ROHM Establishes QuiCur™, that Maximizes the Response Performance of Power Supply ICs

Contributes to reducing power supply circuit design resources by providing stable operation with fewer external components

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ROHM Co., Ltd.
Marketing Communications Dept.

*Please note that this document is current as of the date of publication

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Market Background of Power Supply ICs

◆System becoming highly functional

Market expansion of 48V system

Conventional

Forklift
DC48V (Pb)

Base Station
Backup Power
DC48V (Pb)

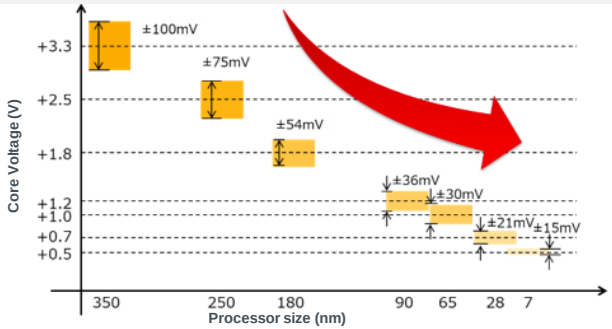
Industrial Robot
DC48V

+

New

48V Mild Hybrid Vehicle

CPU miniaturization and lower voltage



Lower system voltage & higher system current consumption ➡ Need the stable power supply (Increasing Output Capacitance)

◆System becoming miniaturizing and space-saving

Miniaturization of wearables / IoT devices

Multi-functionalization of Automotive system

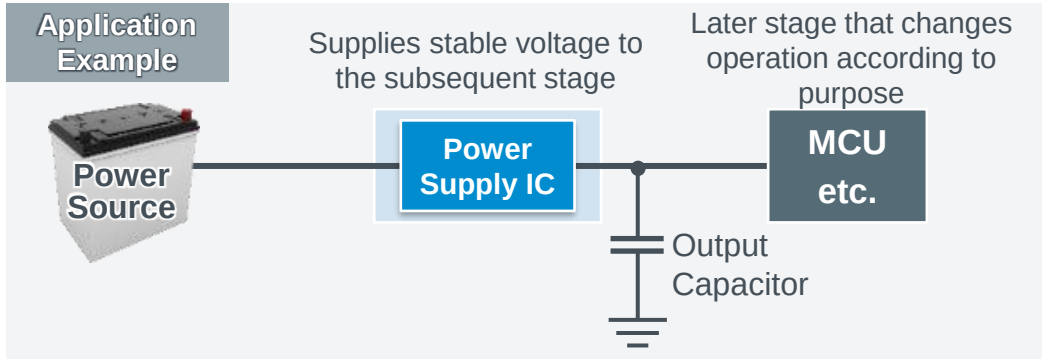
Increasing demand for capacitors (parts)

Reducing system mounting space ➡ Want to reduce the parts (Reducing Output Capacitance)

Power Supply IC is required not only to reduce the size of Output Capacitor, but also to adapt to a wide range of Output Capacitance

Requirements of Power Supply ICs

◆Requirements of Power Supply ICs



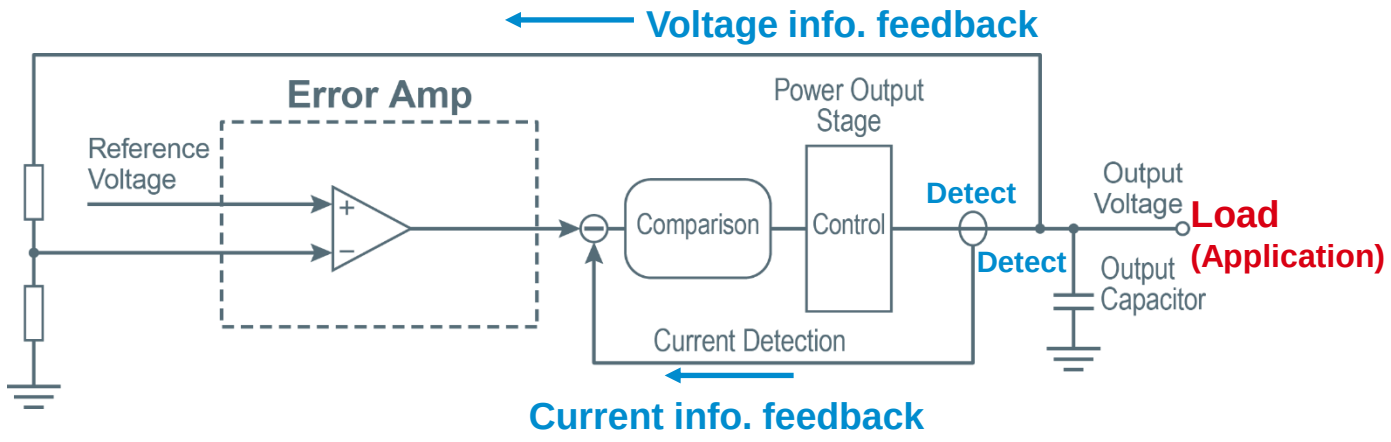
Under any conditions, it is required to supply a stable voltage to the subsequent stage

- When stable operation
- When changing input voltage by power source
- When changing load current by later stage

Output stability during load current fluctuation is determined by the Power Supply IC response performance and the Output Capacitance

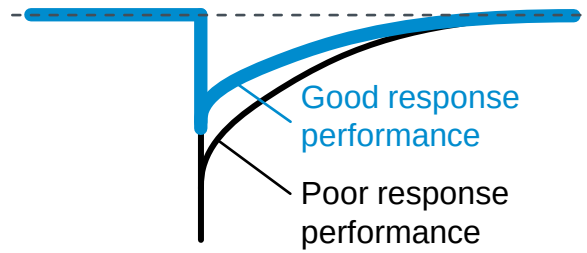
◆How to achieve voltage stability during load current fluctuation

Feedback circuit of a Power Supply IC



If the power supply IC feedback circuit can respond more quickly, the output voltage fluctuation when the load current fluctuates will be smaller

Output voltage response waveform by load current fluctuation

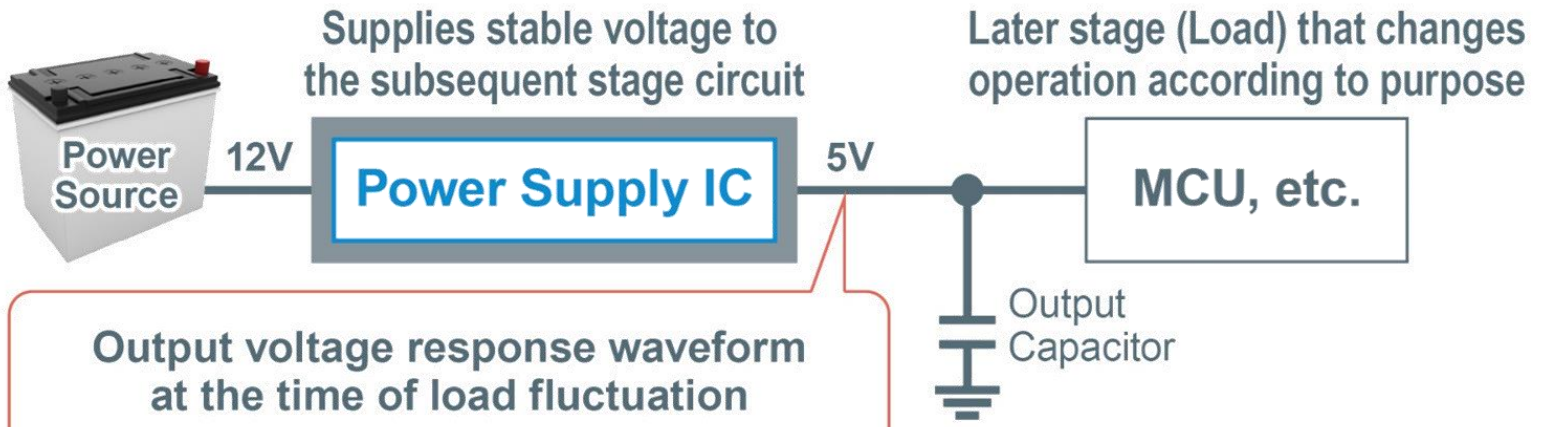


*Assuming the same output capacitance

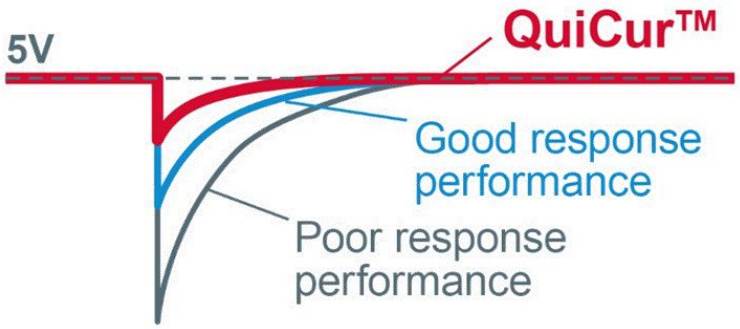
Power Supply IC constantly monitors the output voltage and compares the information with the reference voltage to return the output voltage to the desired value even when the load current fluctuates

