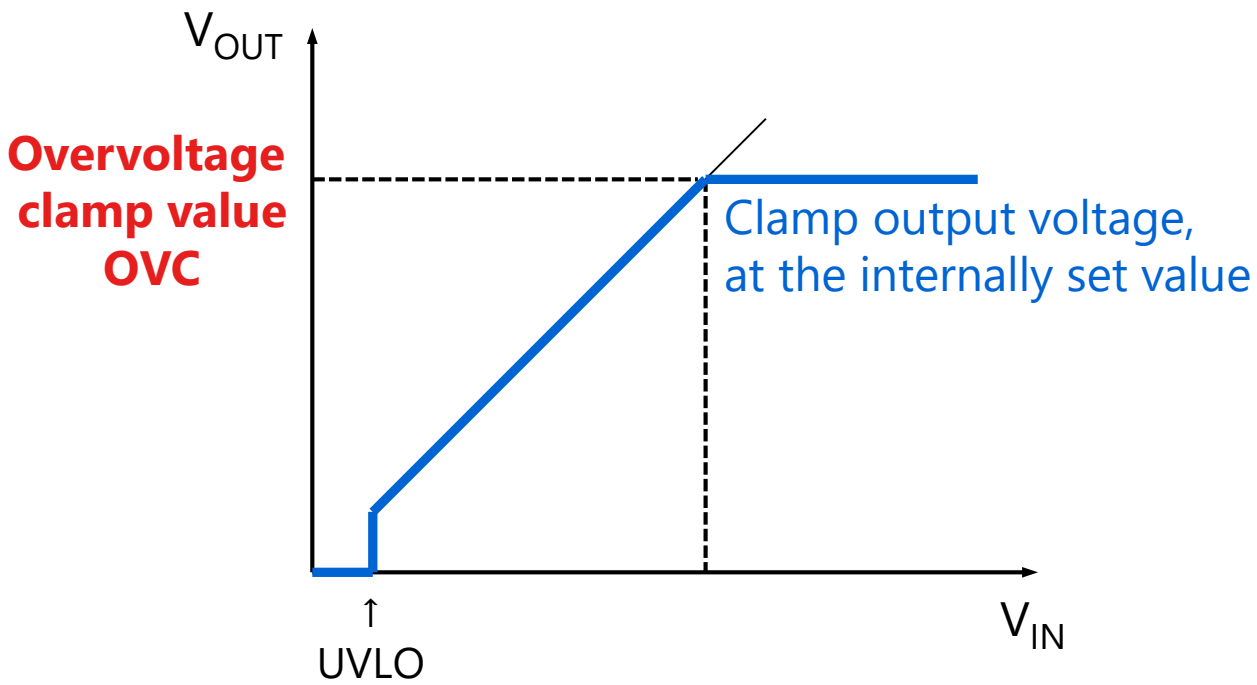
For TCKE8 Series, when the input voltage of the VIN pin of the eFuse IC exceeds the overvoltage clamp value (OVC) , the output voltage VOUT is limited to the overvoltage clamp value(OVC) so that the overvoltage is not applied to the subsequent IC or circuits.

There are two types of overvoltage protection functions:

