XCL230/XCL231 Series

ETR28019-003a

36V, 600mA Inductor Built-in Step-down "micro DC/DC" Converter

■GENERAL DESCRIPTION

The XCL230/XCL231 Series is a small (3.0mm×3.0mm, h=1.7mm) 36V, 600mA step-down DC/DC converter with an integrated control IC and coil. Integrating the coil makes for easier circuit board layout and minimizes malfunction and noise from the component and wiring layout.

The input voltage range is 3.0 to 36V, the switching frequency is 1.2MHz, and a synchronous rectification circuit is used to achieve a stable power supply at high efficiency. The XCL230 Series fixes the operation frequency using PWM control to suppress output ripple voltage.

The XCL231 Series automatically switches between PWM and PFM control to reduce loss by lowering the operation frequency during low loads to achieve high efficiency across the entire range from low to high loads.

A 0.75V standard voltage supply is built in, and the output voltage can be set to 1.0V to 5.0V using an external resistance.

The soft start time is internally set to 2.0ms, and a time that is longer than the internal soft-start can be freely set depending on the resistance and capacity connected to the EN/SS pin.

An overcurrent protection function and thermal shutdown function are built in as protective functions to ensure safe use in the event of a short circuit.
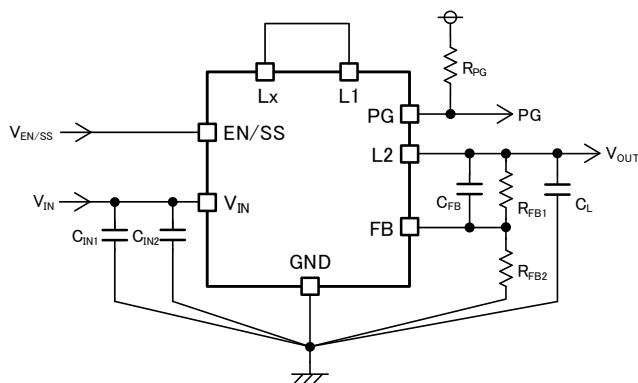
■APPLICATIONS

- ● Electricity Meters
- ● Gas Detectors
- ● Various Sensors
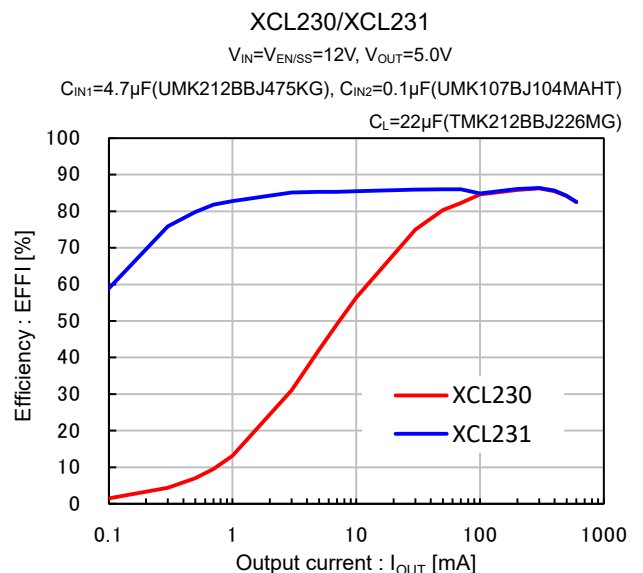- ● Industrial Equipment
- ● Home Appliances

■FEATURES

Input Voltage Range	:	3.0V ~ 36V (Absolute Max 40V)
Output Voltage Range	:	1.0V ~ 5.0V
FB Voltage	:	0.75V ± 1.5%
Output Current	:	600mA
Oscillation Frequency	:	1.2MHz
Efficiency	:	86%(V_{IN}=12V,V_{OUT}=5V, I_{OUT}=300mA)
Control Methods	:	PWM control (XCL230)
	:	PWM/PFM Auto (XCL231)
Function	:	Soft-start External settings
		Power good
Protection Circuits	:	Over Current Protection (Automatic recovery)
		Thermal Shutdown
Output Capacitor	:	Ceramic Capacitor
Operating Ambient Temperature	:	-40℃ ~ 105℃
Packages	:	DFN3030-10B
Environmentally Friendly	:	EU RoHS Compliant, Pb Free

■TYPICAL APPLICATION CIRCUIT

■TYPICAL PERFORMANCE CHARACTERISTICS

XCL230/XCL231

$V_{IN}=V_{EN/SS}$=12V, V_{OUT}=5.0V

C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)

C_L=22µF(TMK212BBJ226MG)