Concept of QuiCur™: ROHM's New High-Speed Load Response Technology

Power Supply IC application example



Output voltage response waveform at the time of load fluctuation



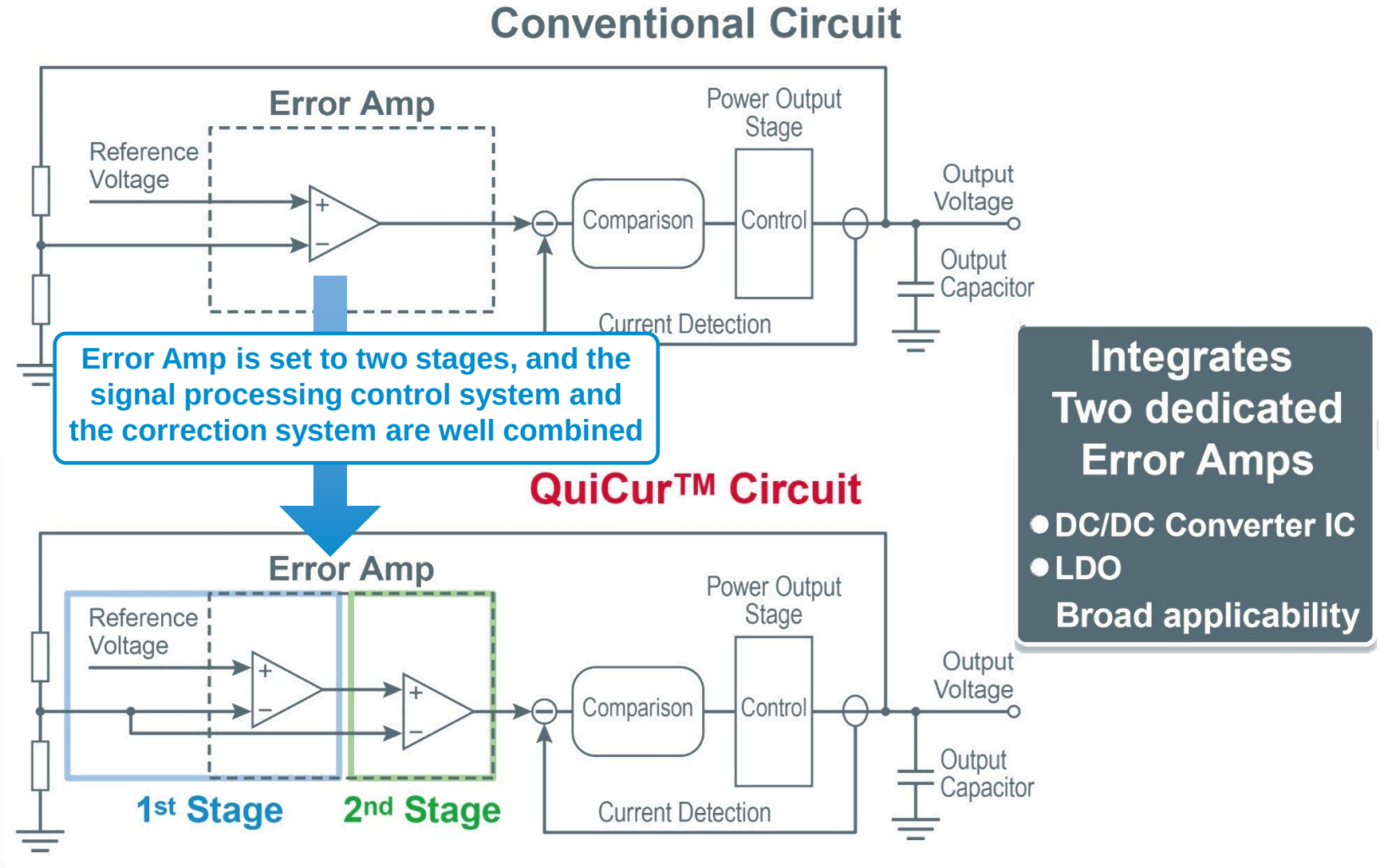
Voltage stability during load current fluctuation depends on the response performance of the power supply IC

*Assuming the same output capacitance

QuiCur™ is an innovative technology designed to maximize the response performance of power supply ICs

Circuit Overview of QuiCur™

Comparison in the feedback circuit of a DC/DC Converter IC



Contribution of QuiCur™

QuiCur™ is named after ROHM's original Quick Current circuit that provides high-speed load response

This allows users to achieve ideal load transient response characteristics without causing instability in feedback circuits

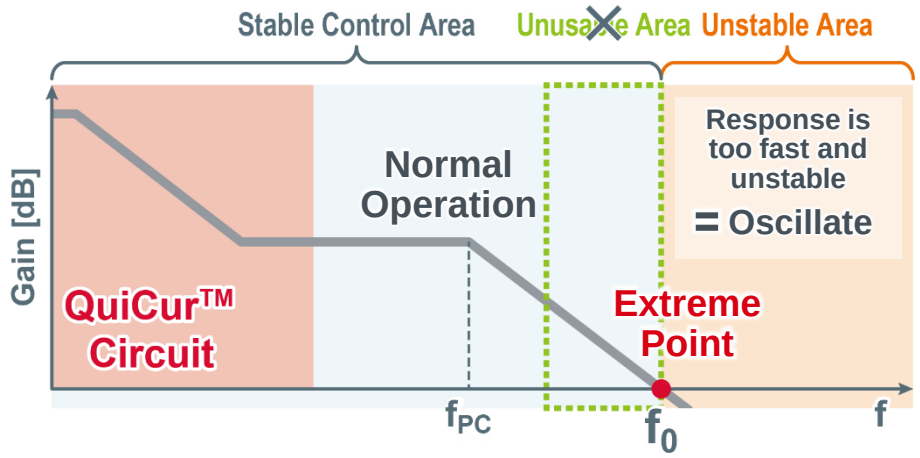
Feature1 Reduces the number of capacitors along with board mounting area

QuiCur™ can quickly respond to output fluctuations in response to load current. Decreasing the external parts together with board space by minimizing the output capacitance required by the power supply IC.

Feature2 Easily achieves stable operation even when specifications change

QuiCur™ enables linear adjustment of both the output capacitance and output voltage fluctuation since the instantaneous response performance does not change even when the output capacitance increases.
This makes it easy to achieve the expected output voltage fluctuation value when changing specifications.

Frequency response graphs by Bode Plot



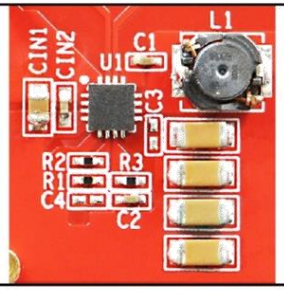
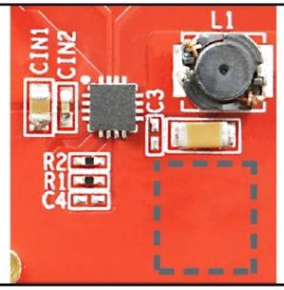
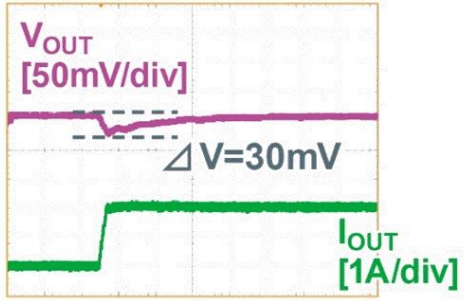
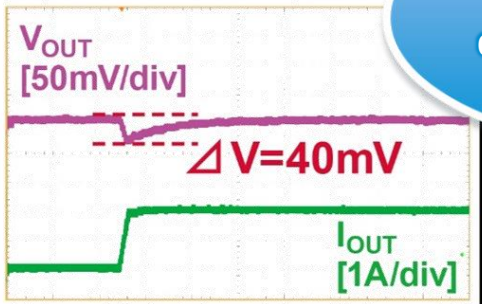
Measure of response performance: Zero-cross Frequency (f_0) is set to the extreme point where it will not become unstable

QuiCur™ contributes to reducing power supply circuit design resources by providing stable operation with fewer external components

Feature 1:
Reduces the number of capacitors along with board mounting area

Effects of QuiCur™ on DC/DC Converter IC

Comparison with conventional product: When reducing Output Capacitance

	ROHM Conventional DC/DC Converter IC	QuiCur™-equipped DC/DC Converter IC (Under Development)
Output Capacitance	88µF (22µF×4)	**22µF** (22µF×1)
Board Image		
Zero-Cross Frequency	100kHz	**300kHz**
Load Response Waveforms (0A→2A) V_{IN}=5.0V, V_{OUT}=1.0V, I_{OUT} =0A→2A (1A/µs)		

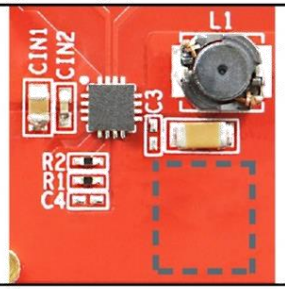
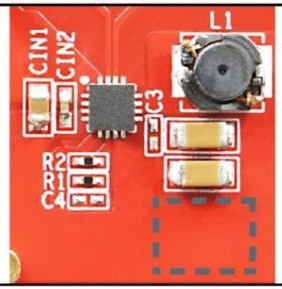
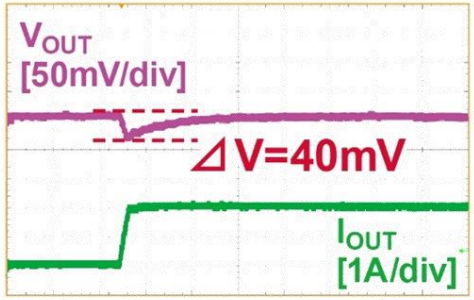
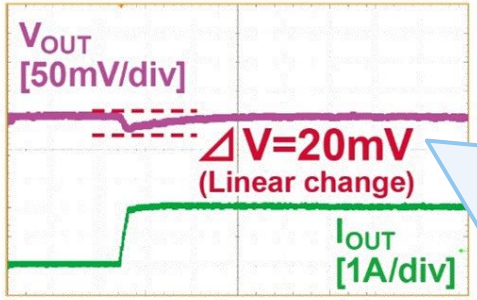
In LDO, response performance can be dramatically improved by QuiCur™