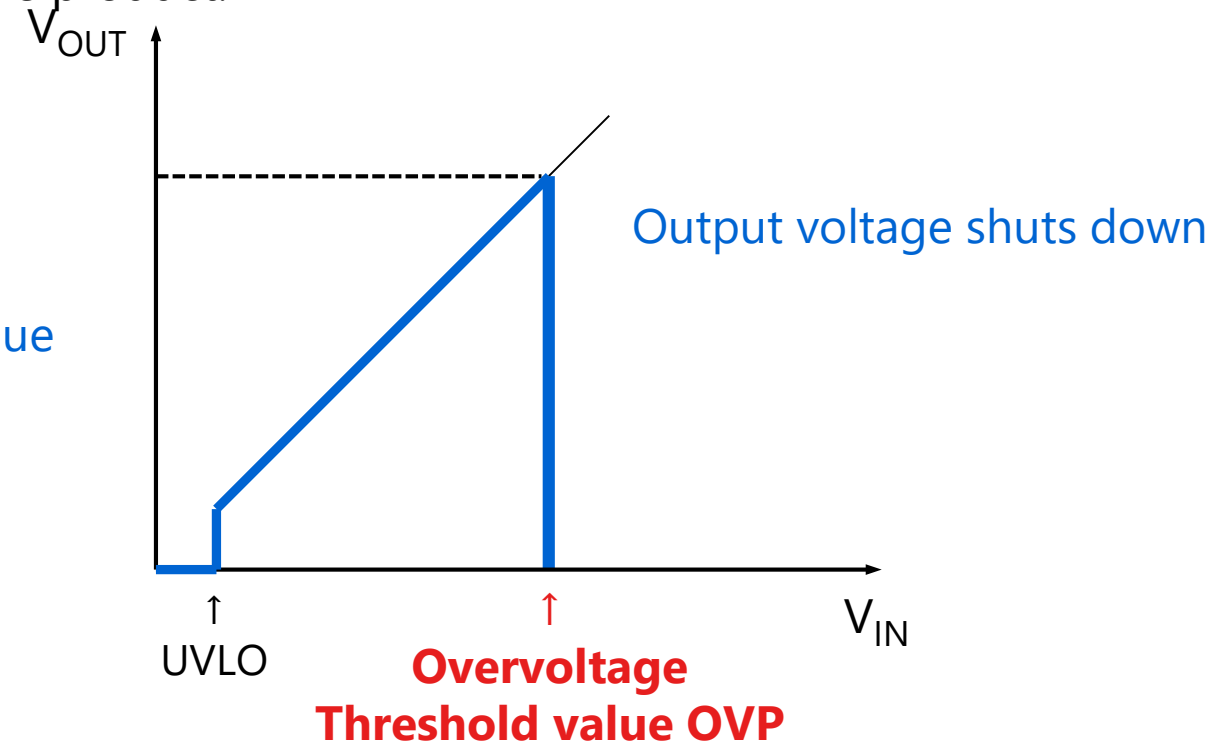
a type that clamps the output voltage

a type that shuts off the output voltage.

Please check the data sheet for details as it depends on the product.