■BLOCK DIAGRAM
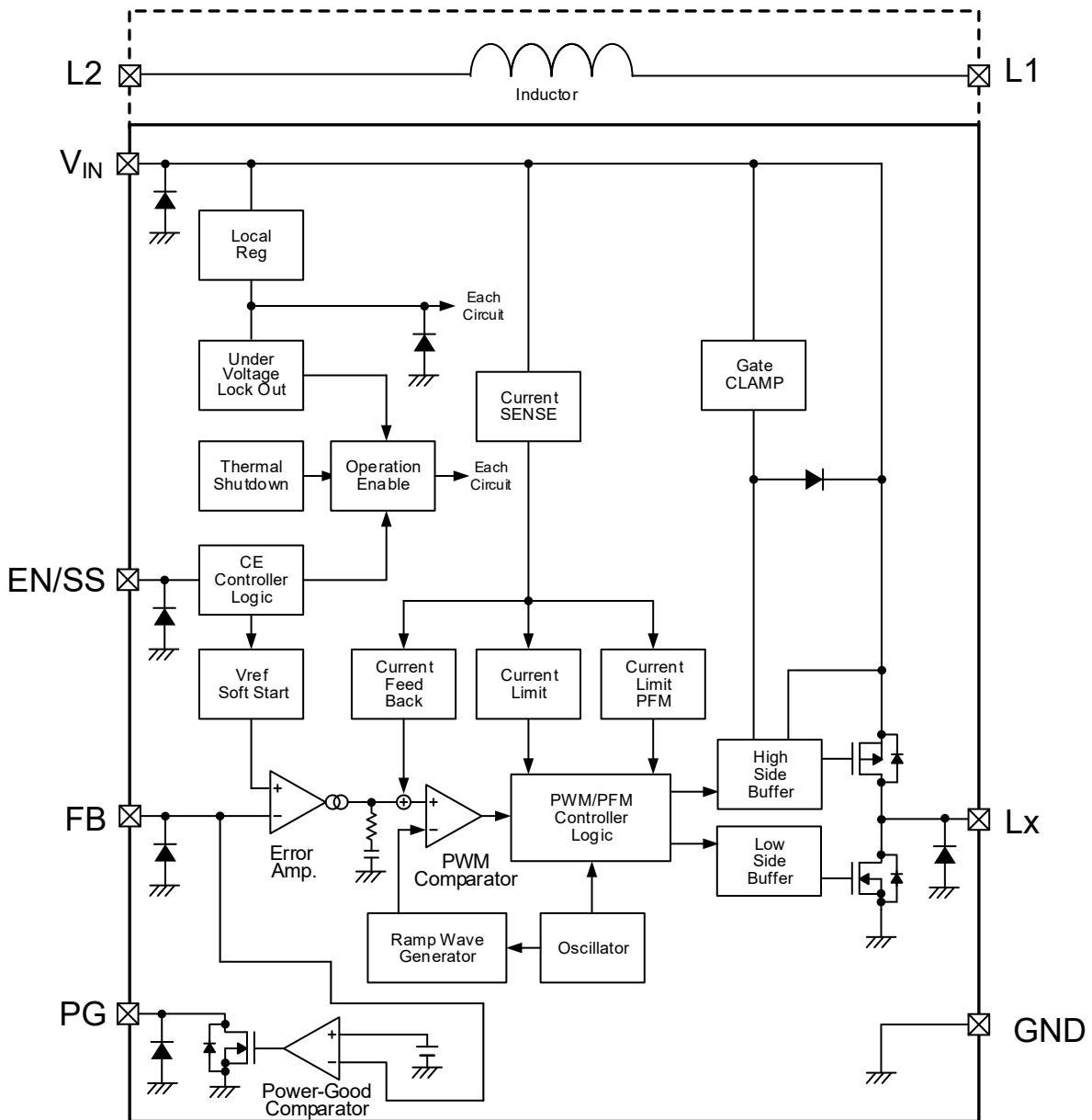
* "PWM/PFM Controller Logic" in the XCL230 series is fixed to PWM control.

"PWM/PFM Controller Logic" In the XCL231 series is fixed to PWM/PFM automatic switching control.

Diodes inside the circuit are an ESD protection diode and a parasitic diode.

