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Tips and Hints for Using eFuse ICs
—Useful functions available with eFuse ICs

Toshiba Electronic Devices & Storage Corporation

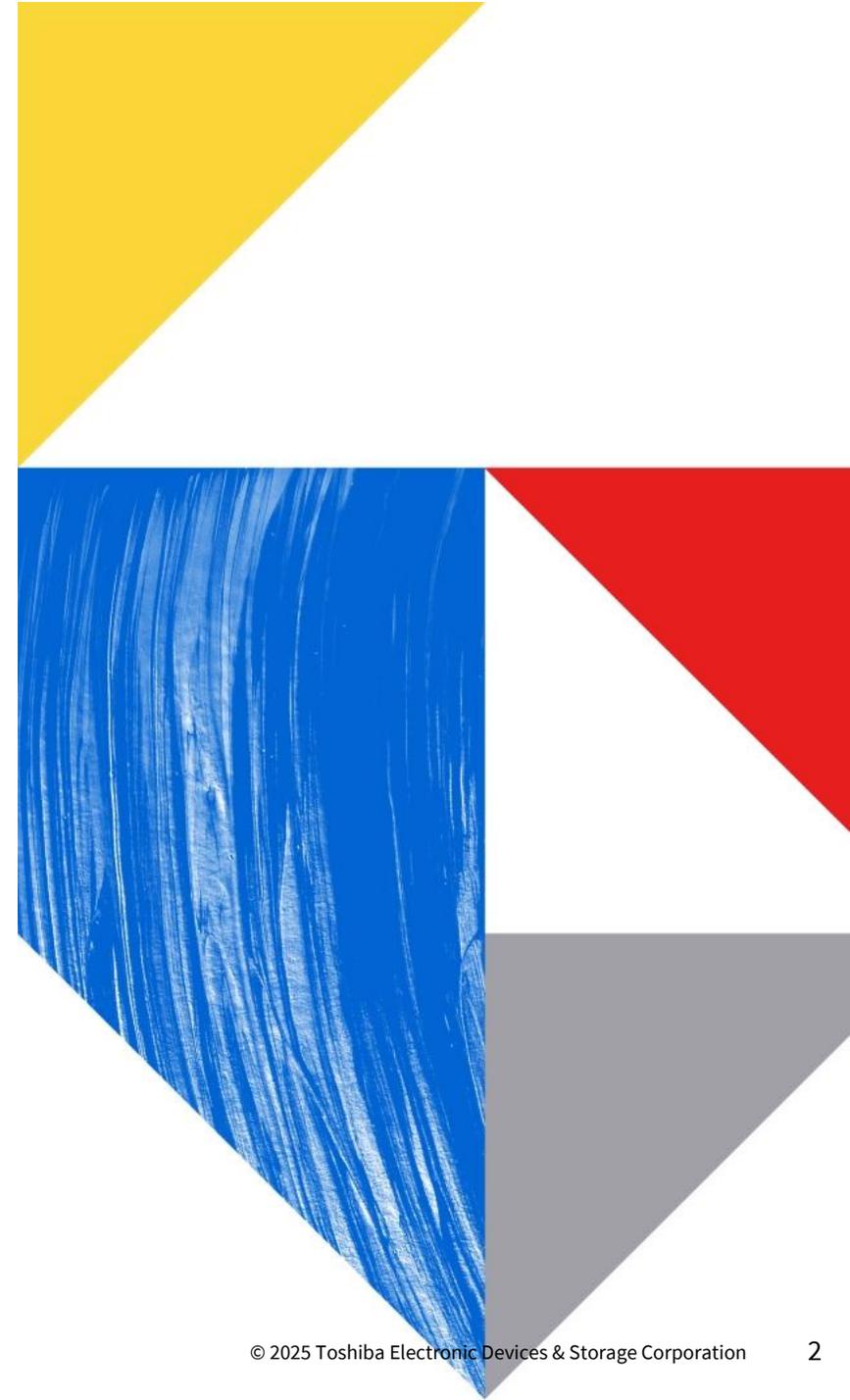# Contents

01

Introduction

Review of the basics of eFuse ICs

Advantages of eFuse ICs, electronic fuses

eFuse ICs provide three major advantages.

◆ Being semiconductor devices, eFuse ICs can be used repeatedly.

◆ eFuse ICs provide better protection performance than conventional mechanical fuses.

◆ eFuse ICs help simplify the process of obtaining certification for IEC 62368-1, a new safety standard.
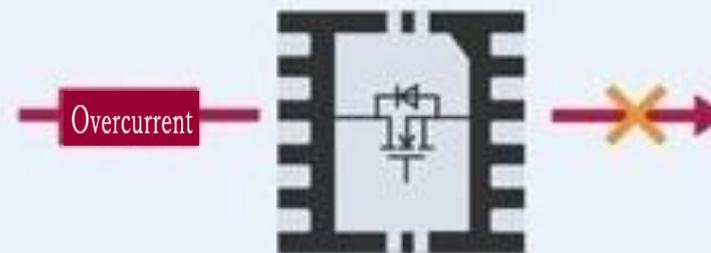
eFuse ICs can be used repeatedly

Mechanical fuse

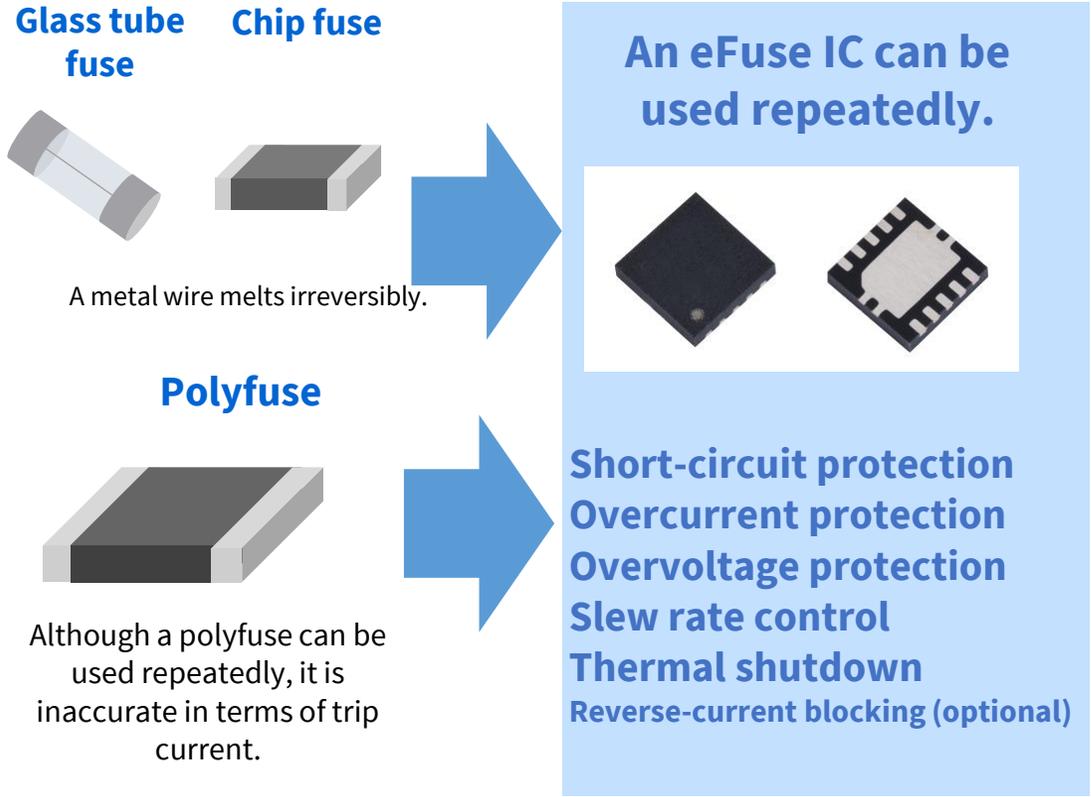The mechanical fuse relies on the irreversible melting process.

Overcurrent

A mechanical fuse must be replaced.

eFuse IC

Electronic control

Overcurrent

An eFuse IC can be used repeatedly.

eFuse ICs provide better protection performance than conventional mechanical fuses.

Glass tube fuse   **Chip fuse**

A metal wire melts irreversibly.

Polyfuse

Although a polyfuse can be used repeatedly, it is inaccurate in terms of trip current.

An eFuse IC can be used repeatedly.

Short-circuit protection
Overcurrent protection
Overvoltage protection
Slew rate control
Thermal shutdown
Reverse-current blocking (optional)

	Glass tube fuses	Chip fuses	Polyfuses	Electronic fuses eFuse ICs
Repeated use	Impossible	Impossible	Possible but with constraints	Possible without any constraints
Speed and accuracy of overcurrent protection	Slow	Slow	Slow	Fast
Additional protection features	N/A	N/A	N/A	Available
Sensitivity to ambient temperature	Large (adverse)	Large (adverse)	Large (adverse)	Small
Fuse footprint	Large	Small	Large	Moderate
Total footprint required, including protection circuitry	Large	Large	Large	Small
Fuse cost	Moderate	Low	Very high	Moderate
Total cost, including costs of protection circuitry and maintenance	Very high	Very high	Very high	Very low

Advantages of eFuse ICs (3)

eFuse ICs help reduce the workload required to obtain IEC 62368-1 certification for an electronic system.

Withdrawn in December 2020

Enforced in December 2020

IEC 60950-1

Safety standard for information technology equipment

IEC 60065

Safety standard for audio, video and similar electronic apparatus

IEC 62368-1

New safety standard for audio/video, information and communication technology equipment

IEC 62368-1 is a new safety standard developed based on the principles of hazard-based safety engineering (HBSE) that emphasizes the protection of the human body from harm.

IEC 62368-1 G9
Tests for integrated circuit (IC) current limiters
- Continuous operation test under the maximum load
- Continuous operation test with the output short-circuited
- Continuous output short-circuit test
- Continuous operation test in overcurrent protection mode

etc.

Using certified fuses helps reduce the workload required to obtain IEC 62368-1 certification for an electronic system.

Examples of applications using electronic fuses
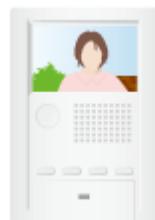
Notebook PCs

SSDs/HDDs

Servers

Printers

Video players and recorders

Game consoles

VR and AR goggles

Smart speakers

Headsets

Many other I/O devices

Electronic fuses have diverse applications.

Summary of eFuse ICs

eFuse ICs provide solutions for various technical issues while meeting time and cost constraints.