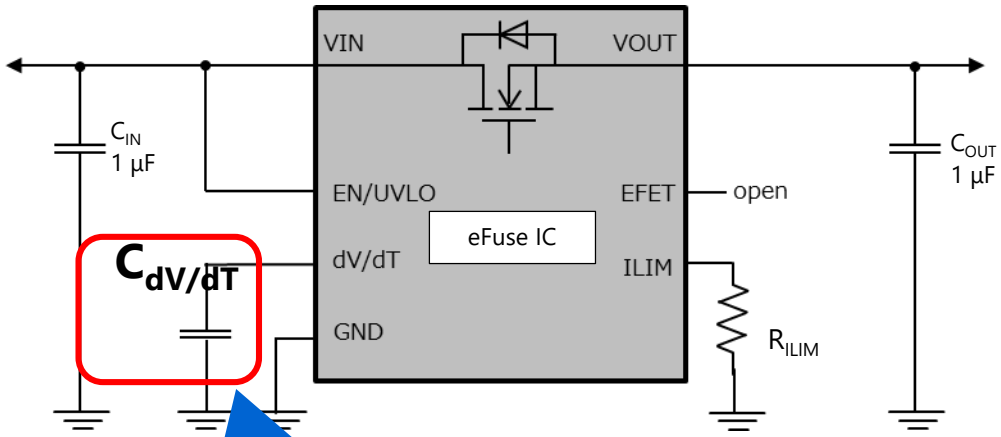
For TCKE8 series



For TCKE712BNL

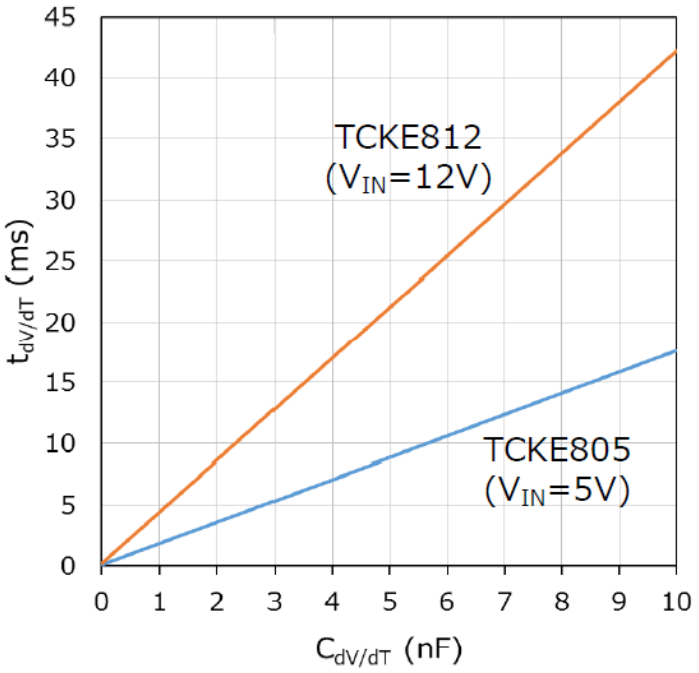
Slew rate control (Suppressing rush current)

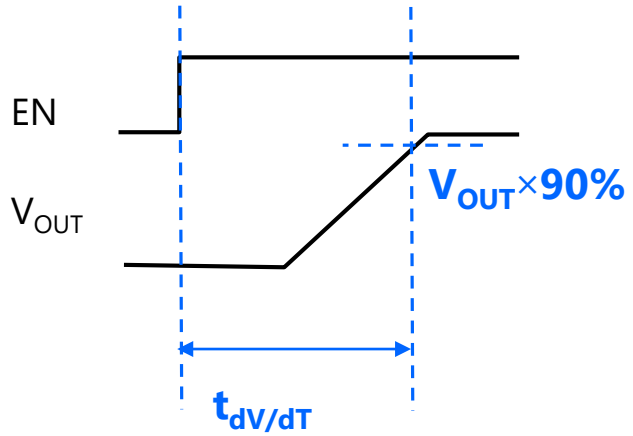
When the output is turned on, an inrush current flows to charge the capacitor connected to the load side. If this current is too large, the overcurrent protection circuit may malfunction, making it impossible to start up, or overshooting may occur in the output voltage.
To prevent this, this function limits the inrush current and controls the slew rate at the rise of the output voltage.



Slew Rate Control
Adjustable by external capacitors
($C_{dV/dT}$)

Slew rate control calculation formula
$t_{dV/dT}(s)=0.36\times10^{6}\times VIN\times(Cdvdt+50pF)+3\times10^{-4}$