■PRODUCT CLASSIFICATION
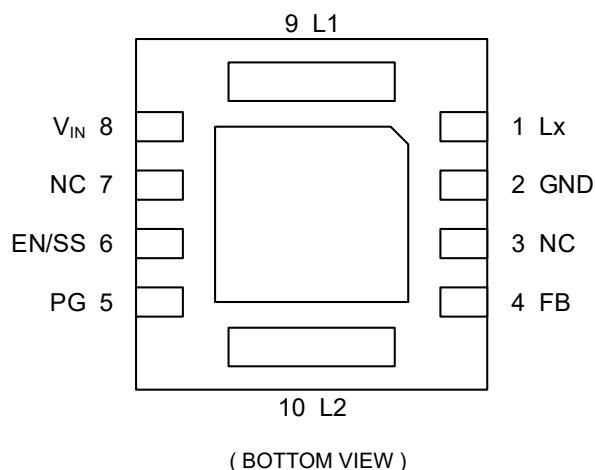
● Ordering Information

XCL230①②③④⑤⑥   PWM Control

XCL231①②③④⑤⑥   PWM/PFM Automatic Switching Control

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Type	B	Refer to Selection Guide
②③	FB Voltage	0K	0.75V (Output voltage can be adjusted in 1.0V to 5.0V)
④	Oscillation Frequency	1	1.2MHz
⑤⑥	Packages (Order Unit)	H2	DFN3030-10B (3,000pcs/Reel)

● Selection Guide

FUNCTION	B TYPE
Chip Enable	Yes
UVLO	Yes
Thermal Shutdown	Yes
Soft Start	Yes
Power-Good	Yes
Current Limiter (Automatic Recovery)	Yes