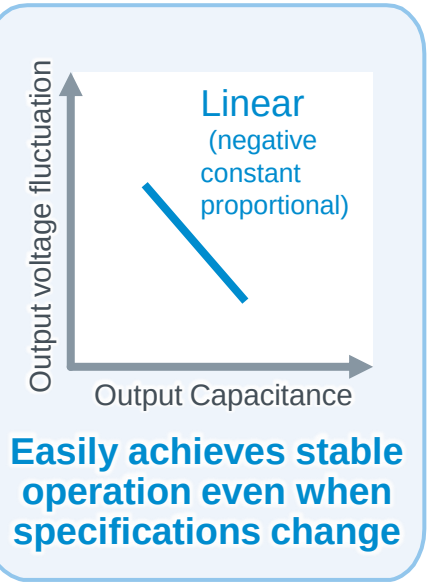
QuiCur™ can maintain response performance even at a quarter of the Output Capacitance

Feature 2:
Easily achieves stable operation even when specifications change

Effects of QuiCur™ on DC/DC Converter IC

Comparison with QuiCur™-equipped product: When increasing Output Capacitance

	QuiCur™-equipped DC/DC Converter IC (Under Development)	QuiCur™-equipped DC/DC Converter IC (Under Development)
Output Capacitance	22µF (22µF×1)	44µF (22µF×2)
Board Image		
Zero-Cross Frequency	300kHz	300kHz (No change)
Load Response Waveforms (0A→2A) V_{IN}=5.0V, V_{OUT}=1.0V, I_{OUT} =0A→2A (1A/µs)		

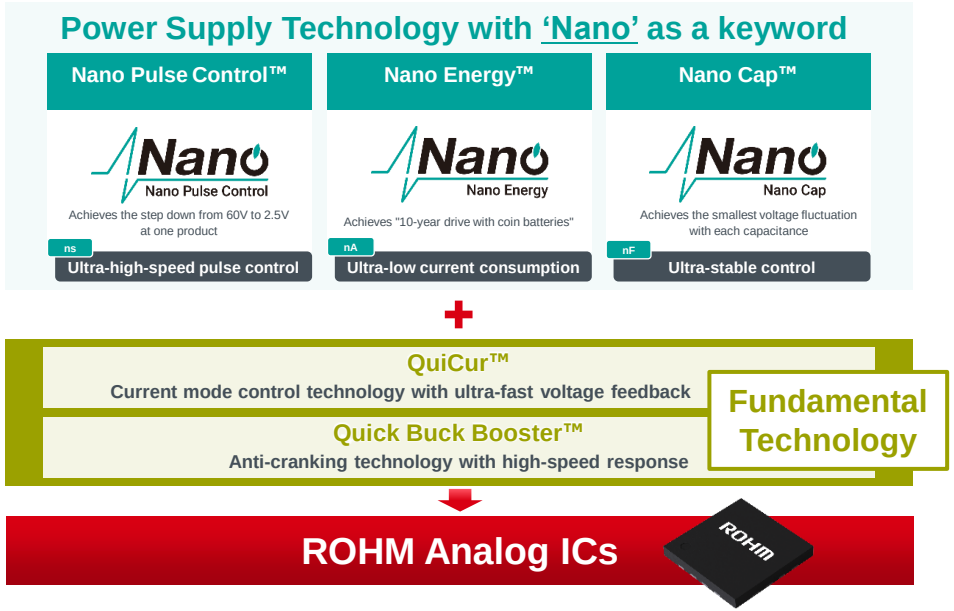


Easily achieves stable operation even when specifications change

QuiCur™ allows for linear adjustment of the Output Capacitance and Output Voltage fluctuation

QuiCur™ Deployment to Products

◆Roles of QuiCur™ and "Nano" Power Supply Technology



Nano

- Power Supply Technology to achieve flagship specifications in various fields
- Contribute to solving customer issues with easy-to-understand numerical values

QuiCur™

- Power Supply Technology that can pursue the response performance of feedback circuit to the limit
- Contribute to customers by improving the response performance of a wide range of products as a fundamental technology

The combination of the two technologies adds depth to the ROHM's Power Supply Technology

◆Activity to QuiCur™-equipped product (in 2022)

Product	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.
DC/DC Converter ICs (Buck, Automotive grade)				✓					
LDOs (Automotive grade)							✓		

✓: Product sample available

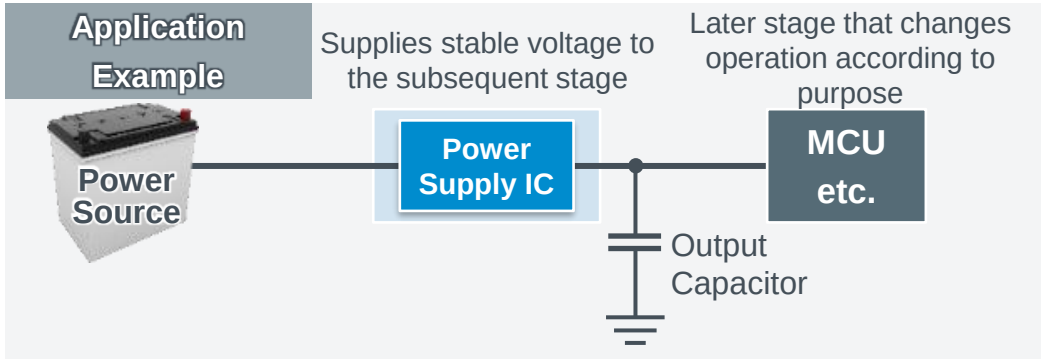
Deploy QuiCur™ in a wide type of Power Supply ICs

Technical detail description of QuiCur™ using frequency response graphs by Bode Plot

Requirements of Power Supply IC (Technical)

TechWeb: Evaluating Frequency Characteristics for Checking Output Stability and Response
https://techweb.rohm.com/tech-info/engineer/9477

◆Requirements of Power Supply IC



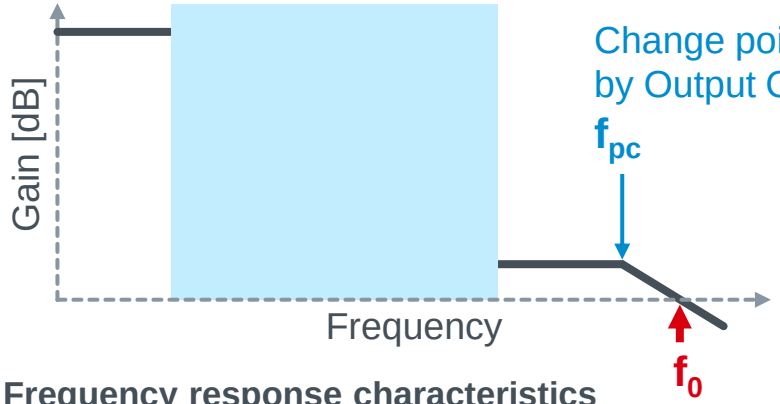
Under any conditions, it is required to supply a stable voltage to the subsequent stage

- When stable operation
- When changing input voltage by power source
- When changing load current by later stage

Output stability during load current fluctuation is determined by the Power Supply IC response performance and the Output Capacitance

◆How to think of stability during load current fluctuation

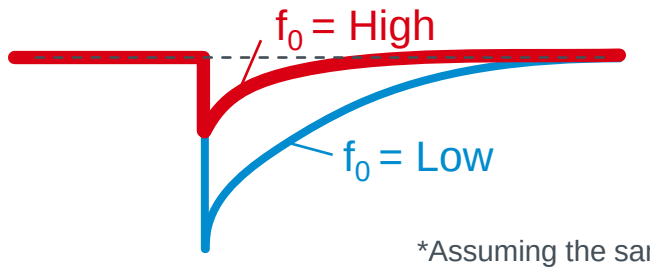
Load response performance is determined by frequency response characteristics



Ex) Frequency response characteristics graph of Power Supply IC

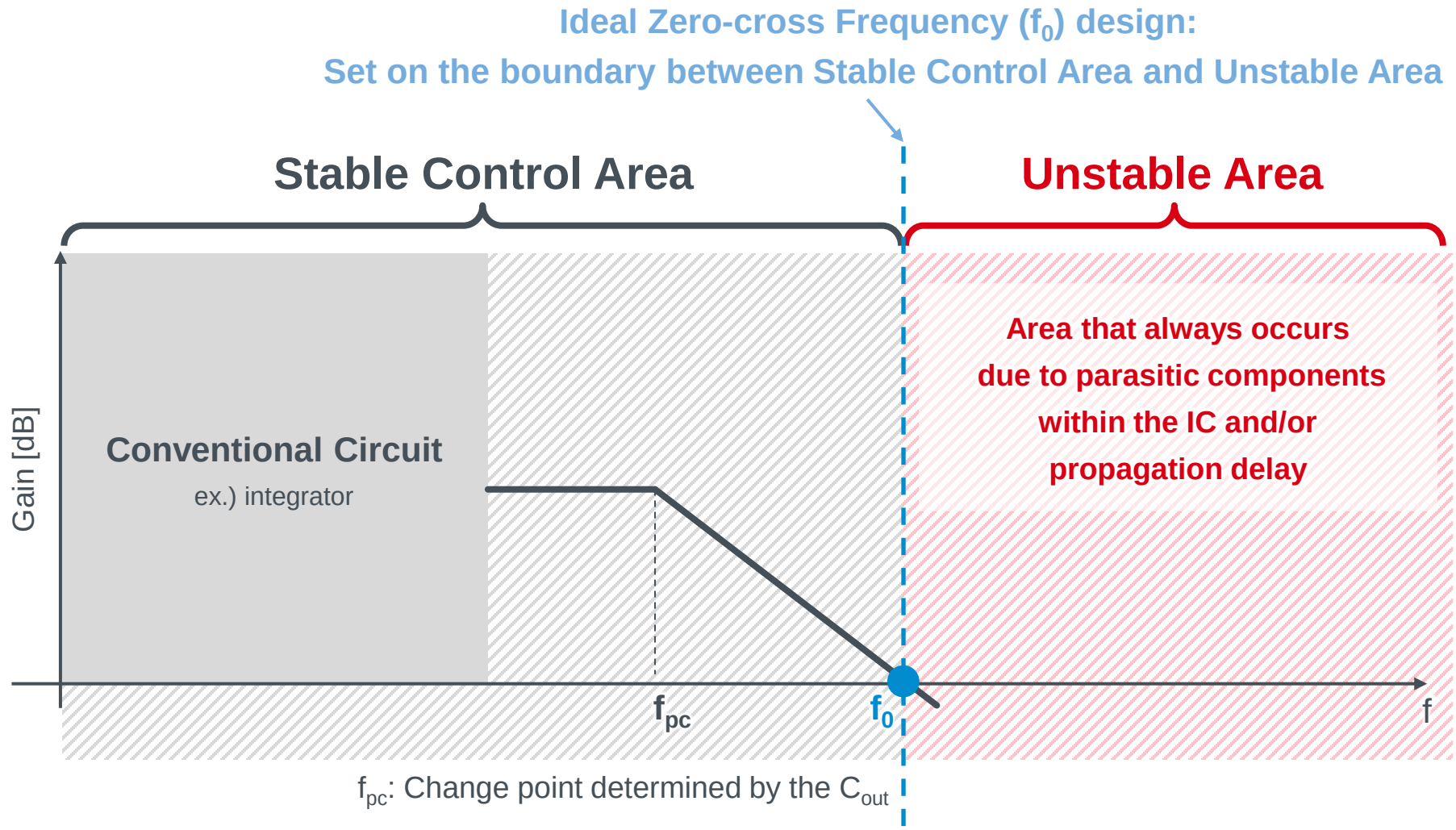
If higher f_0, the better the response performance and the smaller the amount of out voltage fluctuation when the load current fluctuates