- ✓ Voltage and current specifications
- ✓ Power and heat dissipation
- ✓ Protection operation
- ✓ Requirements of reliability tests and various technical standards
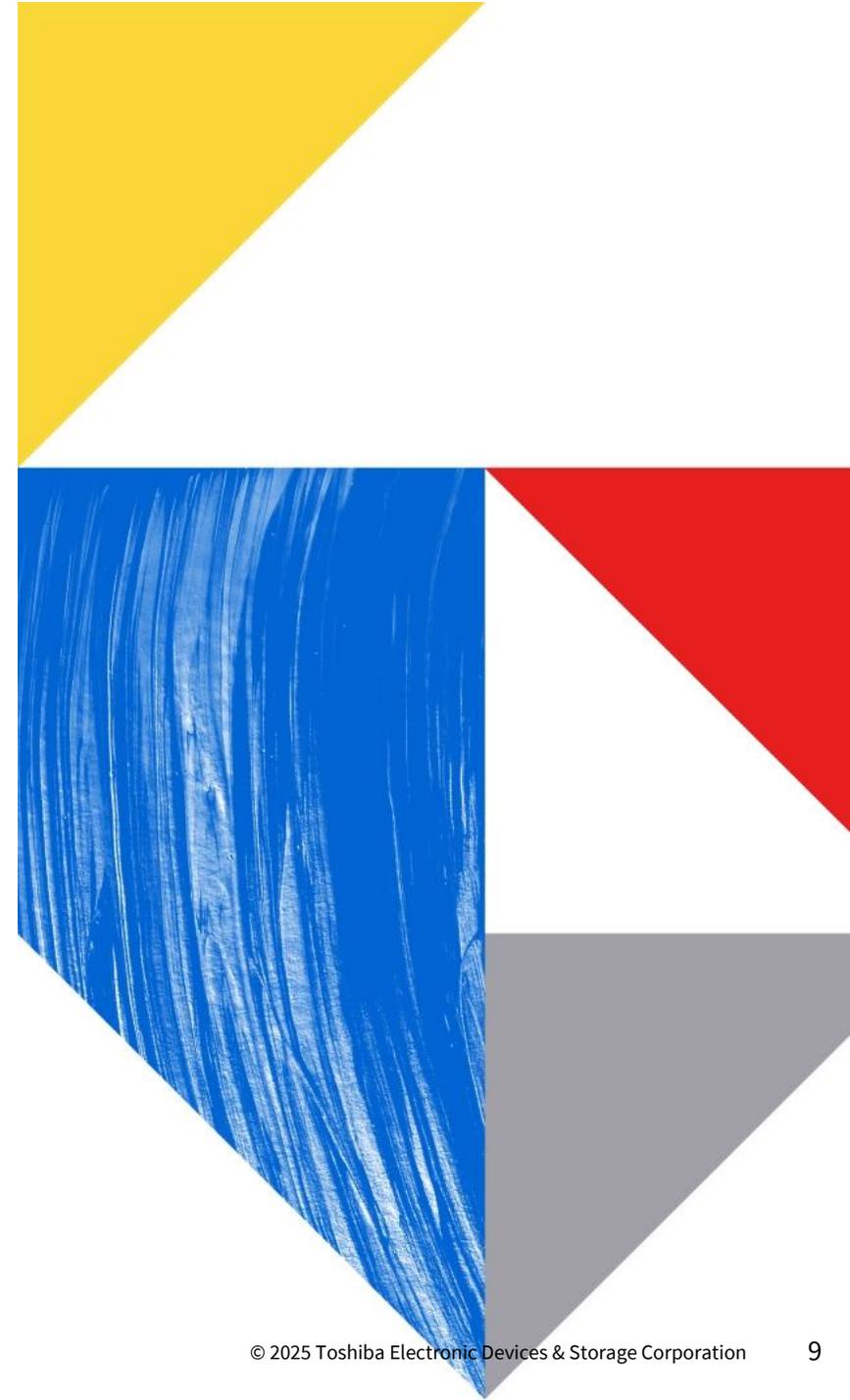
- ✓ Part count
- ✓ Board area requirement
- ✓ Time
- ✓ Cost

Various technical issues

Cure-all

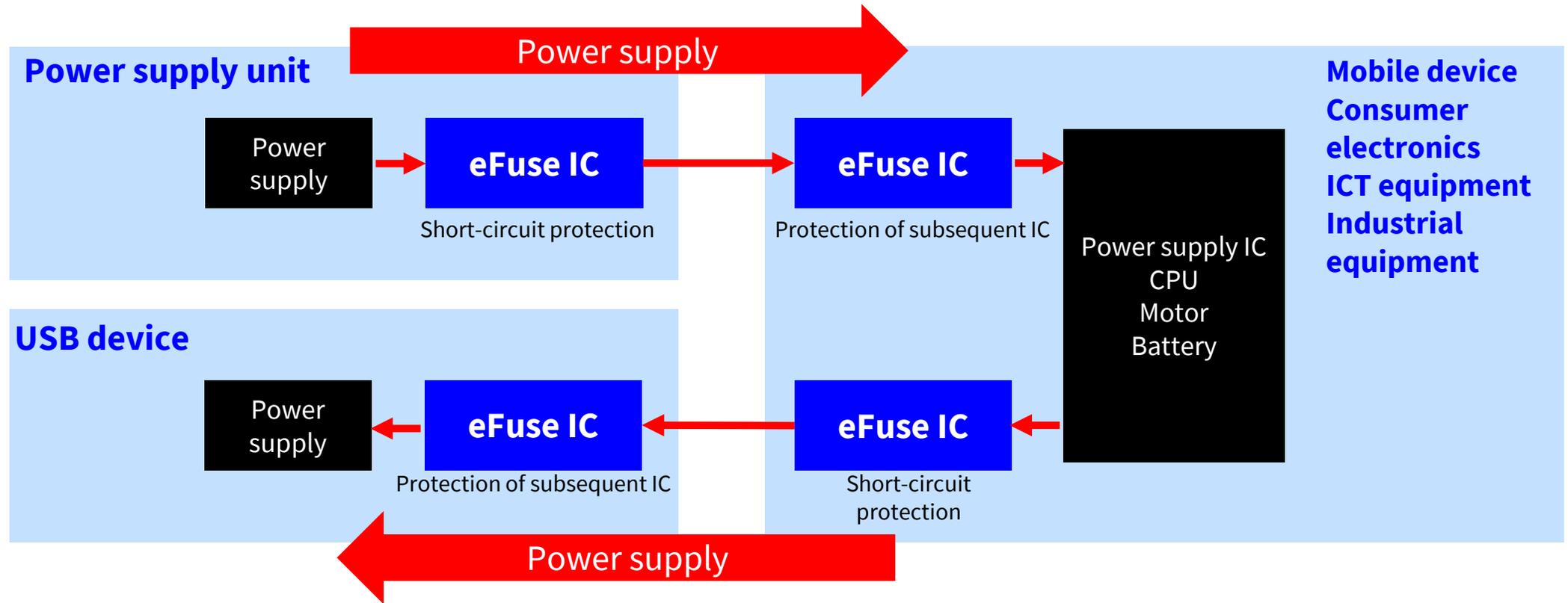**Various time and cost constraints**
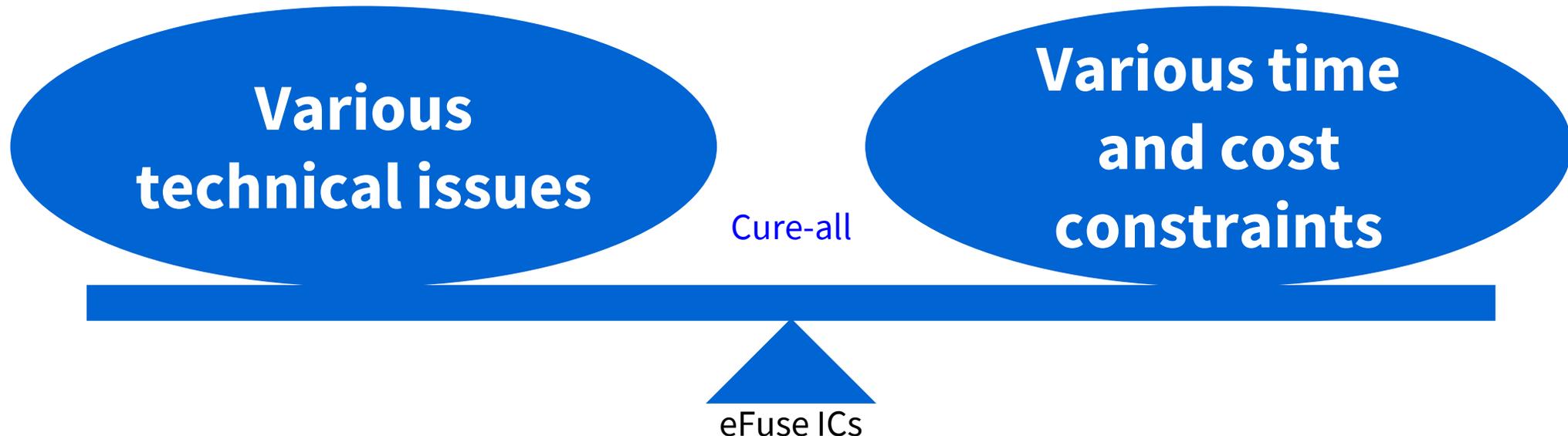
eFuse ICs

02

Application examples and usage

1. Protection of power rails from hot plugging
2. System fault detection and power rail protection using the FLAG output
3. Multiplexing and protection of two power rails

Basic usage of eFuse ICs

Power supply unit

Power supply → **eFuse IC** (Short-circuit protection) → **eFuse IC** (Protection of subsequent IC) → Power supply IC / CPU / Motor / Battery

Power supply →

USB device

Power supply ← **eFuse IC** (Protection of subsequent IC) ← **eFuse IC** (Short-circuit protection) ← Power supply IC / CPU / Motor / Battery

← Power supply

Mobile device
Consumer electronics
ICT equipment
Industrial equipment

This section shows the basic usage of eFuse ICs.

3 application examples using some of the features available with eFuse ICs.

1. Protection of power rails from hot plugging

2. System fault detection and power rail protection using the FLAG output

3. Multiplexing and protection of two power rails
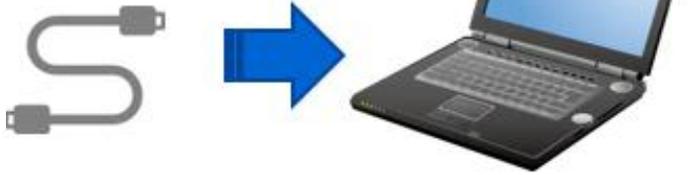
1. Protection of power rails from hot plugging

Protection of power rails from hot plugging

What is hot plugging?

Insertion and removal of a component to/from a running system

Examples of hot-swapping/hot-plugging

Plugging a cable into a notebook PC

Replacing an HDD/SSD of a server

Considerations for power rails during hot plugging

- ◆ Short-circuiting of a power supply port due to dust, etc.