■PIN CONFIGURATION

```
                    9  L1
          ┌─────────────────────────┐
          │      ┌───────────┐       │
V_IN  8 ──┤ ▭    ┌─────────┐   ▭ ├── 1  Lx
          │      │         │       │
NC   7 ──┤ ▭    │         │   ▭ ├── 2  GND
          │      │         │       │
EN/SS 6 ──┤ ▭    │         │   ▭ ├── 3  NC
          │      └─────────┘       │
PG   5 ──┤ ▭    ┌───────────┐ ▭ ├── 4  FB
          │      └───────────┘     │
          └─────────────────────────┘
                   10  L2

              ( BOTTOM VIEW )
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* The dissipation pad for the DFN3030-10B package should be solder plated in recommended mount pattern and metal masking so as to enhance mounting strength and heat release. If the pad needs to be connected to other pins, it should be connected to the GND (No.2) pin.

■PIN ASSIGNMENT

PIN NUMBER	PIN NAME	FUNCTION
1	LX	Switching Output
2	GND	Ground
3	NC	No Connection
4	FB	Output Voltage Sense
5	PG	Power good Output
6	EN/SS	Enable Soft-start
7	NC	No Connection
8	V_{IN}	Power Input
9	L1	Inductor Electrodes
10	L2	Inductor Electrodes

* The NC terminals (pin numbers 3 & 7) are not connected to the IC chip.

■FUNCTION CHART

PIN NAME	SIGNAL	STATUS
EN/SS	H	Active
	L	Stand-by
	OPEN	Undefined State[*1]

[*1] Please do not leave the EN/SS pin open. Each should have a certain voltage

PIN NAME	CONDITION		SIGNAL
PG	EN/SS = H	$V_{FB} > V_{PGDET}$	H (High impedance)
		$V_{FB} \leqq V_{PGDET}$	L (Low impedance)
		Thermal Shutdown	L (Low impedance)
		UVLO ($V_{IN} < V_{UVLOD}$)	Undefined State
	EN/SS = L	Stand-by	L (Low impedance)

■ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATINGS	UNITS
V_{IN} Pin Voltage	V_{IN}	-0.3 ~ 40	V
EN/SS Pin Voltage	$V_{EN/SS}$	-0.3 ~ 40	V
FB Pin Voltage	V_{FB}	-0.3 ~ 6.2	V
PG Pin Voltage	V_{PG}	-0.3 ~ 6.2	V
PG Pin Current	I_{PG}	8	mA
Lx Pin Voltage	V_{Lx}	-0.3 ~ V_{IN} + 0.3 or 40 [*1]	V
Power Dissipation (Ta=25℃)	Pd	1950 (JESD51-7 board) [*2]	mW
Operating Ambient Temperature	Topr	-40 ~ 105	℃
Storage Temperature	Tstg	-55 ~ 125	℃

All voltages are described based on the GND pin.