Output voltage response waveform by load current fluctuation



*Assuming the same output capacitance

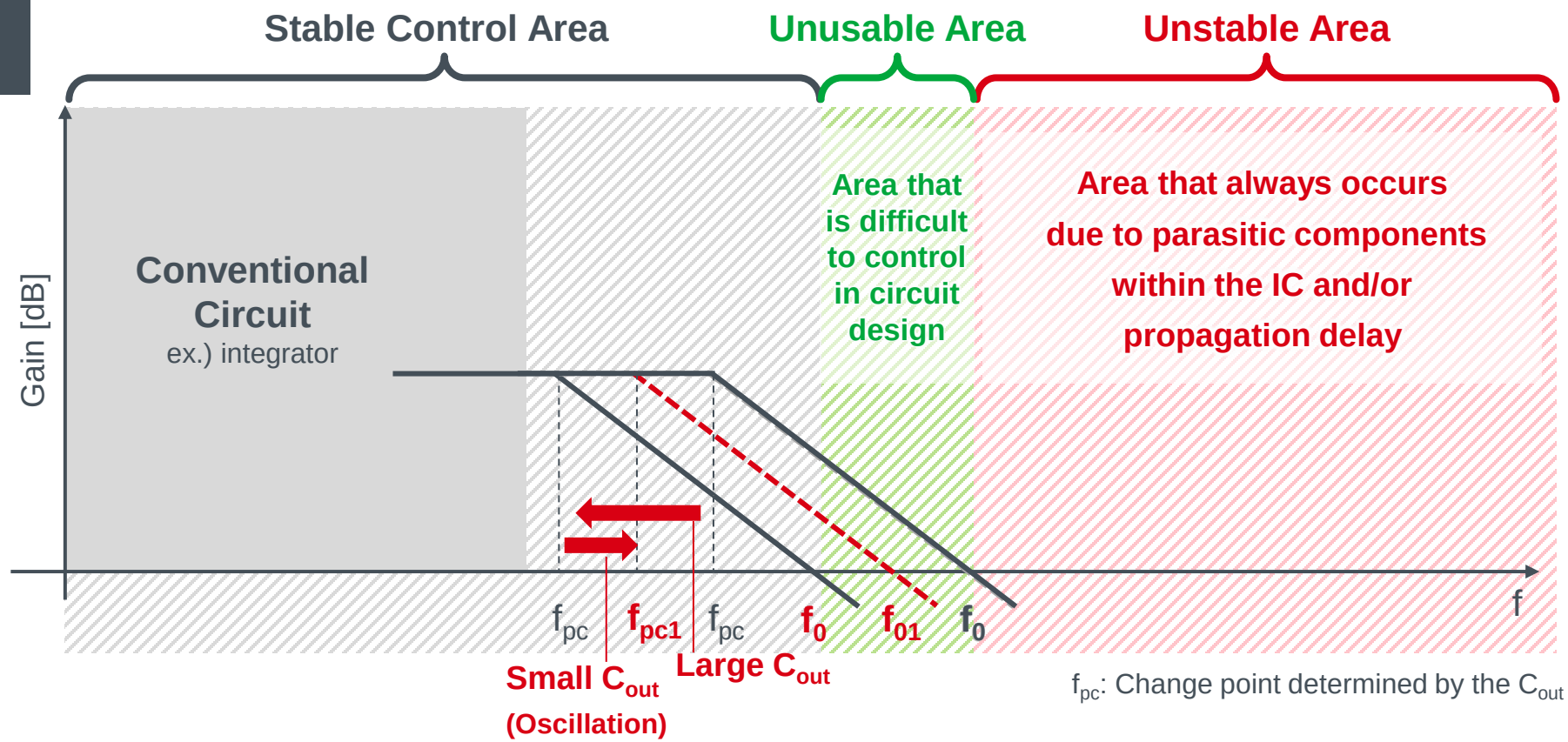
What is ROHM's QuiCur™ ?: Preamble



QuiCur™ can achieve the ideal design concept, which was natural but difficult to realize

What is ROHM's QuiCur™ ?: Conventional Issue

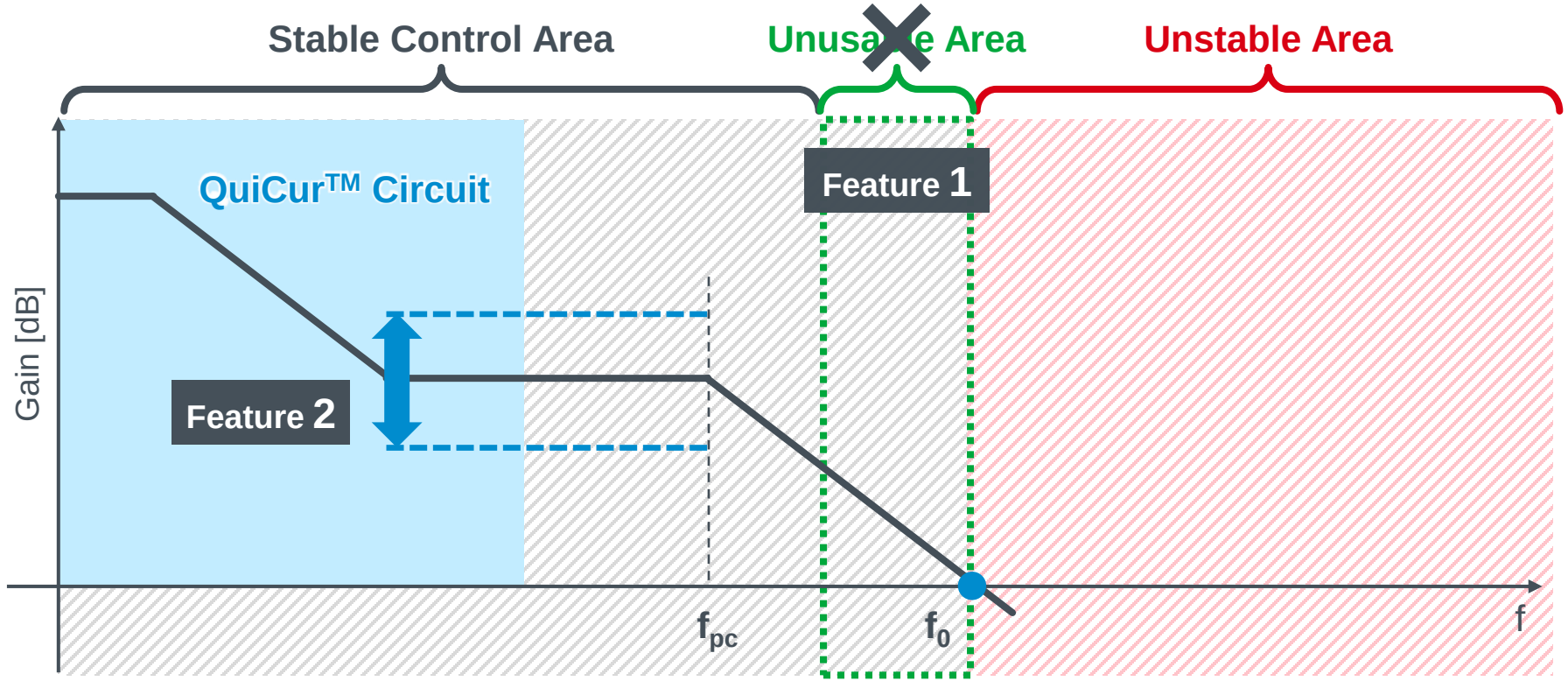
Conventional Circuit Issue



Conventional Circuit has often constrained response performance by Output Capacitance

Issue 1	**An unusable area occurs before the unstable area (The zero-cross frequency cannot be high)**
Issue 2	**The zero-cross frequency (f_0) changes depending on the output capacitance**

What is ROHM's QuiCur™ ?