- ◆ Chatter or inrush current upon electrical contact

- ◆ Unexpected application of excessive voltage due to wrong connections

eFuse ICs simplify hot-plug protection.

Short-circuit and overcurrent protection

Short-circuit protection

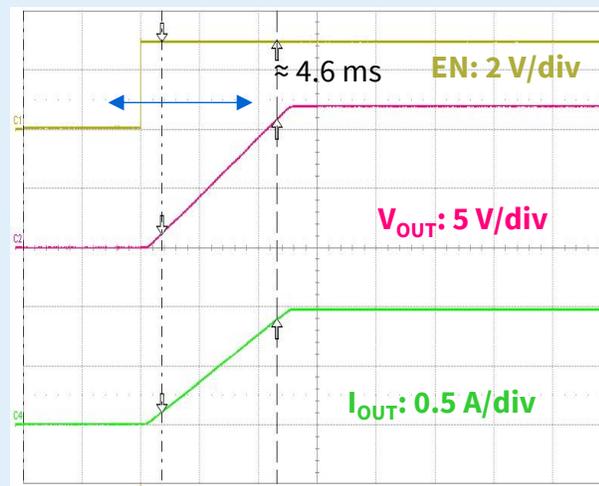V_{IN} 5V/div

Instantaneous protection

V_{OUT} 5V/div

150ns

I_{OUT}
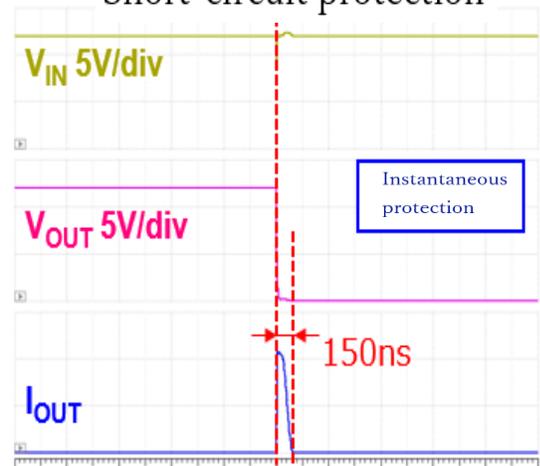
This is a simulated waveform of the TCKE8 series.

I_{LIM}

-40°C
25°C
85°C
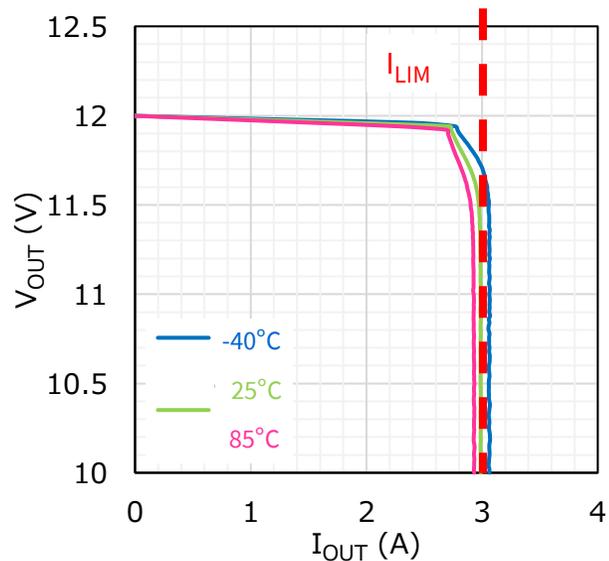
Inrush current suppression

V_{IN} = 12 V, $C_{dV/dT}$ = 1 nF

≈ 4.6 ms   EN: 2 V/div

V_{OUT}: 5 V/div

I_{OUT}: 0.5 A/div

Time: 2 ms/div

Overvoltage protection

V_{IN}

18 V

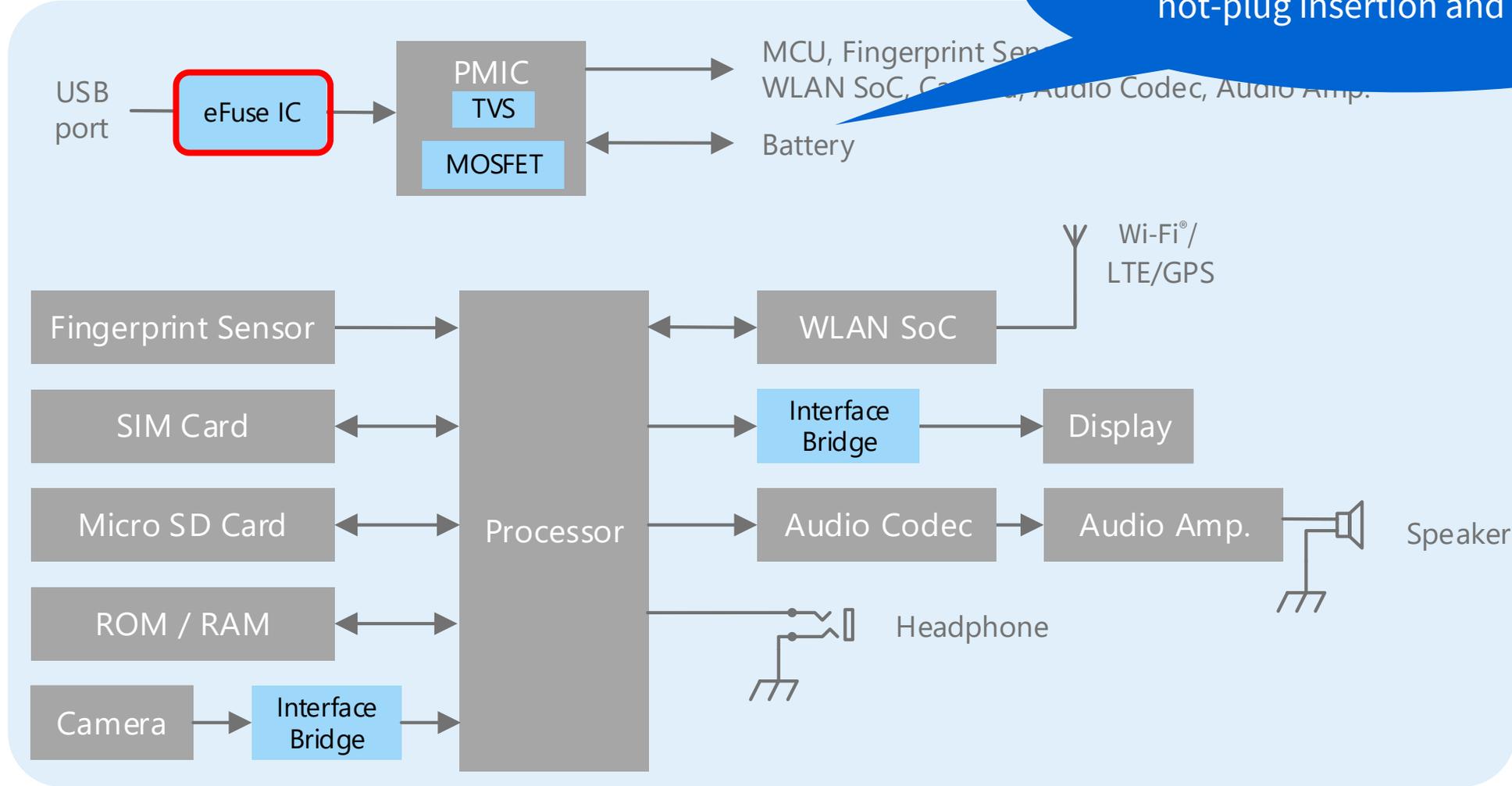12 V

V_{OUT}

12 V

15.1 V
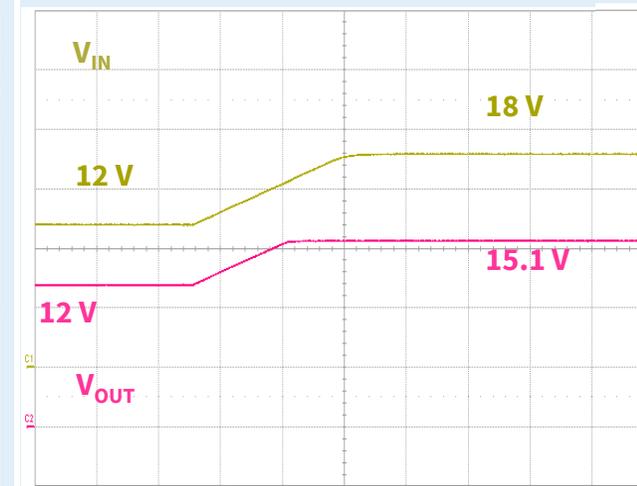
Time: 5 ms/div

Protection of power rails from hot plugging

Example: Application block diagram of a tablet

For example, USB ports support hot-plug insertion and removal.

USB port → eFuse IC → PMIC (TVS, MOSFET) → MCU, Fingerprint Sensor, WLAN SoC, Camera, Audio Codec, Audio Amp.

Battery

Fingerprint Sensor ↔ Processor

SIM Card ↔ Processor

Micro SD Card ↔ Processor

ROM / RAM ↔ Processor

Camera → Interface Bridge → Processor

Processor ↔ WLAN SoC → Wi-Fi®/ LTE/GPS

Processor → Interface Bridge → Display

Processor → Audio Codec → Audio Amp. → Speaker

Processor → Headphone

◆ Applications web page: **Click**

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2. System fault detection and power rail protection using the FLAG output