[*1] The maximum value should be either V_{IN}+0.3V, or 40V, whichever is the lowest.

[*2] The power dissipation figure shown is PCB mounted and is for reference only.
    Please refer to PACKAGING INFORMATION for mounting conditions.

■ELECTRICAL CHARACTERISTICS

XCL230/XCL231 Series   Ta=25℃

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNIT	CIRCUIT
FB Voltage	V_{FBE}	V_{FB}=0.739V→0.761V, FB Voltage when Lx pin voltage changes from"H" level to "L" level		0.739	0.750	0.761	V	②
Output Voltage Setting Range	V_{OUTSET}	-		1.0	-	5.0	V	-
Input Voltage Operating Range	V_{IN}	-		3.0	-	36.0	V	-
UVLO Detect Voltage	V_{UVLOD}	$V_{EN/SS}$=12V,V_{IN}=2.8V→2.6V,V_{FB}=0V V_{IN} Voltage which Lx pin voltage holding "H" level	Ta=25℃	2.6	2.7	2.8	V	②
			Ta=-40~105℃[*1]	2.53	-	2.87		
UVLO Release Voltage	V_{UVLOR}	$V_{EN/SS}$=12V,V_{IN}=2.7V→2.9V,V_{FB}=0V V_{IN} Voltage which Lx pin voltage holding "L" level	Ta=25℃	2.7	2.8	2.9	V	②
			Ta=-40~105℃[*1]	2.63	-	2.97		
Quiescent Current (XCL230)	I_q	V_{FB}=0.825V		-	180	350	μA	④
Quiescent Current (XCL231)	I_q	V_{FB}=0.825V		-	12.5	21.0	μA	④
Stand-by Current	I_{STBY}	V_{IN}=12V, $V_{EN/SS}$=V_{FB}=0V		-	1.65	2.50	μA	④
Oscillation Frequency	f_{OSC}	Connected to external components, I_{OUT}=150mA		1.098	1.200	1.302	MHz	①
Minimum On Time	t_{ONMIN}	Connected to external components		-	85 [*1]	-	ns	①
Minimum Duty Cycle	D_{MIN}	V_{FB}=0.825V		-	-	0	%	②
Maximum Duty Cycle	D_{MAX}	V_{FB}=0.675V		100	-	-	%	②
Lx SW "H" On Resistance	R_{LxH}	V_{FB}=0.675V, I_{Lx}=200mA		-	1.20	1.38	Ω	⑤
Lx SW "L" On Resistance	R_{LxL}			-	0.60[*1]	-	Ω	−
High side Current Limit [*2]	I_{LIMH}	V_{FB}=V_{FBE}×0.98		1.0	1.3	-	A	⑤
Internal Soft-Start Time	t_{SS1}	V_{FB}=0.675V		1.6	2.0	2.4	ms	②
External Soft-Start Time	t_{SS2}	V_{FB}=0.675V R_{SS}=430kΩ, C_{SS}=0.47μF		21	26	33	ms	③
PFM Switch Current (XCL231)	I_{PFM}	Connected to external components, V_{IN}=$V_{EN/SS}$=12V、I_{OUT}=1mA		-	450	-	mA	①
Efficiency	EFFI	Connected to external components, V_{IN}=12V, V_{OUT}=5V, I_{OUT}=300mA		-	86	-	%	①
FB Voltage Temperature Characteristics	$\Delta V_{FB}/(\Delta T_{opr} \cdot V_{FBE})$	-40℃≦T_{opr}≦105℃		-	±100	-	ppm/℃	②