Feature

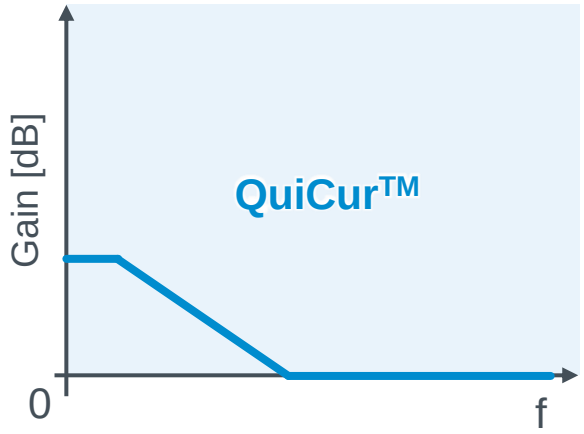
1. No unusable area occurs before the unstable area
2. Can adjust the high-frequency Gain

Core Technology

- 1 Pole, 1 Zero system and High-frequency Gain = 0dB system
- High-frequency Gain adjustment system by quick current drive

Core Technology of QuiCur™

1 Pole, 1 Zero system and High-frequency Gain = 0dB system



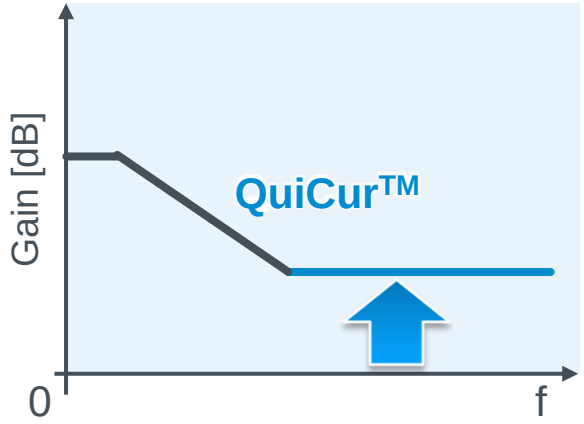
1 Pole, 1 Zero

Maintain stability up to high-frequency (f_{pc}) with 1 Pole and 1 Zero

High-frequency Gain = 0dB

By setting Gain to low, Gain can be maintained up to high-frequencies (f_{pc})

High-frequency Gain adjustment system by quick current drive



Gain adjustment by quick current drive

Gain can be maintained up to high-frequency (f_{pc}) by quick current drive

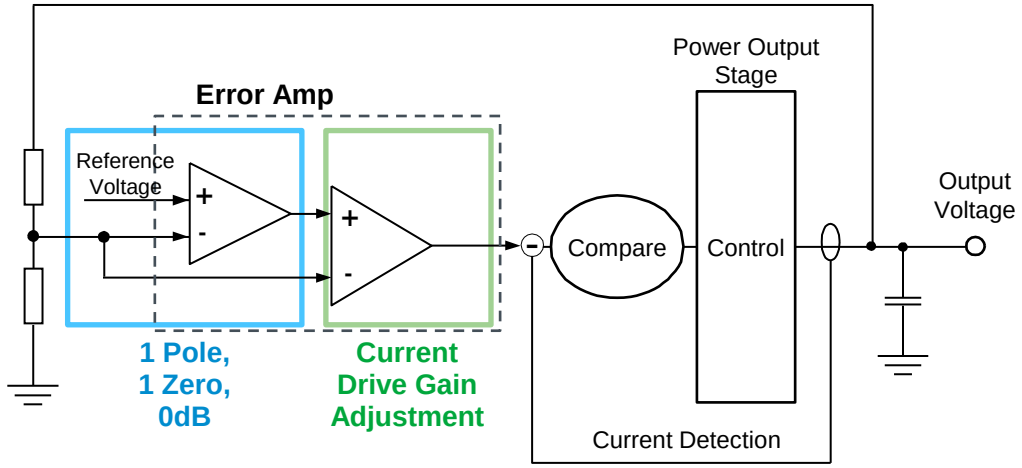
Quick Current is the naming origin of QuiCur™

QuiCur™ is made by the advanced combination of two core technologies

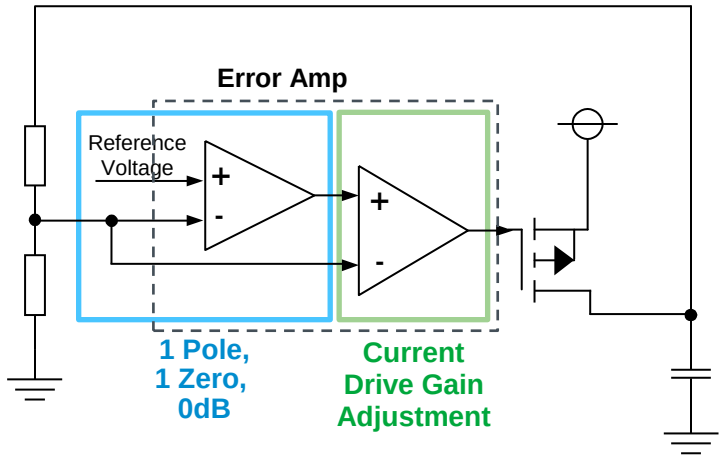
QuiCur™ Circuit Topology for each Power Supply ICs

Proper use for DC/DC Converter IC and LDO

QuiCur™-equipped DC/DC Converter IC (Switching Regulator)



QuiCur™-equipped LDO (Linear Regulator)



Integrates Two dedicated Error Amps

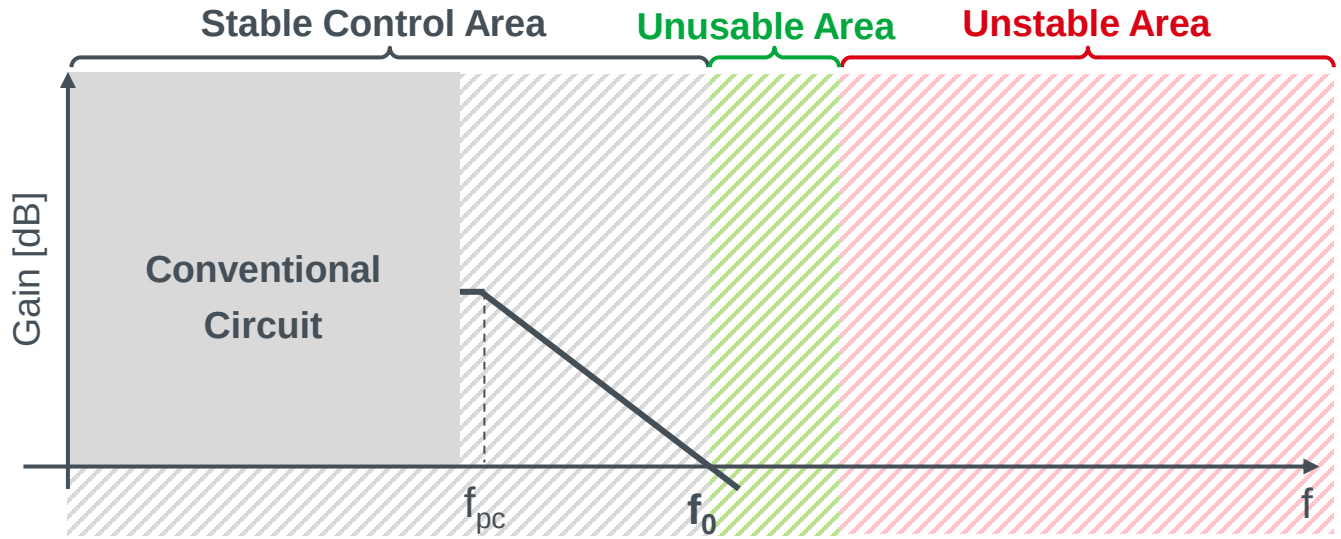
1st Stage Amp: 1 Pole, 1 Zero system and High-frequency Gain 0dB system

2nd Stage Amp: High-frequency Gain adjustment system by quick current drive

QuiCur™ can be applied to DC/DC converter IC or LDO, and can improve the response performance of a wide range of power supply ICs

Issue 1: Correspondence to "Zero-cross Frequency (f_0) cannot be set to the boundary with Unstable Area"

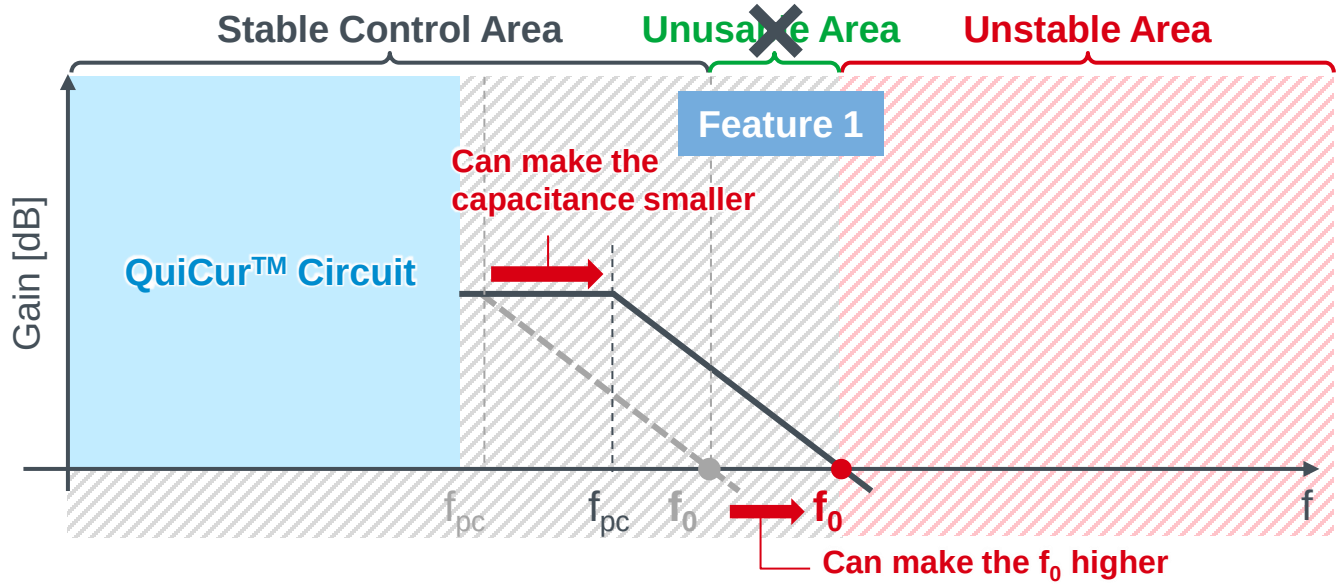
Conventional Circuit



Issue

An unusable area occurs before the unstable area by pole. Zero-cross Frequency (f_0) cannot be set to the boundary with Unstable Area.