System fault detection and power rail protection using the FLAG output
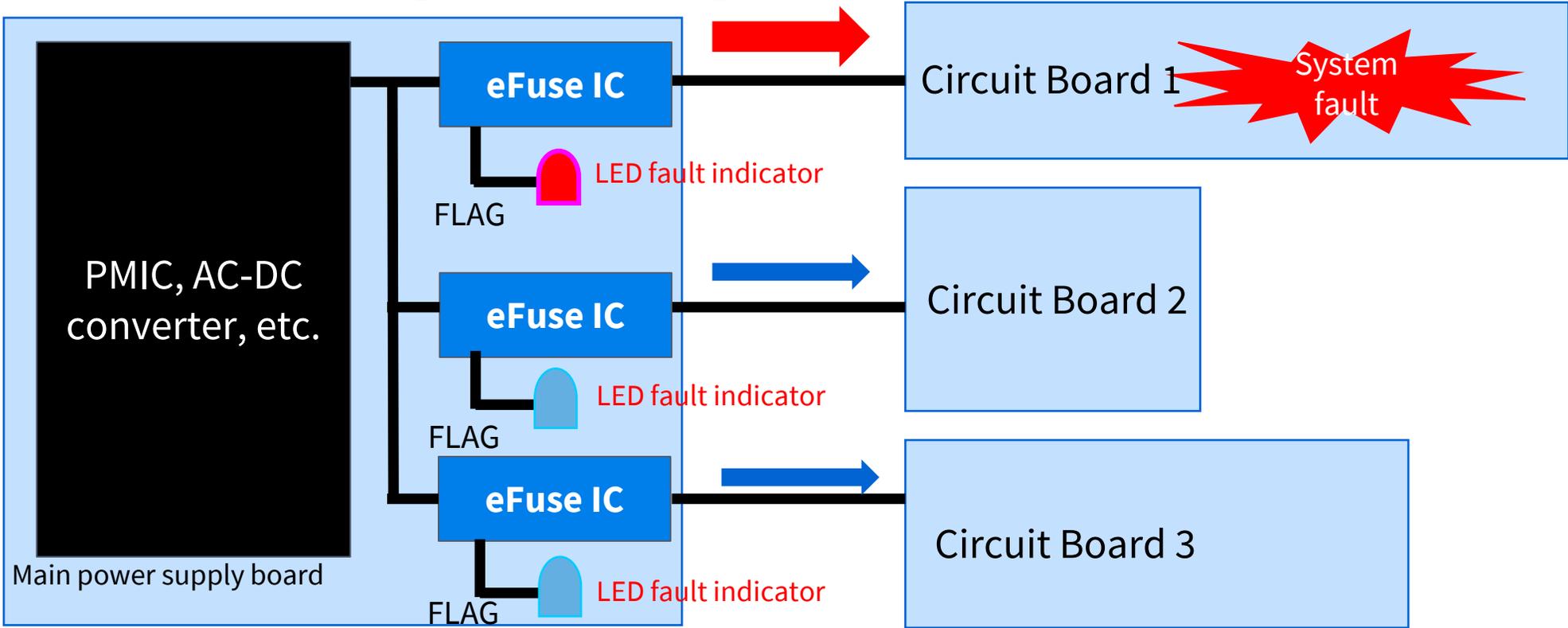
Example of a circuit configuration using a mechanical fuse
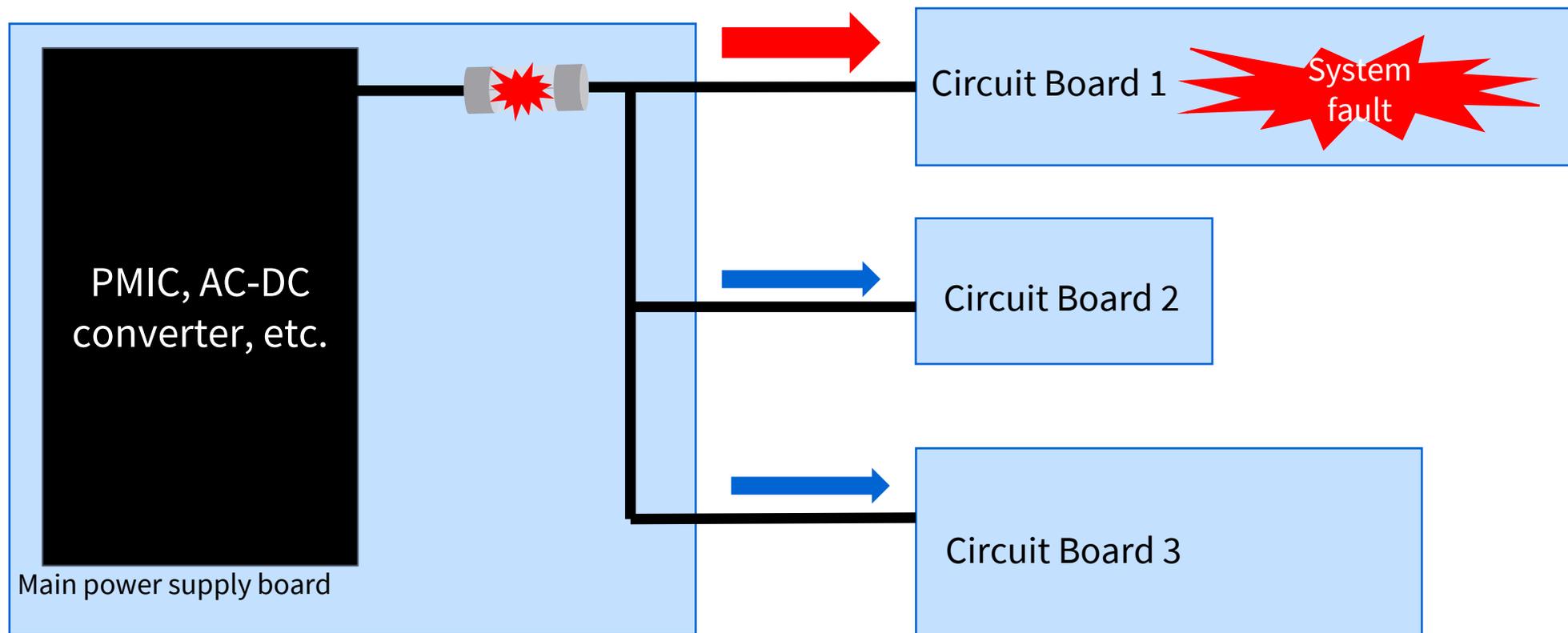
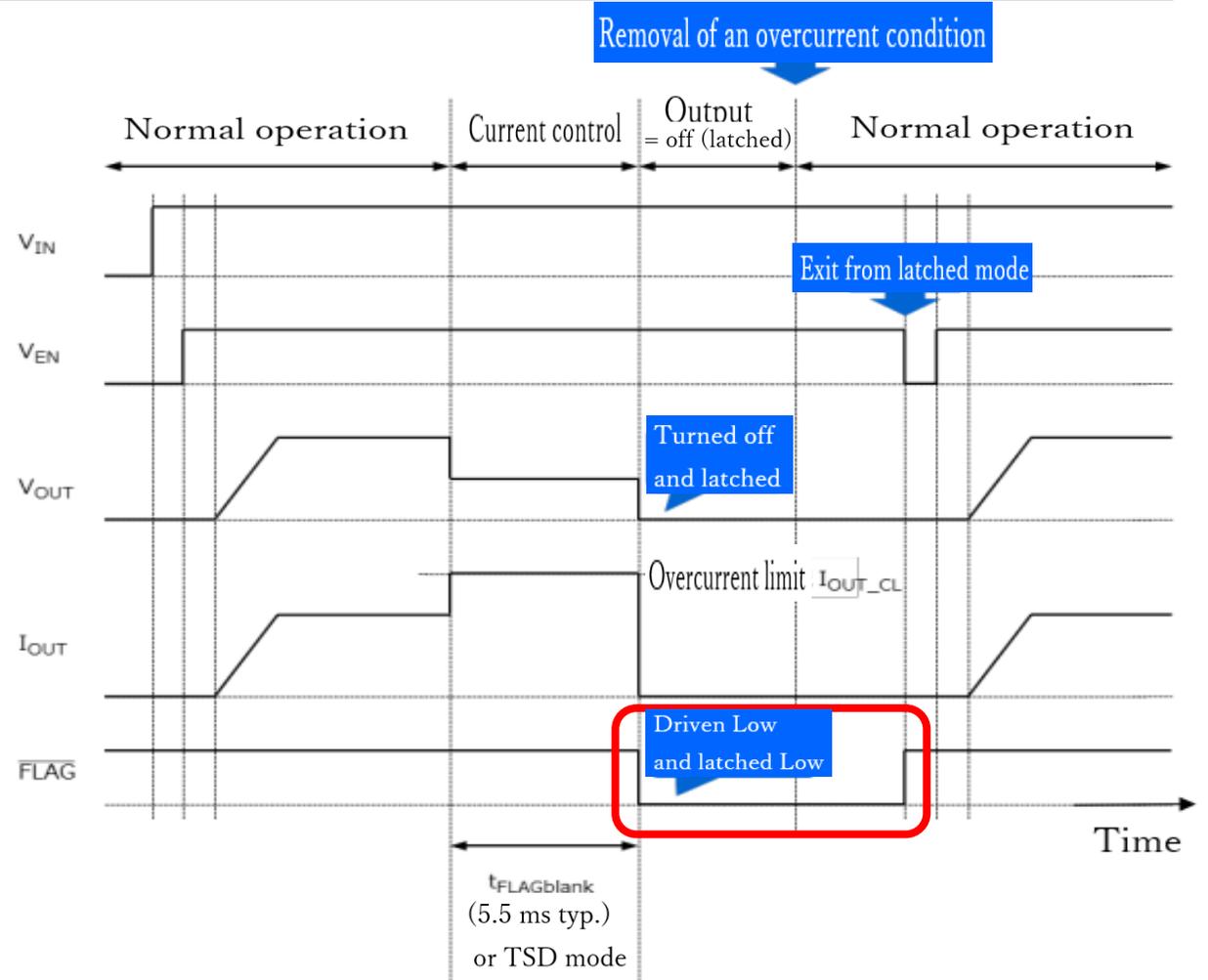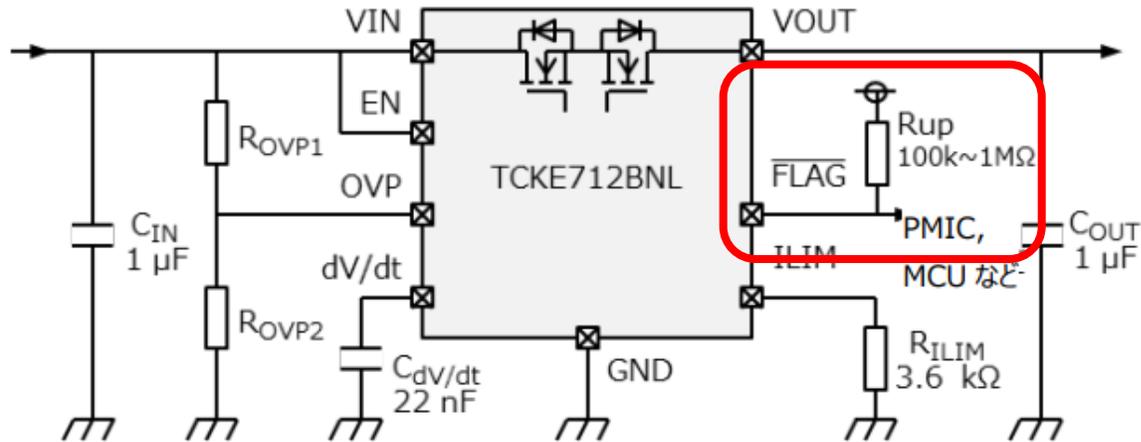The mechanical fuse cannot identify where a system fault occurred.