Test Condition: Unless otherwise stated, V_{IN}=12V, $V_{EN/SS}$=12V, PG=OPEN
Peripheral parts connection conditions (V_{OUT}=5.0V): R_{FB1}=680kΩ, R_{FB2}=120kΩ, C_{FB}=15pF, C_L=22μF, C_{IN}=4.7μF
[*1] Design reference value. This parameter is provided only for reference.
[*2] Current limit denotes the level of detection at peak of coil current.

■ELECTRICAL CHARACTERISTICS (Continued)

XCL230/XCL231 Series   Ta=25℃

PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNIT	CIRCUIT
PG Detect Voltage	V_{PGDET}	V_{FB}=0.712V→0.638V, R_{PG}:100kΩ pull-up to 5V FB Voltage when PG pin voltage changes from"H" level to "L" level		0.638	0.675	0.712	V	⑤
PG Output Voltage	V_{PG}	V_{FB}=0.6V, I_{PG}=1mA		-	-	0.3	V	②
FB "H" Current	I_{FBH}	$V_{IN}=V_{EN/SS}$=36V, V_{FB}=3.0V		-0.1	0.0	0.1	µA	④
FB "L" Current	I_{FBL}	$V_{IN}=V_{EN/SS}$=36V, V_{FB}=0V		-0.1	0.0	0.1	µA	④
EN/SS "H" Voltage	$V_{EN/SSH}$	$V_{EN/SS}$=0.3V→2.5V, V_{FB}=0.71V EN/SS Voltage when Lx pin voltage changes from "L" level to "H" level	Ta=25℃	2.5	-	36.0	V	②
			Ta=-40~105℃[*1]					
EN/SS "L" Voltage	$V_{EN/SSL}$	$V_{EN/SS}$=2.5V→0.3V, V_{FB}=0.71V EN/SS Voltage when Lx pin voltage changes from "H" level to "L" level	Ta=25℃	GND	-	0.3	V	②
			Ta=-40~105℃[*1]					
EN/SS "H" Current	$I_{EN/SSH}$	$V_{IN}=V_{EN/SS}$=36V, V_{FB}=0.825V		-	0.1	0.3	µA	④
EN/SS "L" Current	$I_{EN/SSL}$	V_{IN}=36V, $V_{EN/SS}$=0V, V_{FB}=0.825V		-0.1	0.0	0.1	µA	④
Thermal Shutdown Temperature	T_{TSD}	Junction Temperature		-	150	-	℃	-
Thermal Shutdown Hysteresis Width	T_{HYS}	Junction Temperature		-	25	-	℃	-
Inductance	L	Test Freq.=1MHz		-	4.7	-	µH	-
Inductor Rated Current	I_{DC}	⊿T=+40℃		-	1.8	-	A	-

Test Condition: Unless otherwise stated, V_{IN}=12V, $V_{EN/SS}$=12V, PG=OPEN

[*1] Design reference value. This parameter is provided only for reference.

■TEST CIRCUITS

Circuit No.①
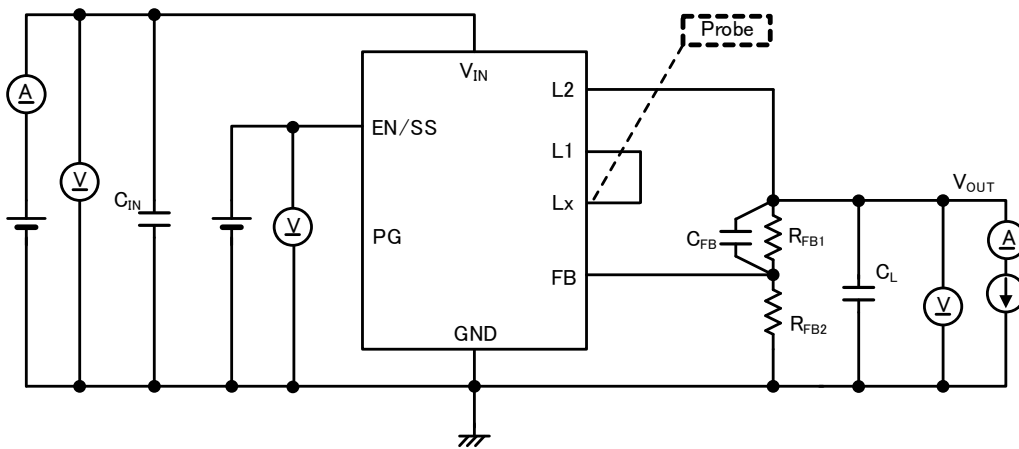
Circuit No.②
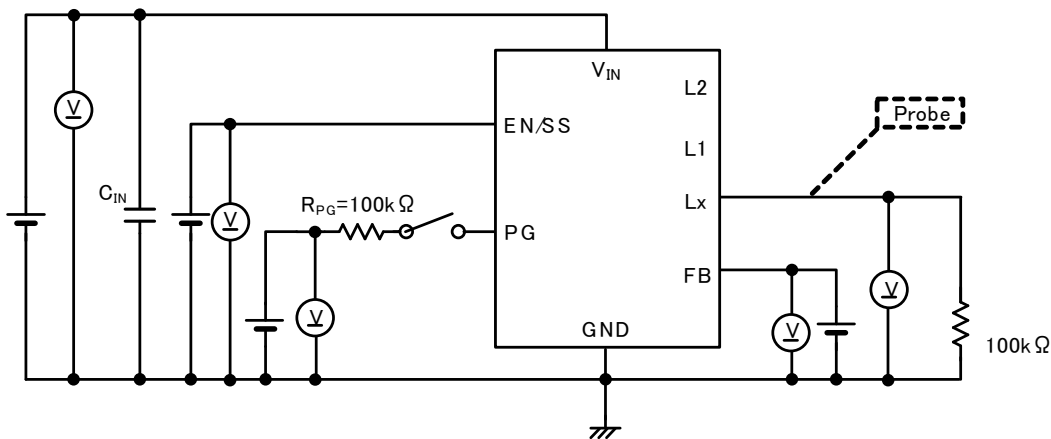
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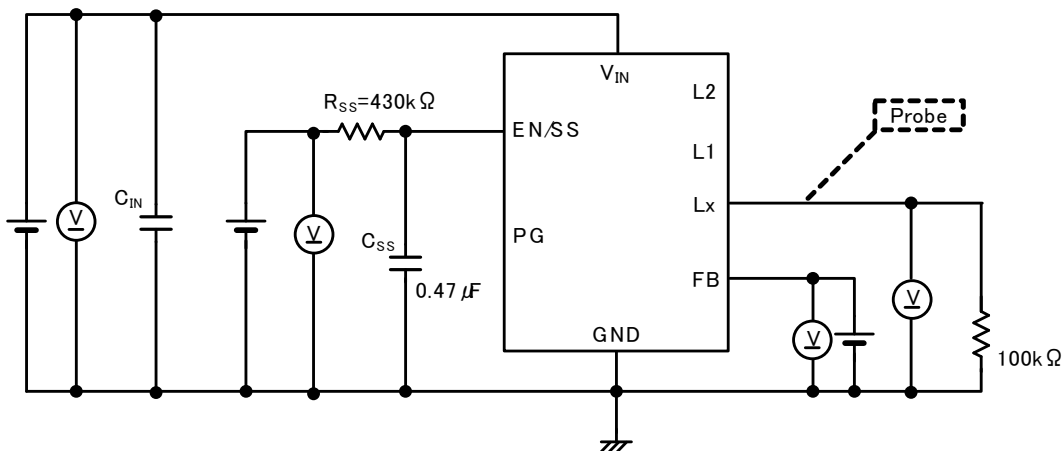
■TEST CIRCUITS (Continued)

Circuit No.④
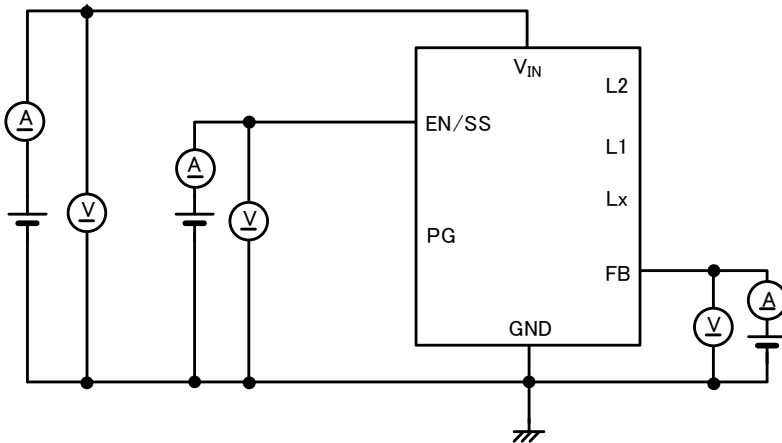
Circuit No.⑤
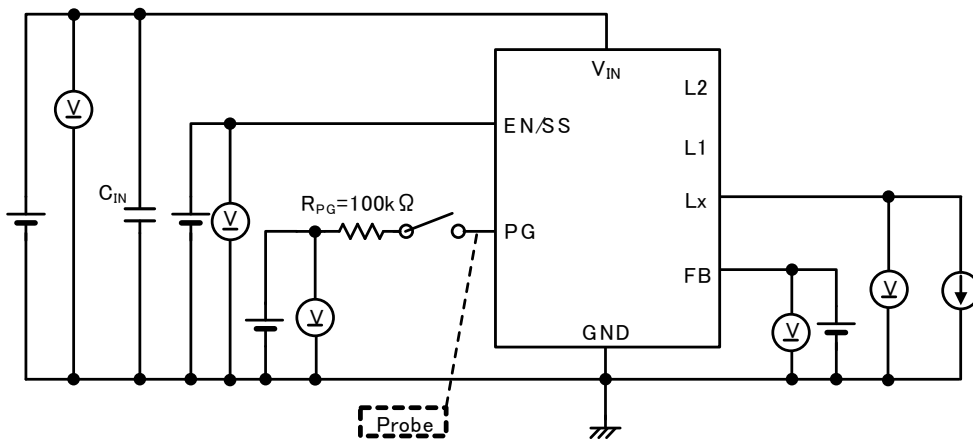