QuiCur™ Feature 1



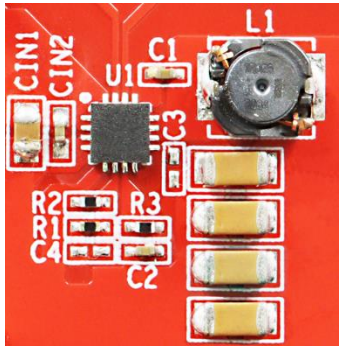
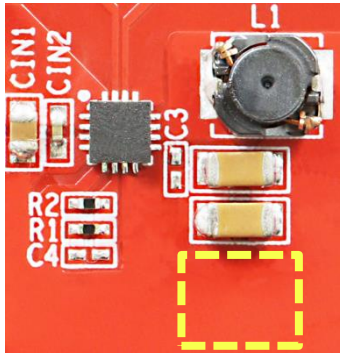
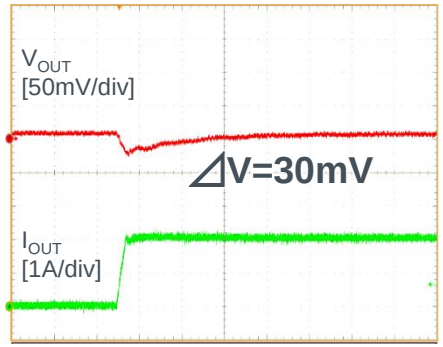
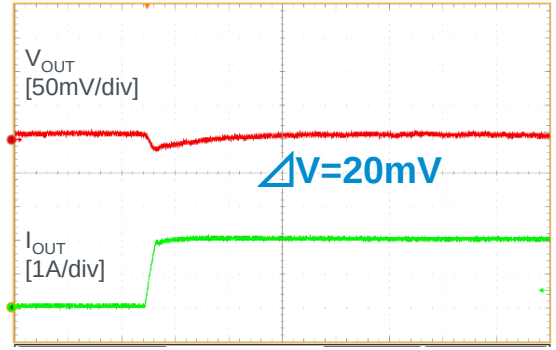
Feature 1

No unusable area occurs before the unstable area.

Effects

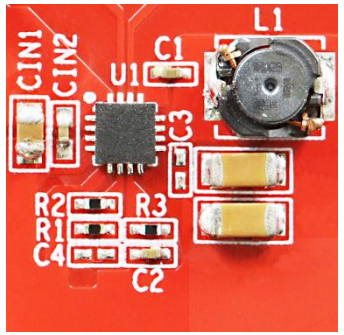
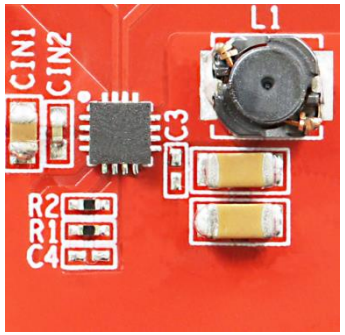
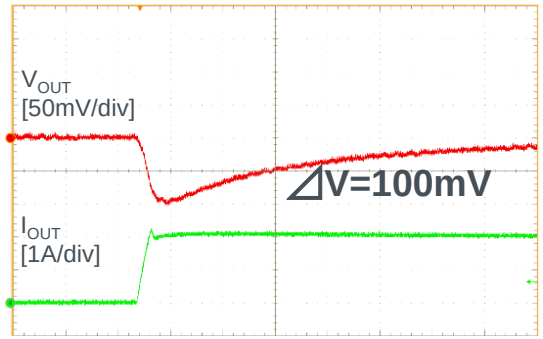
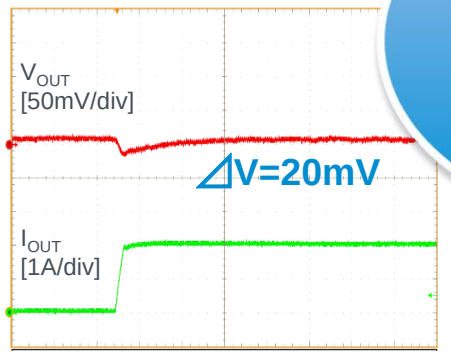
By reducing the lower limit of Output Capacitance, Zero-cross Frequency (f_0) can be set to the boundary with Unstable Area.

Effects of QuiCur™ on DC/DC Converter IC
Issue 1: "Occurrence of Unusable Area" effect verification

	ROHM Conventional	QuiCur™-equipped DC/DC Converter IC (Under Dev.)
Output Capacitance	88µF (22µF×4)	44µF (22µF×2)
Board Image		
Load Response Waveforms (0 → 2A)	 VIN=5.0V, VOUT=1.0V, IOUT =0A→2A (1A/µs)	 VIN=5.0V, VOUT=1.0V, IOUT =0A→2A (1A/µs)

QuiCur™ can reduce the lower limit of output capacitance and achieve stable operation

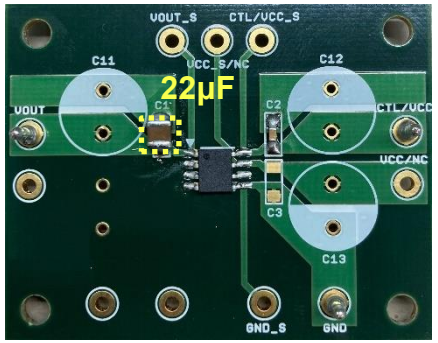
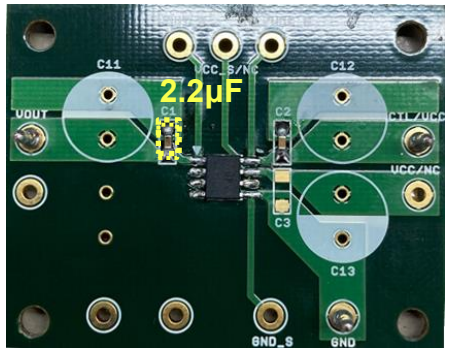
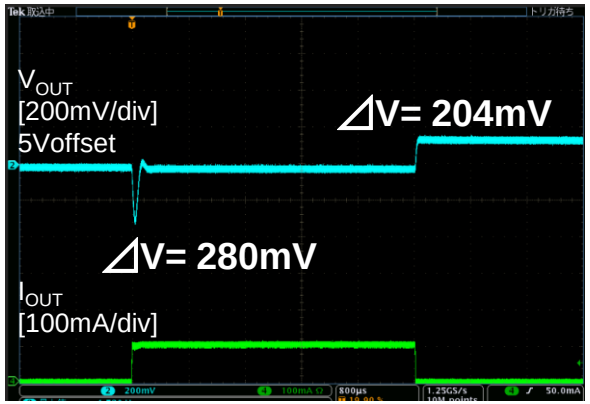
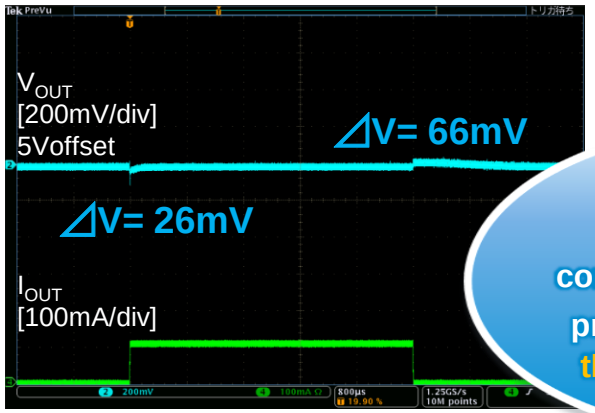
(Add.) Effects of QuiCur™ on DC/DC Converter IC
Comparison of output voltage fluctuations with the same output capacitance

	ROHM Conventional	QuiCur™-equipped DC/DC Converter IC (Under Dev.)
Output Capacitance	44µF (22µF×2)	44µF (22µF×2)
Board Image		
Zero-cross Frequency	100kHz	300kHz
Load Response Waveforms (0 → 2A)	 VIN=5.0V, VOUT=1.0V, IOUT =0A→2A (1A/µs)	 VIN=5.0V, VOUT=1.0V, IOUT =0A→2A (1A/µs)

QuiCur™ is overwhelming when compared to conventional products with same output capacitance

QuiCur™ achieves dramatic responsiveness performance

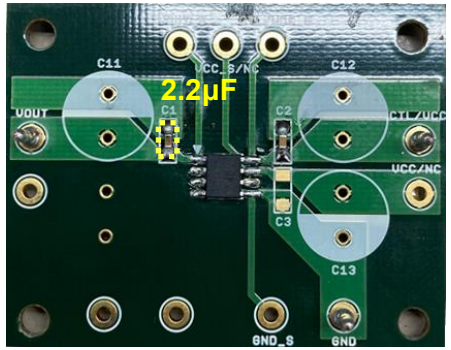
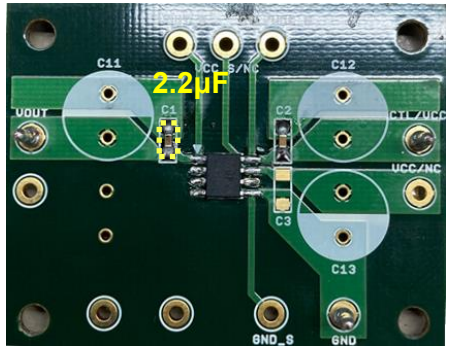
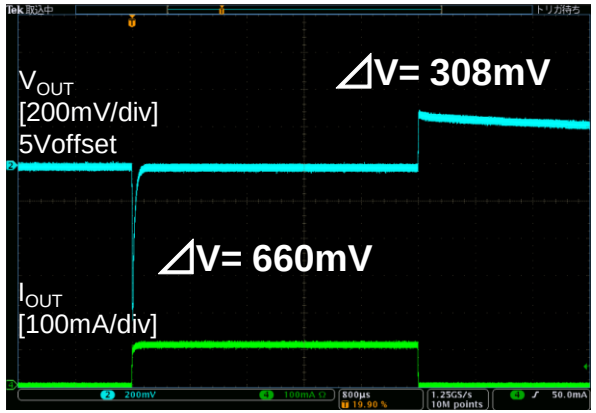
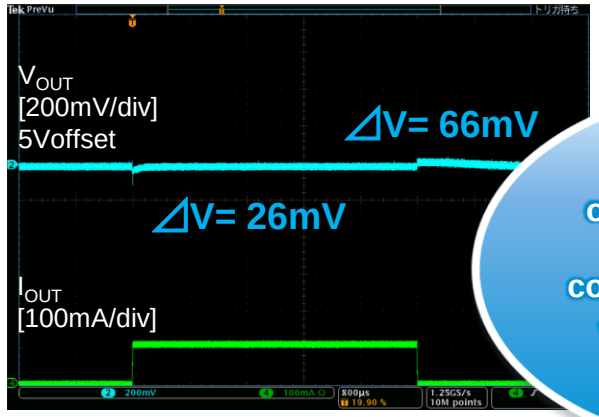
Effects of QuiCur™ on LDO
Issue 1: "Occurrence of Unusable Area" effect verification