Example of a circuit configuration using the FLAG output of eFuse ICs

In addition to protecting power rails, eFuse ICs can detect system faults.
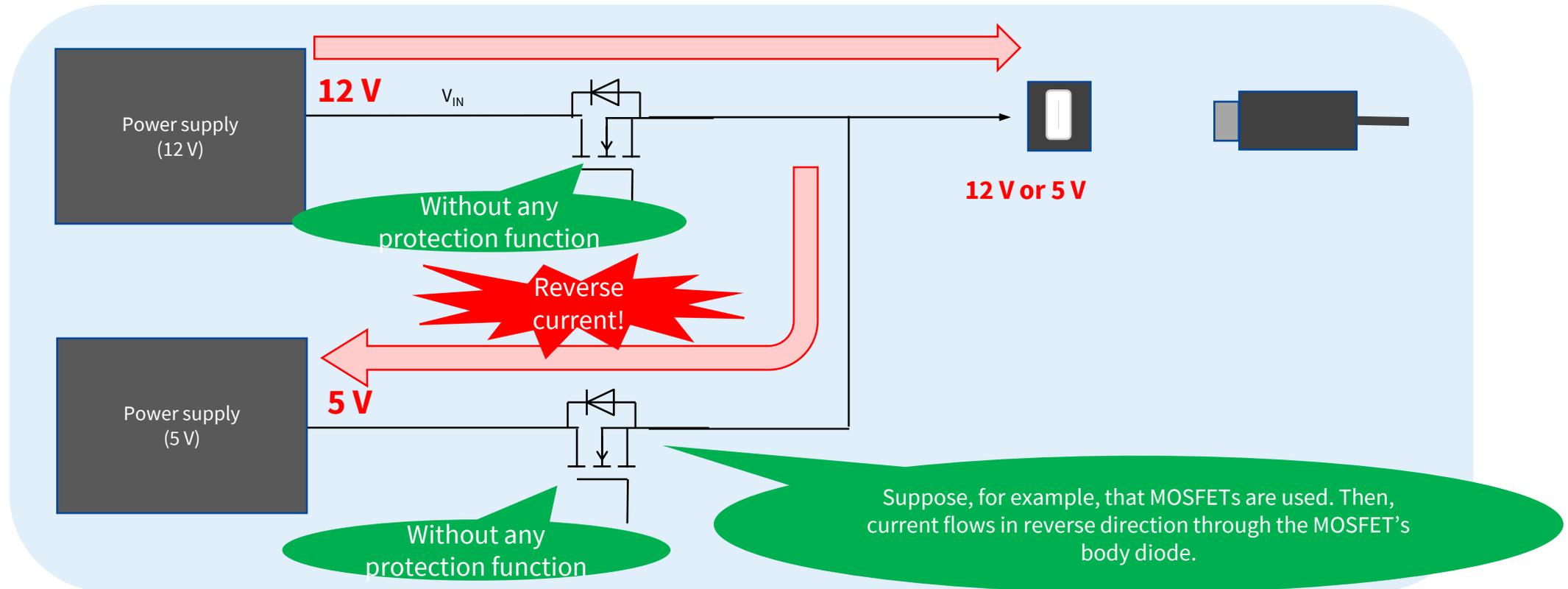
Example using the TCKE712BNL

The FLAG output is driven to an active state upon detection of a system fault (e.g., upon tripping of overcurrent protection and thermal shutdown).

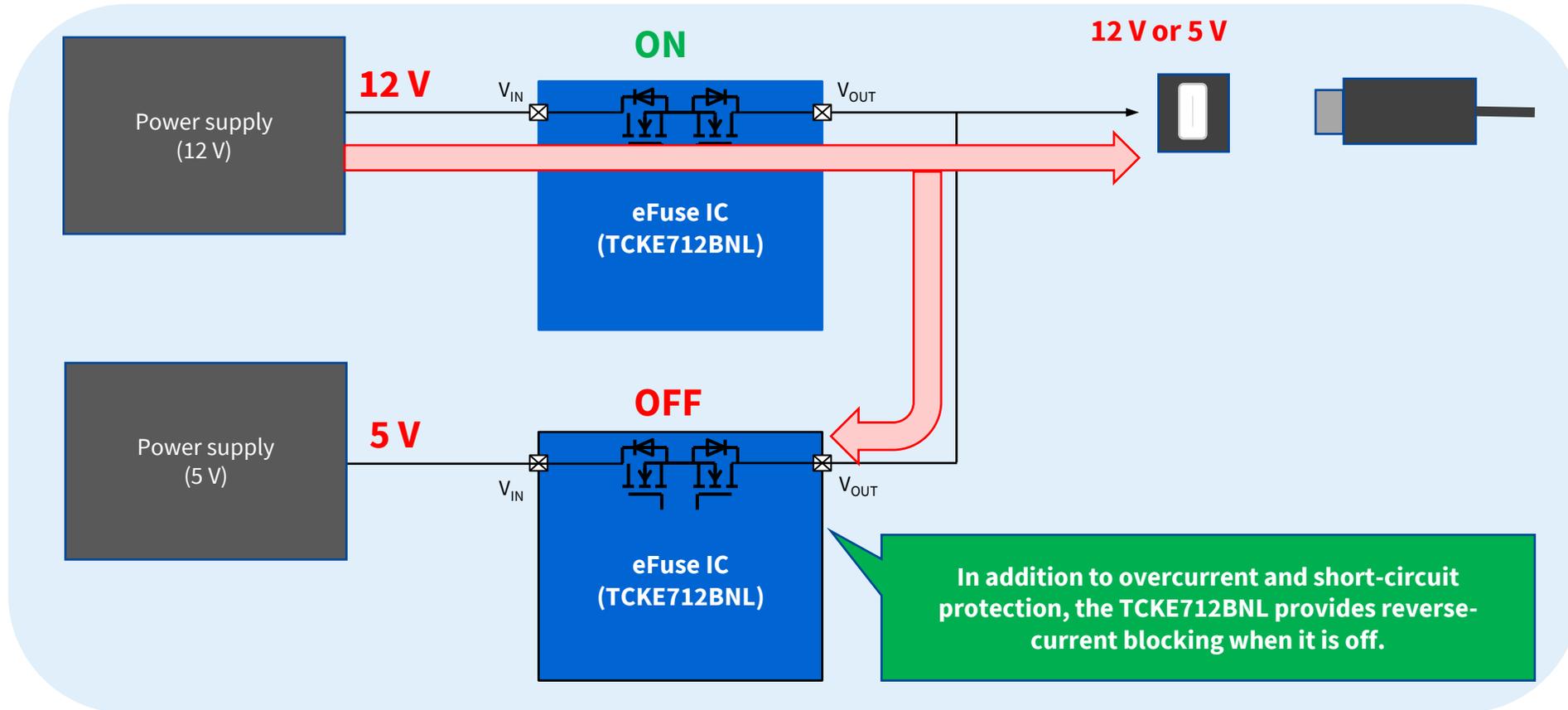# 3. Multiplexing and protection of two power rails

Example of a circuit configuration using discrete MOSFETs

Current flows in reverse direction when the circuit switches between two power rails.

Example of a circuit configuration using eFuse ICs with a reverse-current blocking

ON

12 V or 5 V

Power supply (12 V) — 12 V — V_{IN} — eFuse IC (TCKE712BNL) — V_{OUT}

Power supply (5 V) — 5 V — V_{IN} — **OFF** — eFuse IC (TCKE712BNL) — V_{OUT}

In addition to overcurrent and short-circuit protection, the TCKE712BNL provides reverse-current blocking when it is off.

eFuse ICs with a reverse-current blocking function simplify 2-to-1 power multiplexing.