■TYPICAL APPLICATION CIRCUIT / Parts Selection Method
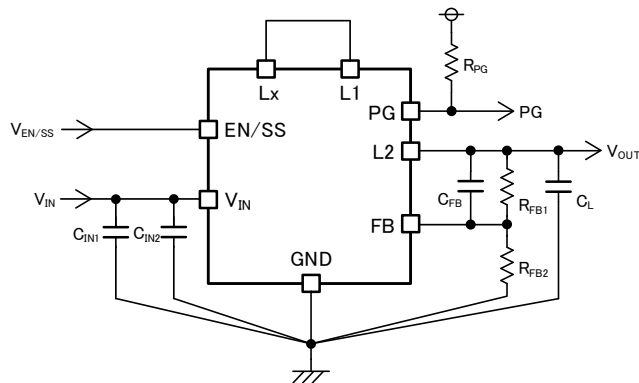
* The inductor is dedicated to this product. Please do not use it for purposes other than this product.

【Typical Example】

	VALUE	PRODUCT NUMBER	Notes
C_{IN1} [*1]	50V/4.7µF	UMK212BBJ475KG (Taiyo Yuden)	$V_{IN}<20V$
			$V_{IN}\geqq20V$, 2 parallel
		C2012X7R1H475K125AC (TDK)	$V_{IN}<20V$
			$V_{IN}\geqq20V$, 2 parallel
C_{IN2}	50V/0.1µF	C1608X7R1H104K080AE (TDK)	
		UMK107BJ104MAHT (Taiyo Yuden)	
C_L [*2]	10V/10µF	C2012X7R1A106K125AC (TDK)	2 parallel
	35V/10µF	C3216X7R1E106K160AB (TDK)	
	25V/22µF	TMK212BBJ226MG (Taiyo Yuden)	

Select parts considering the DC bias characteristics and rated voltage of ceramic capacitors.

[*1] For C_{IN1}, use a capacitor with the same or higher effective capacity value as the recommended components.

[*2] For C_L, use a capacitor with the same or higher effective capacity value as the recommended components.
If a capacitor with a low effective capacity value is used, the output voltage may become unstable.
However, if large capacity capacitors, such as electrolytic capacitors, are connected in parallel, the inrush current during startup could increase or the output could become unstable.

■TYPICAL APPLICATION CIRCUIT / Parts Selection Method (Continued)

< Output Voltage Setting Value V_{OUTSET} Setting >
 The output voltage can be set by adding an external dividing resistor.
The output voltage is determined by the equation below based on the values of R_{FB1} and R_{FB2}.

$$V_{OUTSET} = 0.75V \times (R_{FB1} + R_{FB2}) / R_{FB2}$$
$$\text{With } R_{FB2} \leqq 200k\Omega \text{ and } R_{FB1} + R_{FB2} \leqq 1M\Omega$$

< C_{FB} Setting >
 Adjust the value of the phase compensation speed-up capacitor C_{FB} using the equation below.

$$C_{FB} = \frac{1}{2\pi \times fzfb \times R_{FB1}}$$
$$fzfb = \frac{1}{2\pi\sqrt{C_L \times L}}$$

【Setting Example】
When the output voltage setting is 5V with fosc=1.2MHz, CL=22μF, L=4.7μH,
V_{OUTSET} = 0.75V × (680kΩ + 120kΩ) / 120kΩ = 5.0V,
From the above formula, fzfb = 15.66kHz is targeted,