	ROHM Conventional	QuiCur™-equipped LDO (Under Dev.)
Output Capacitance	22µF	2.2µF
Board Image		
Load Response Waveforms (0 → 100mA)	 VOUT=5.0V, IOUT =0A→100mA (100mA/µs)	 VOUT=5.0V, IOUT =0A→100mA (100mA/µs)

QuiCur™ is more responsive when compared to conventional products with 10 times the output capacitance

QuiCur™ achieves dramatic responsiveness performance

(Add.) Effects of QuiCur™ on LDOs
Comparison of output voltage fluctuations with the same output capacitance

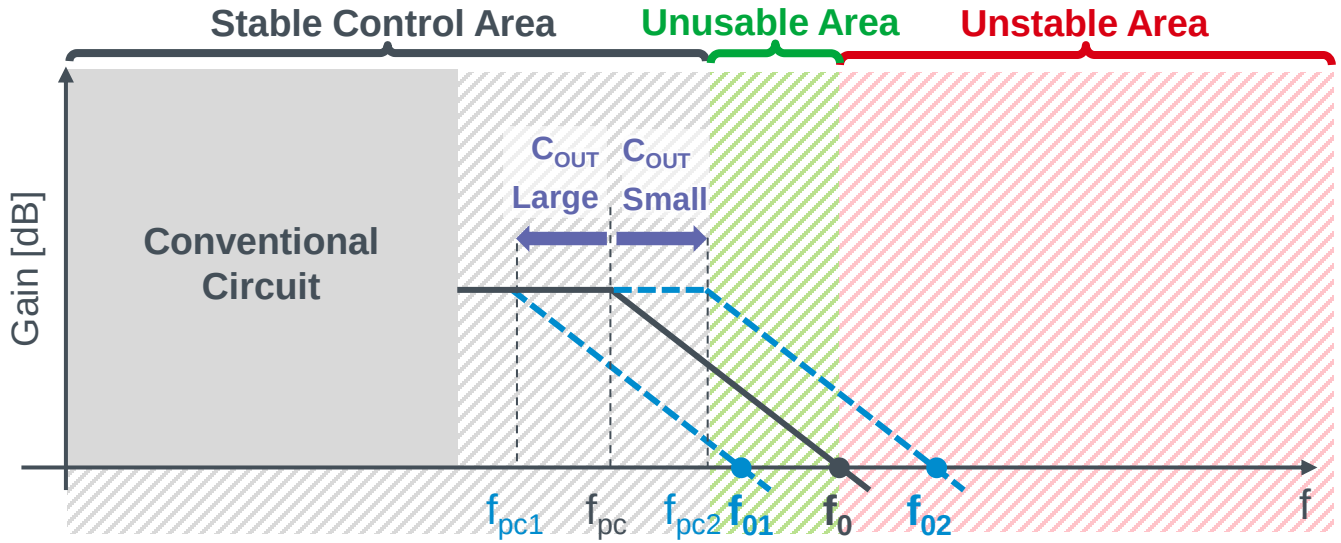
	ROHM Conventional	QuiCur™-equipped LDO (Under Dev.)
Output Capacitance	2.2μF	2.2μF
Board Image		
Load Response Waveforms (0→100mA)	 VOUT=5.0V, IOUT =0A→100mA (100mA/μs)	 VOUT=5.0V, IOUT =0A→100mA (100mA/μs)

QuiCur™ is overwhelming when compared to conventional products with same output capacitance

QuiCur™ achieves dramatic responsiveness performance

Issue 2: Correspondence to "Zero-cross Frequency (f_0) changes by Output Capacitance"

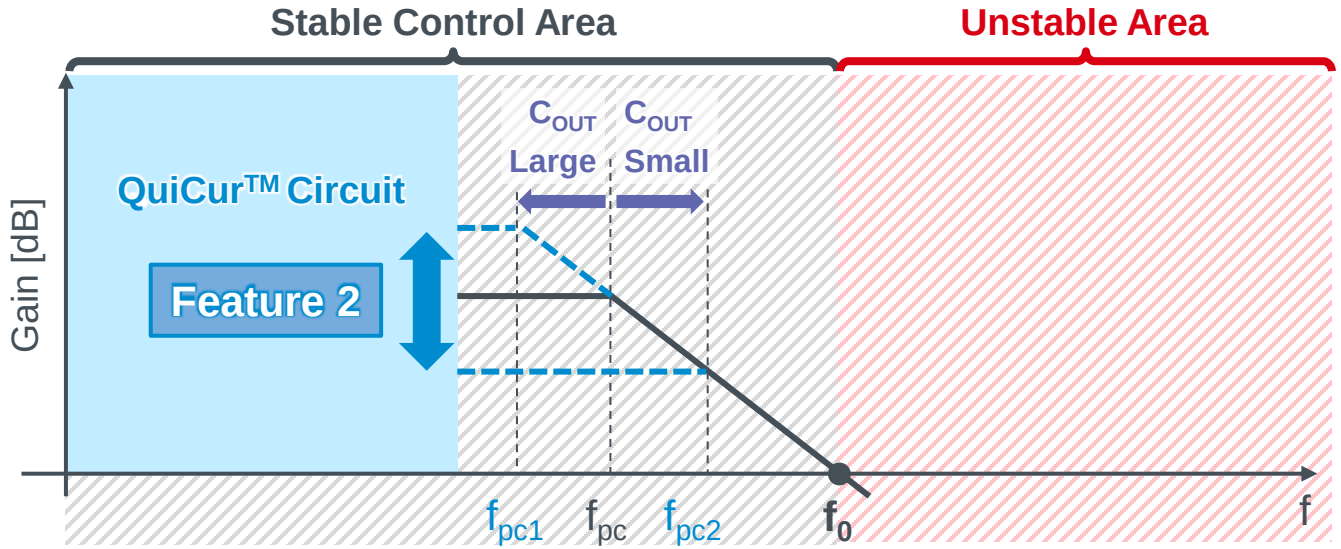
Conventional Circuit



Issue

(In addition to the Unusable Area occurrence in Issue 1,) Even if Zero-cross Frequency (f_0) is pursued to the limit, Zero-cross Frequency cannot be set on the boundary of Unstable Area when output capacitance changes.

QuiCur™ Feature 2



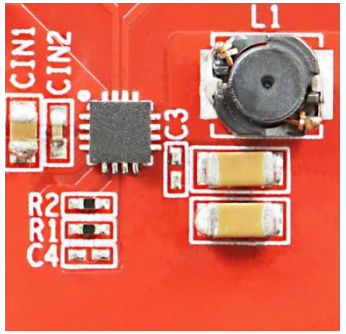
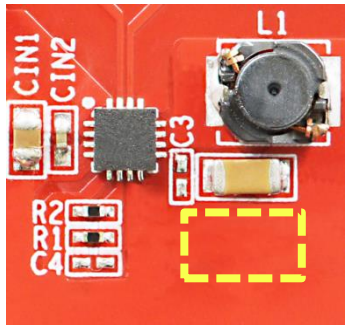
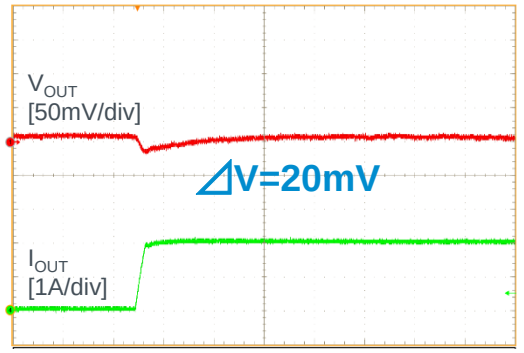
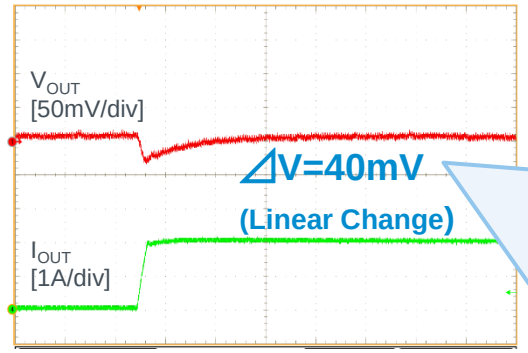
Feature 2

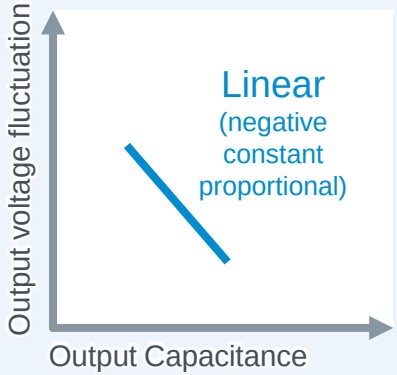
High-frequency Gain adjustable.