Multiplexing and protection of two power delivery paths

Example of a circuit configuration using the TCKE712BNL with a reverse-current blocking function
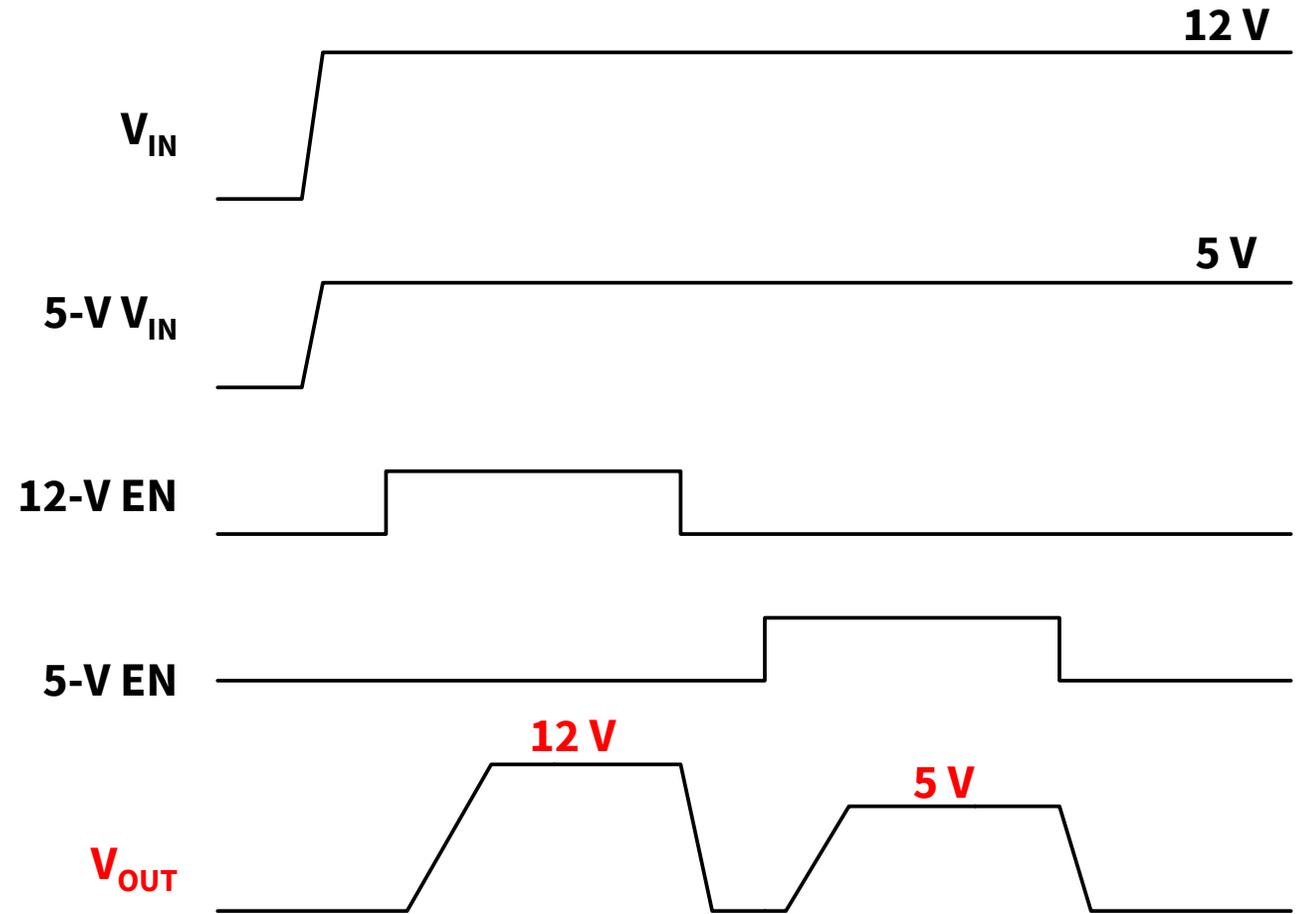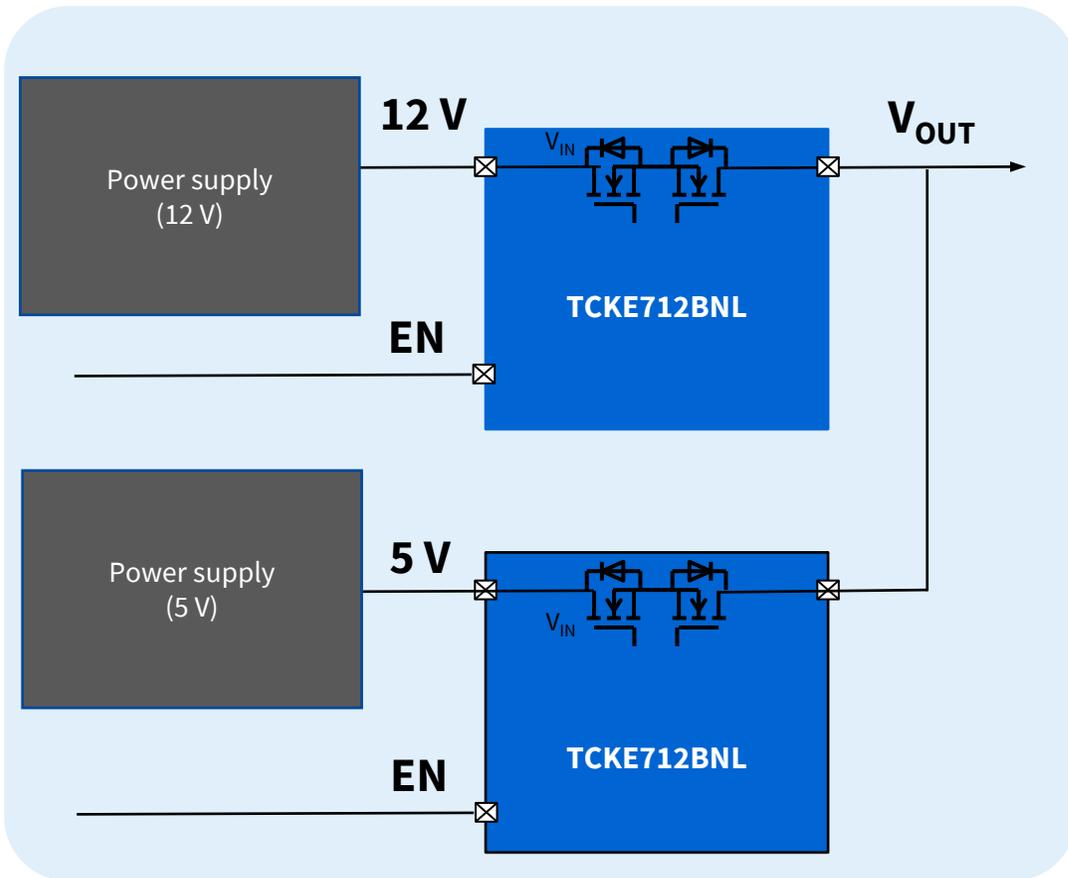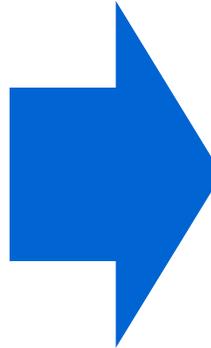
03

Current and future requirements for eFuse ICs

Current and future requirements for eFuse ICs

Applications in which eFuse ICs are currently used

Applications in which eFuse ICs are expected to be used in the future

Notebook PCs

SSDs/ HDDs

Game consoles

Servers

Industrial robots

Power tools

Small wearable devices

Automotive devices

eFuse ICs are expected to expand their application fields.

Current and future requirements for eFuse ICs

Market requirements

◆ **Enhanced ruggedness and safety**

◆ **Low power loss**

◆ **Cost reduction**

◆ **Stable availability**

◆ **Size reduction**

Future requirements for eFuse ICs

◆ **An increase in protection performance and withstand voltage**

◆ **A reduction in on-resistance via a driver configuration**

◆ **Integration of more functions to reduce the number of external parts required**

◆ **General-purpose eFuse ICs to support Mult sourcing**

Toshiba is developing eFuse ICs to expand their application fields.

04

Latest eFuse IC products
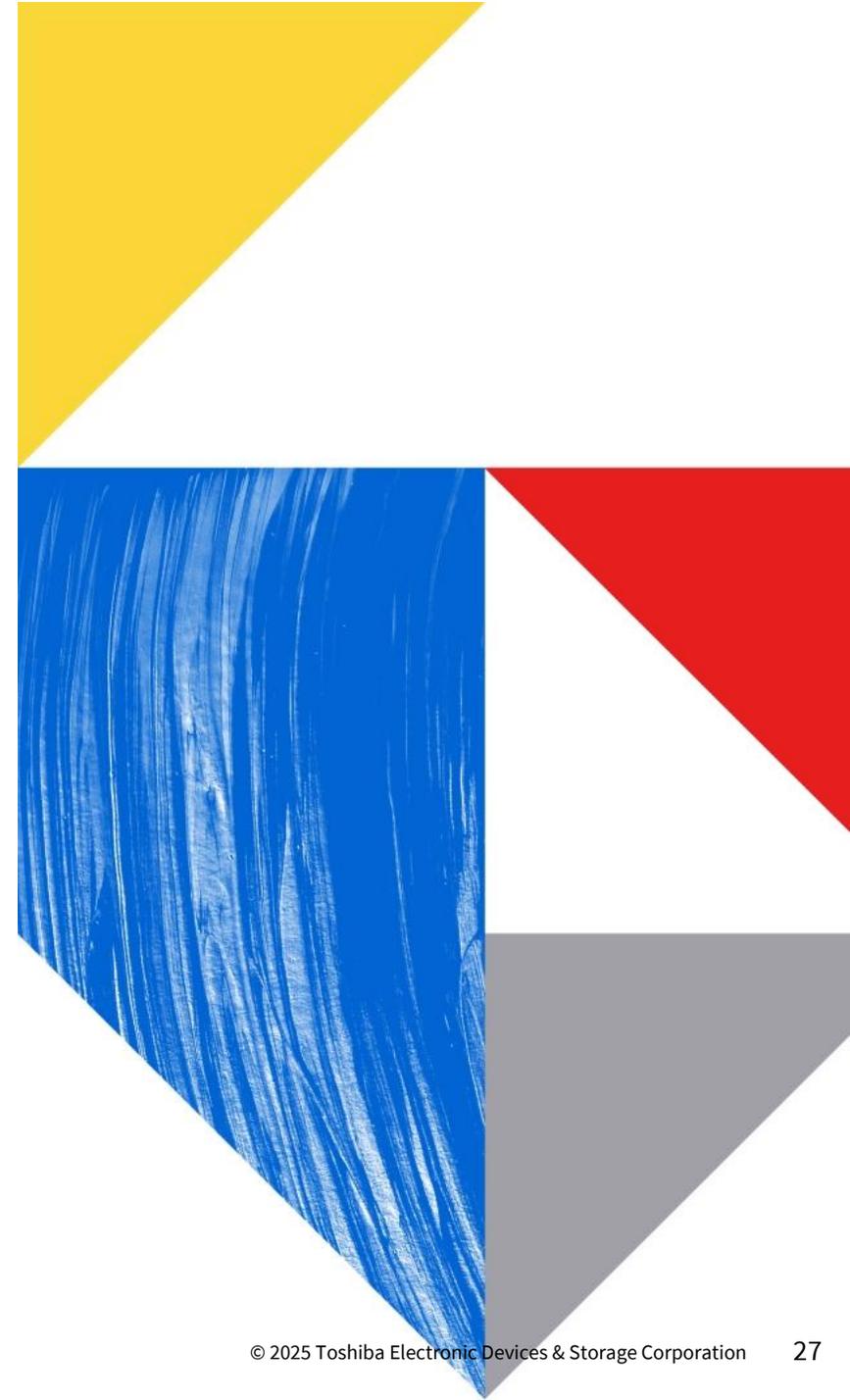
18-V/5-V eFuse ICs with variable overcurrent threshold and slew rate