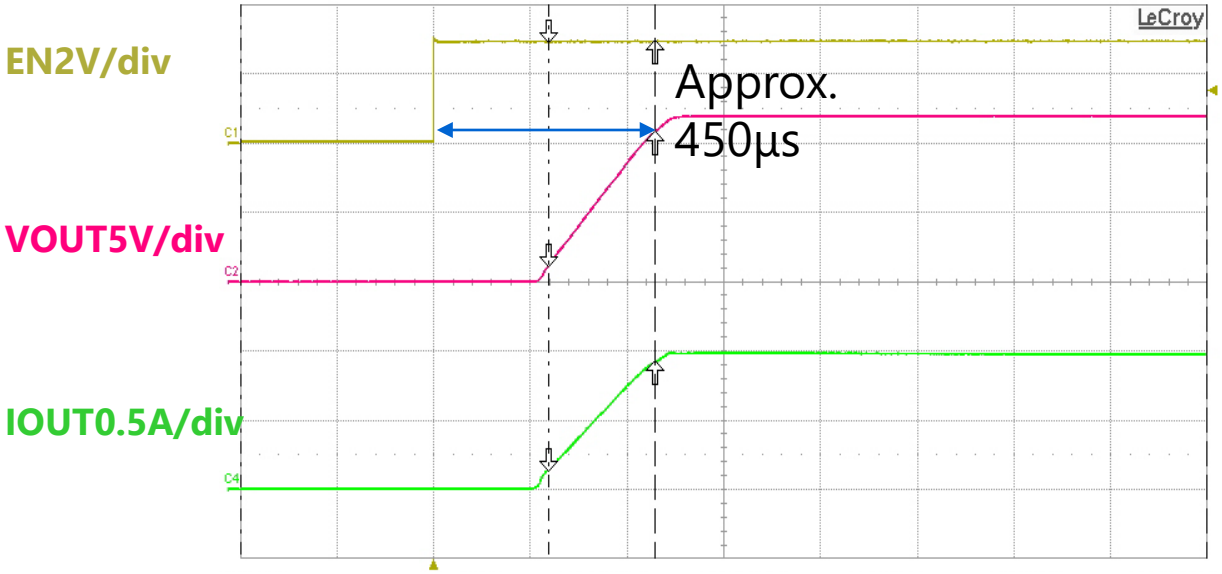
In response to the rush current with an external capacitor, voltage rise and slew rate can be controlled arbitrarily

Slew rate control (Suppressing rush current)

The figure below is an example of rush current suppression using slew rate control.
The waveform on the left is the rising waveform of the output voltage and current with dV / dT terminal open, and the waveform on the right is the waveform when 1nF is added to dV / dT terminal.

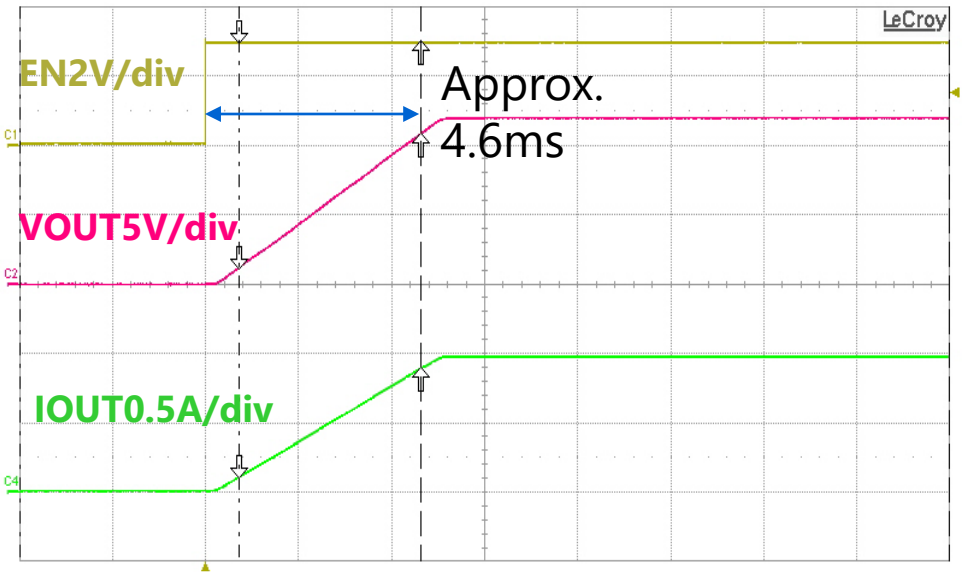
The slew rate can be adjusted by adjusting the CdVdT terminal capacitance.

CdV/dT = Open



Time : 200 us/div

CdV/dT=1nF



Time : 2ms/div

Enable to adjust the slew rate by an external capacitance

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