Effects

Zero-cross Frequency (f_0) can be set on the boundary of Unstable Area by adjusting the high-frequency Gain if output capacitance changes.

Effects of QuiCur™ on DC/DC Converter IC
Issue 2: “Zero-cross Frequency changes by Output Capacitance" effect verification

	QuiCur™-equipped DC/DC Converter IC (Under Dev.)	
Priority (Circuit mode)	**Reducing Output Voltage fluctuation**	**Reducing Output Capacitance**
Output Capacitance	**44µF (22µF×2)**	**22µF (22µF×1)**
Board Image		
Gain Setting	**High**	**Low**
Zero-cross Frequency	**300kHz**	**300kHz (No Change)**
Load Response Waveforms (0 → 2A)	 VIN=5.0V, VOUT=1.0V, IOUT =0A→2A (1A/µs)	 VIN=5.0V, VOUT=1.0V, IOUT =0A→2A (1A/µs)

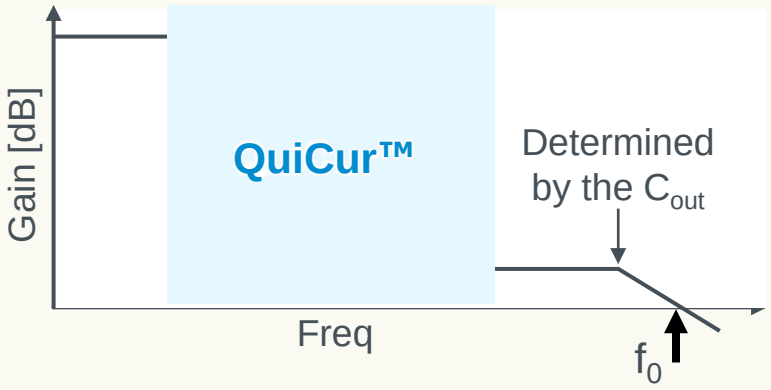


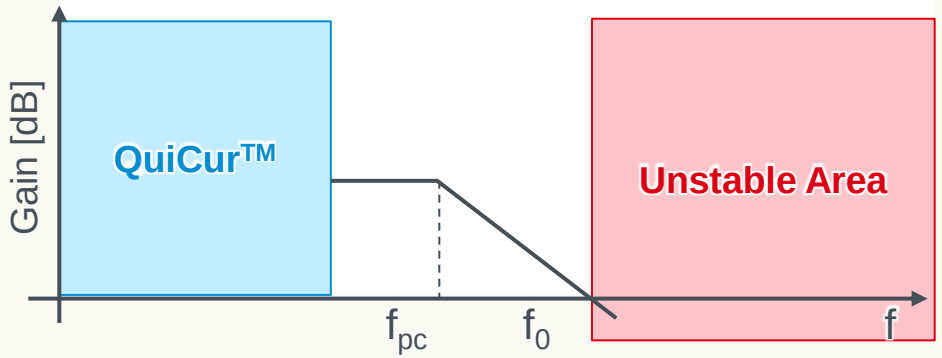
Easily achieves stable operation even when specifications change

QuiCur™ can easily support a wide range of Output Capacitance

(Add.) What is the difference between QuiCur™ and Nano Cap™ ?

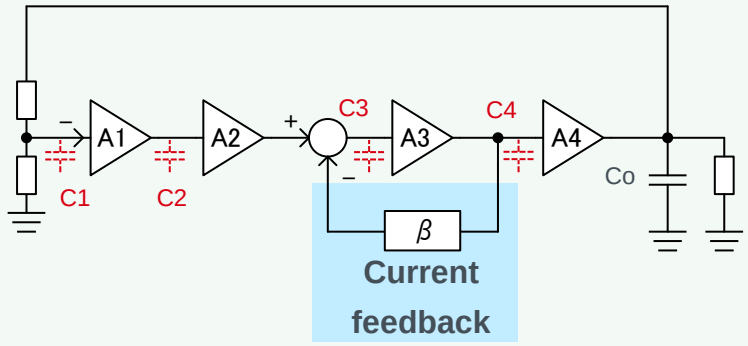
QuiCur™:
High-Speed Load Response Technology

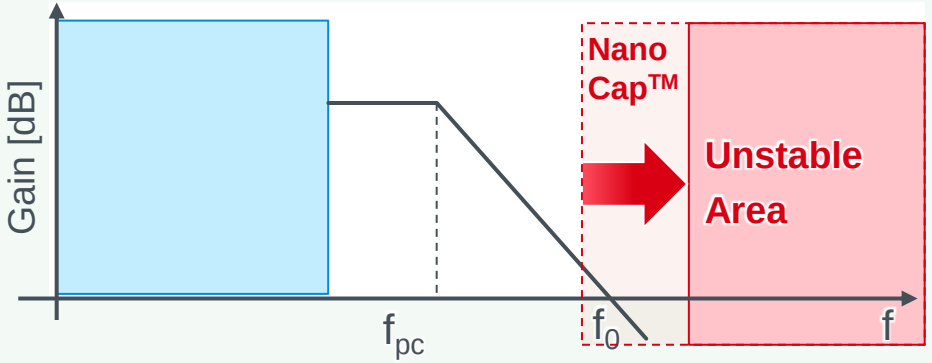




Eliminates the unusable area and allows the zero-cross (f_0) to be set at the limit of the unstable area

Nano Cap™:
Ultra-Stable Control Technology





The stable control area can be extended to higher frequency bands by current feedback

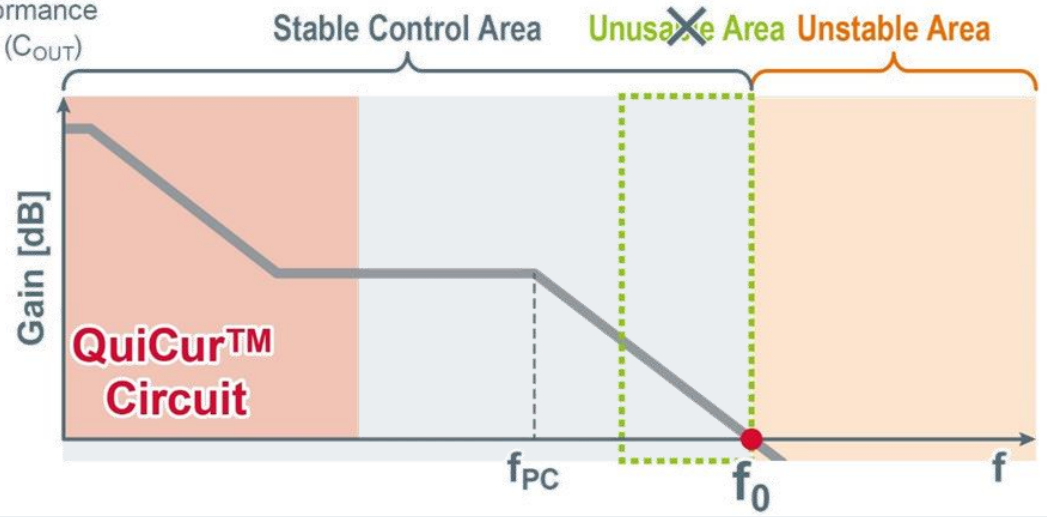
Both technologies are necessary to maximize response performance

(Add.) Combining QuiCur™ with Nano Cap™

f_0: Zero-cross frequency = an index of response performance
f_{PC}: Change point determined by the output capacitor (C_{OUT})

QuiCur™: High-Speed Load Response Technology

Eliminates the unusable area while allowing the zero-cross f_0 to be set at the limit of the unstable area



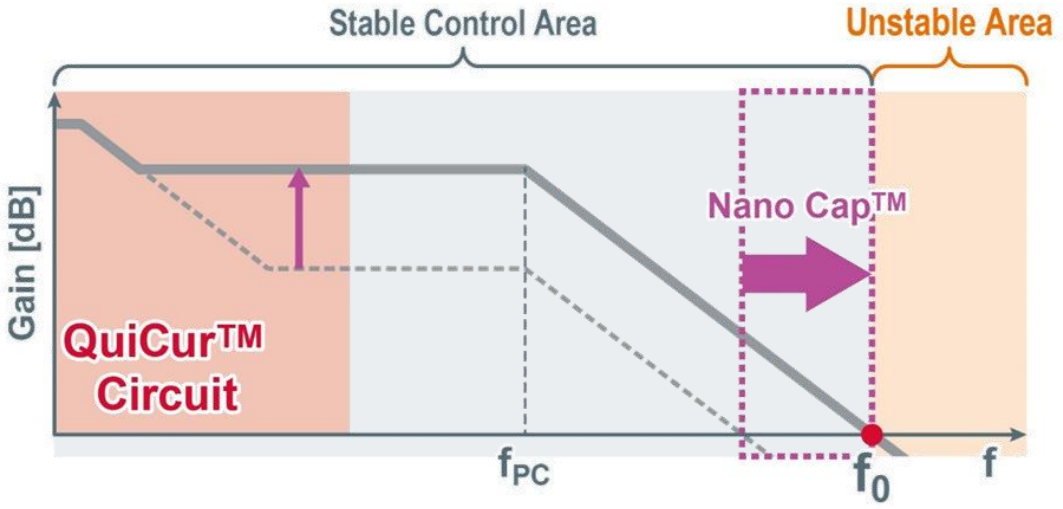
QuiCur™: High-Speed Load Response Technology

Eliminates the unusable area and allows the zero-cross f_0 to be set at the limit of the unstable area

+

Nano Cap™: Ultra-Stable Control Technology

The stable control area can be extended to higher frequency bands



Combining QuiCur™ with Nano Cap™ extends the stable control area and achieves extreme response performance

Notes

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- If you wish to use any such Product, please be sure to refer to the specifications, which can be obtained from ROHM upon request.
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