TCKE800, TCK805, and TCK812 series
18-V/5-V eFuse ICs in a small package

Input voltage: 4.4 to 18 V
- Low R_{ON}: 28 mΩ (typ.), WSON10B

- Programmable OCP threshold via an external resistor: 0.5 to 5.0 A
- OCP threshold accuracy: ±11%
- OVC threshold accuracy: ±7%
  - TCKE805: 6 V (typ.)
  - TCKE805: 15 V (typ.)
  - TCKE800: No OVC
- Adjustable slew rate control via an external capacitor
- Reverse-current blocking via an external MOSFET (EN = Off)
- Thermal shutdown threshold: 160°C (typ.)
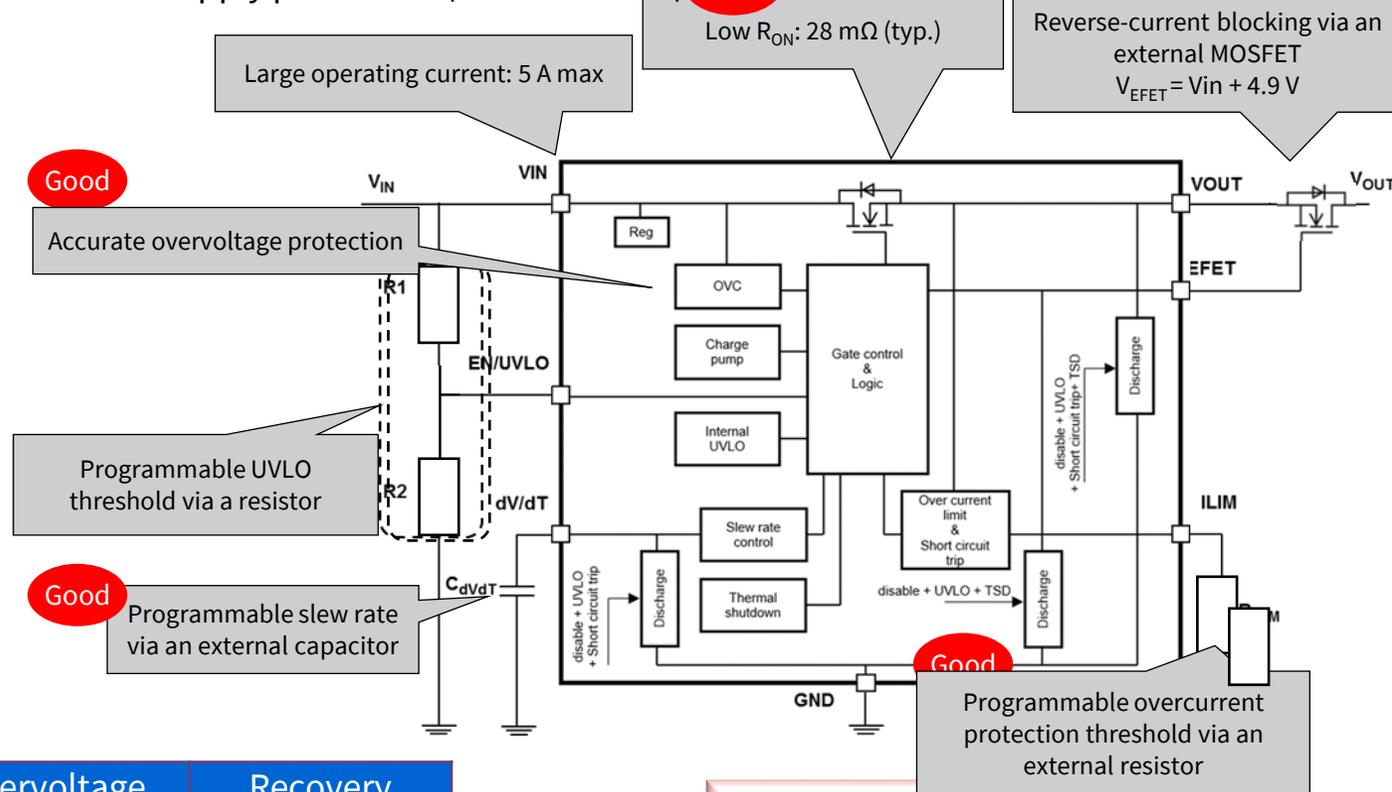- Auto recovery: Auto retry / latched
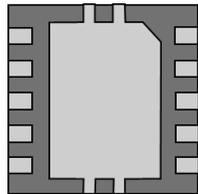
WSON10B
3.0 × 3.0 mm

IEC 62368-1-certified

Part Number	Overvoltage Protection	Recovery Operation
TCKE805NA	6.04 V	Auto retry
TCKE805NL	6.04 V	Latched
TCKE812NA	15.1 V	Auto retry
TCKE812NL	15.1 V	Latched
TCKE800NA	N/A	Auto retry
TCKE800NL	N/A	Latched

Typical applications
Power supply protection (unidirectional)

Good — Low R_{ON}: 28 mΩ (typ.)

Large operating current: 5 A max

Reverse-current blocking via an external MOSFET
V_{EFET} = Vin + 4.9 V

Good — Accurate overvoltage protection

Programmable UVLO threshold via a resistor

Good — Programmable slew rate via an external capacitor

Good — Programmable overcurrent protection threshold via an external resistor

Up to 18 V
Up to 5.0 A

eFuse
TCKE800
TCKE805
TCKE812

PMIC
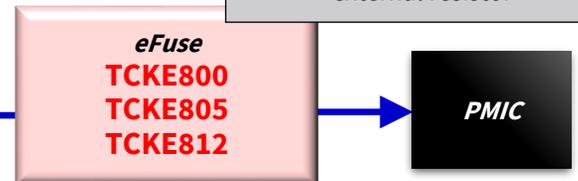
5-V power rail: TCKE805 OVC = 6.04 V (typ.)
12-V power rail: TCKE812 OVC = 15.1 V (typ.)

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eFuse IC with a reverse-current-blocking MOSFET and programmable OVP and OCP thresholds

TCKE712BNL
(with the FLAG output, programmable OVP and OCP thresholds, and a reverse-current-blocking MOSFET)
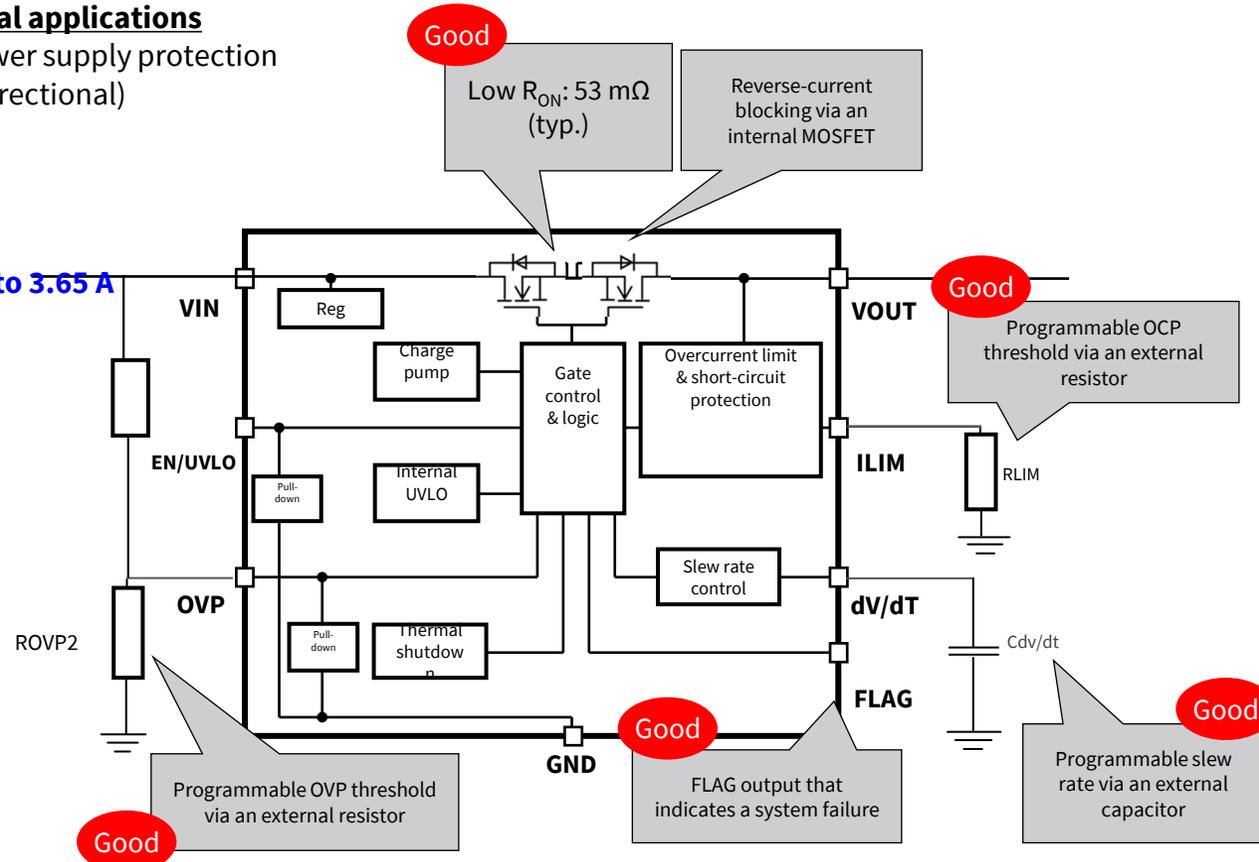
- Maximum input voltage: 18 V
- Operating voltage range: 4.4 to 13.2 V
- Low R_{ON}: 53 mΩ (typ.)
- **Programmable overcurrent protection (OCP) threshold via an external resistor: 0.51 to 3.65 A ± 20%**

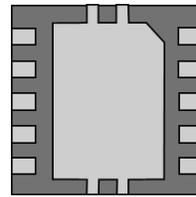| Input voltage	Programmable OCP threshold range
9.9 to 13.2 V	0.51 to 2 A (typ.)
5.5 to 9.9 V	0.51 to 2.58 A (typ.)
4.4 to 5.5 V	0.51 to 3.65 A (typ.)

- **Programmable overvoltage protection (OVP) threshold via an external resistor**
- **Programmable slew rate via an external capacitor**
- Quick short-circuit protection: 320 ns
- **Reverse-current blocking via an internal MOSFET (EN = off)**
- **FLAG output**
- Thermal shutdown: 134°C (typ.)
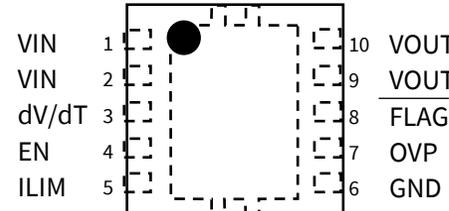- Latched recovery
- To be certified for IEC 62368-1

Available in production quantities

WSON10
3.0×3.0 mm

VIN	1	10 VOUT
VIN	2	9 VOUT
dV/dT	3	8 FLAG
EN	4	7 OVP
ILIM	5	6 GND

Typical applications
Power supply protection (unidirectional)

Good — Low R_{ON}: 53 mΩ (typ.)

Reverse-current blocking via an internal MOSFET

Good — Programmable OCP threshold via an external resistor

Good — Programmable OVP threshold via an external resistor

Good — FLAG output that indicates a system failure

Good — Programmable slew rate via an external capacitor

Application example for an eFuse IC

Up to 15 V
Up to 1.5 A

eFuse TCKE712BNL → PMIC

FLAG

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25-V/4-A eFuse ICs with a Adjustrable overcurrent protection threshold in a small package

TCKE903/905/912 and 920 series
## Small 25-V/4-A eFuse ICs

- High input voltage: VIN = **25.0 V (Max)**
- Low ON resistance RON: 34 mΩ (Typ.)
- Adjustable overcurrent limit: 0.5 A to 4.0 A
- Fixed over voltage clamp
  - TCKE903: VOVC = 3.87 V (Typ.)
  - TCKE905: VOVC = 5.7 V (Typ.)
  - TCKE912: VOVC = 13.7 V (Typ.)
  - TCKE920: VOVC = 22.2 V (Typ.)
- Adjustable slew rate control by external capacitance for inrush current reduction
- Adjustable under voltage lockout by external resistor
- Thermal shutdown
- Quick output discharge: TCKE903QNA, TCKE905QNA
- Small package : WSON8 (2.0 mm (Typ.) x 2.0 mm (Typ.), t: 0.8 mm (Max)).
- IEC62368-1 (G9: Integrated circuit (IC) current limiters) Certified (Under planning)

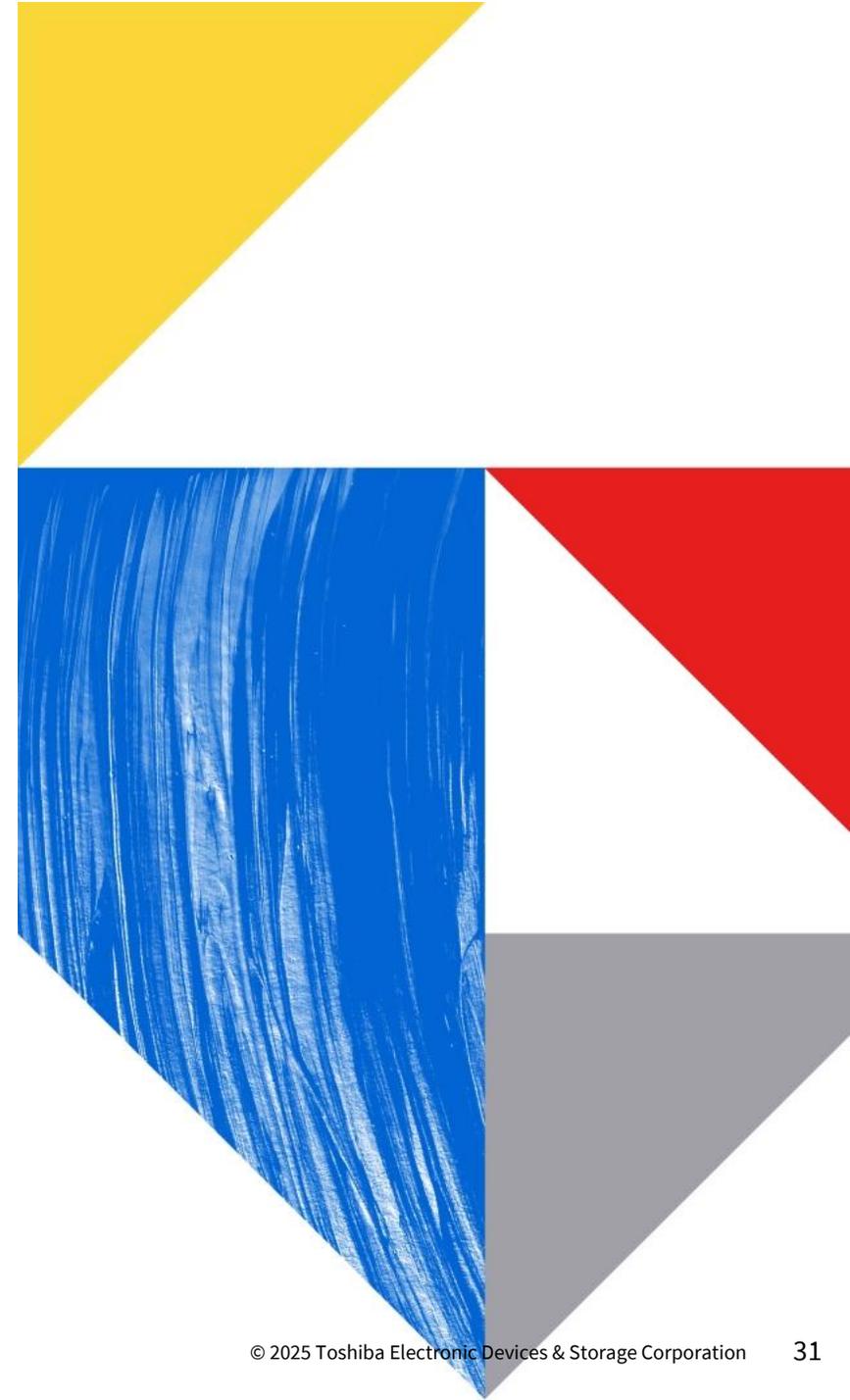**Typical applications**
Power supply protection (unidirectional)

Power rail

TCKE9xx

VIN — VOUT
EN — Fault
dV/dT — ILIM

CdV/dT

RILIM
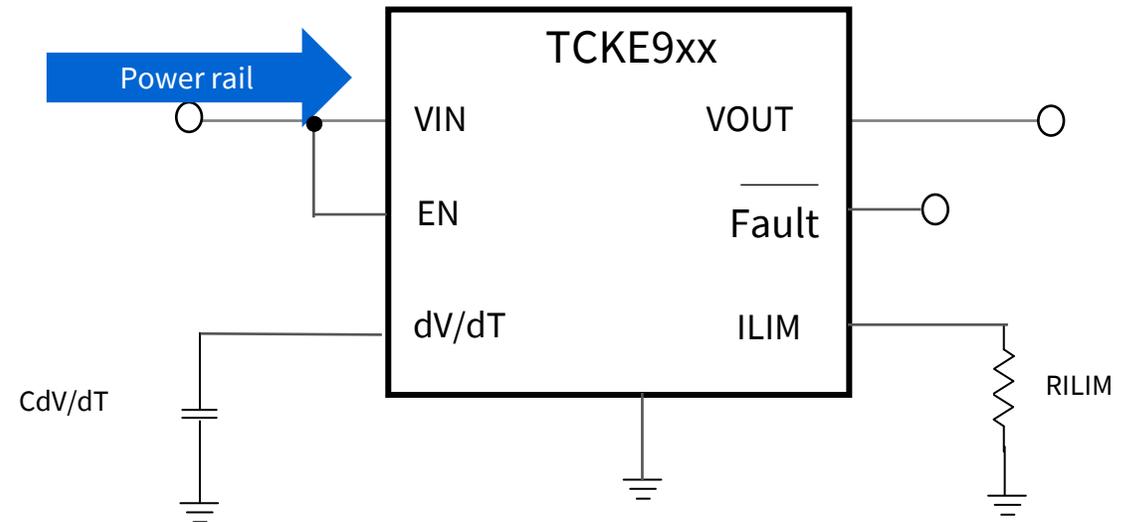
Ultra-small
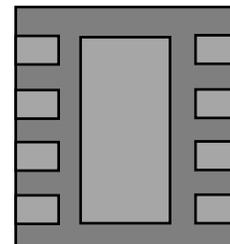
WSON8
2.0 × 2.0 mm

Application example of eFuse

~23V

eFuse
TCKE9xx

~4A

PMIC

FLAG
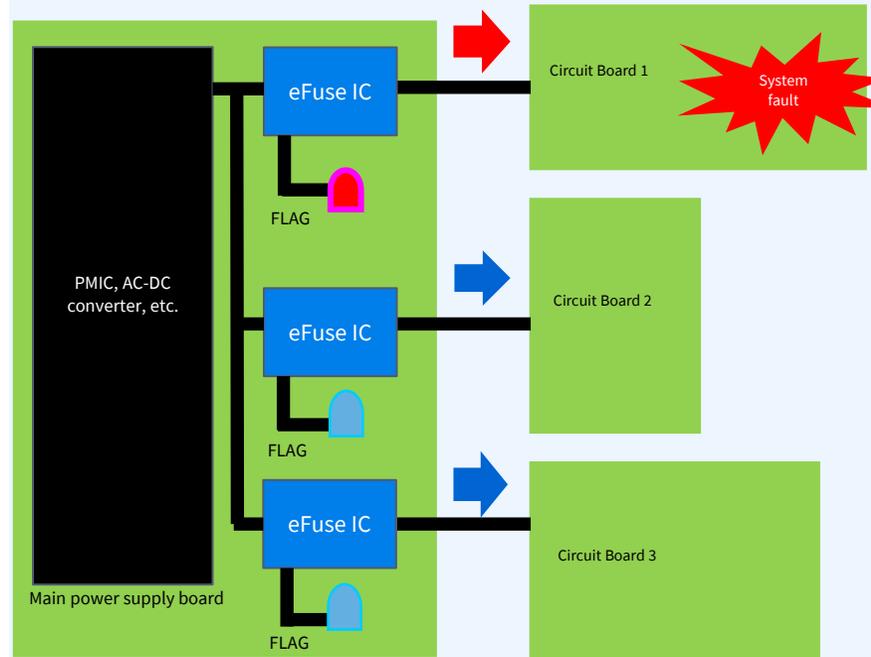
05

Summary of today's webinar

Summary of today's webinar

Protection of power rails from hot plugging

Toshiba's eFuse ICs

Accurate system fault detection using the FLAG output

PMIC, AC-DC converter, etc.

Main power supply board

eFuse IC — FLAG

eFuse IC — FLAG

eFuse IC — FLAG

Circuit Board 1 — System fault

Circuit Board 2

Circuit Board 3

TCKE712BNL
TCKE9xx series (under development)

Power multiplexing using the reverse-current blocking function

Power supply (12 V) — 12 V — VIN — ON — VOUT — TCKE712BNL

Power supply (5 V) — 5 V — VIN — OFF — VOUT — TCKE712BNL
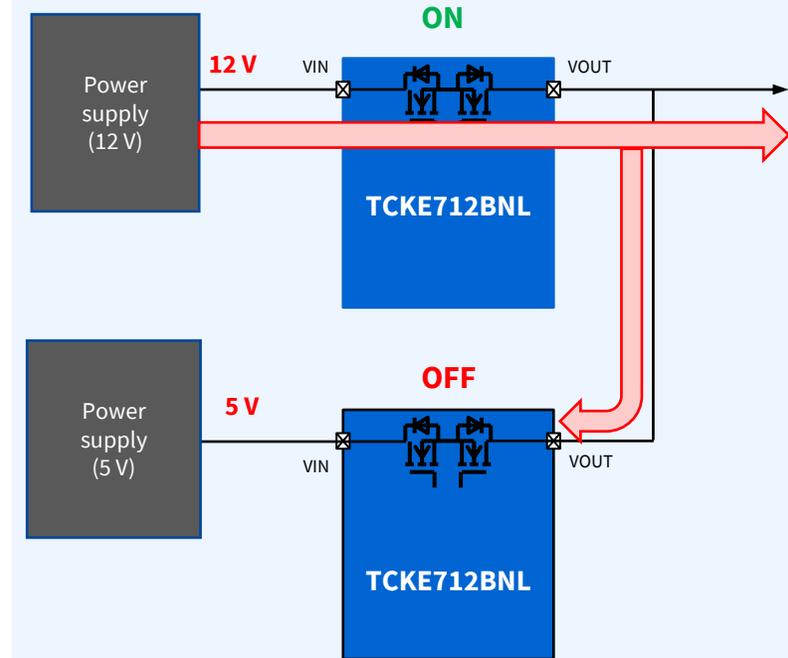
TCKE712BNL
TCKE8xx series (optional)

In addition to accurate overcurrent protection, eFuse ICs provide various features that simplify circuit protection for a wide range of applications.

Summary of today's webinar

◆ Toshiba is expanding its portfolio of eFuse ICs to support protection of high-voltage, high-current power rails.

◆ Toshiba's eFuse ICs simplify accurate power rail protection for a wide range of applications while reducing the board area requirement.

◆ You can purchase all the eFuse ICs shown today from the following site:

Online distributor inventory search & low-volume purchase   **Click**

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Thank you for your attention.

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