C_{FB}= 1 / (2 × π × 15.66kHz × 680kΩ) = 14.95pF, which is 15pF for the E24 series.

XCL230 Series

V_{OUTSET}	R_{FB1}	R_{FB2}	C_{FB}	Target fzfb
1.2V	12kΩ	20kΩ	820pF	15.66kHz
3.3V	51kΩ	15kΩ	220pF	15.66kHz
5.0V	68kΩ	12kΩ	150pF	15.66kHz

XCL231 Series

V_{OUTSET}	R_{FB1}	R_{FB2}	C_{FB}	Target fzfb
1.2V	120kΩ	200kΩ	82pF	15.66kHz
3.3V	510kΩ	150kΩ	22pF	15.66kHz
5.0V	680kΩ	120kΩ	15pF	15.66kHz

■OPERATIONAL EXPLANATION

The XCL230/XCL231 series consists internally of a reference voltage supply with soft-start function, a ramp wave circuit, an error amp, a PWM comparator, a High side driver FET, a Low side driver FET, a High side buffer circuit, a Low side buffer circuit, a current sense circuit, a phase compensation (Current feedback) circuit, a current limiting circuit, an under voltage lockout (UVLO) circuit, an internal power supply (Local Reg) circuit, a gate clamp (CLAMP) circuit and other elements.

The control method is the current mode control method for handling low ESR ceramic capacitors.
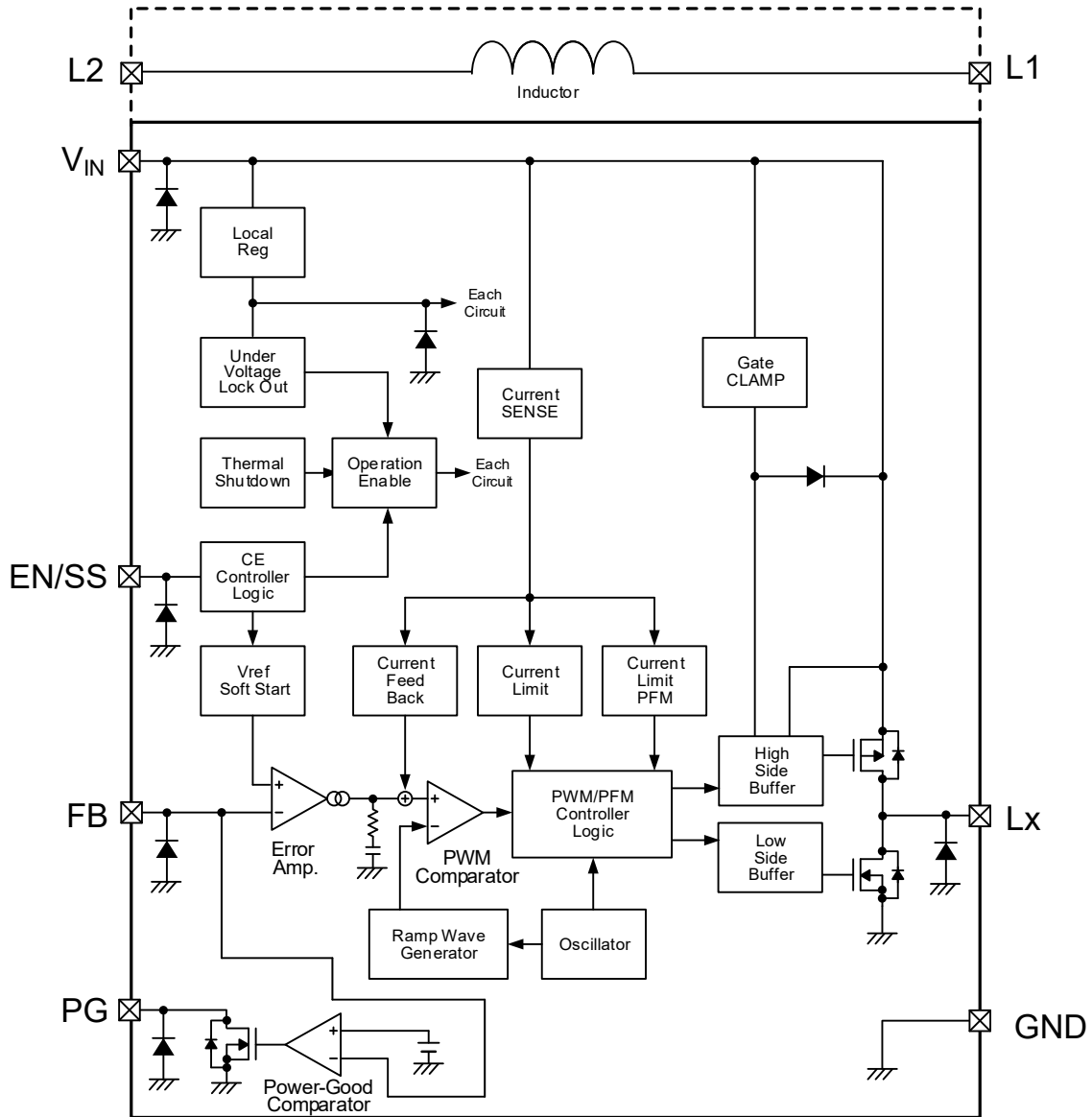
■OPERATIONAL EXPLANATION (Continued)

< Normal Operation >

The standard voltage Vref and FB pin voltage are compared using an error amplifier and then the control signal to which phase compensation has been added to the error amplifier output is input to the PWM comparator. The PWM comparator compares the above control signal and lamp wave to control the duty width during PWM control. Continuously conducting these controls stabilizes the output voltage.

In addition, the current detecting circuit monitors the driver FET current for each switching and modulates the error amplifier output signal into a multiple feedback signal (current feedback circuit). This achieves stable feedback control even when low ESR capacitors, such as ceramic capacitors, are used to stabilize the output voltage.

XCL230 Series

The XCL230 Series (PWM control) performs switching at a set switching frequency f_{OSC} regardless of the output current. At light loads the on time is short and the circuit operates in discontinuous mode, and as the output current increases, the on time becomes longer and the circuit operates in continuous mode.
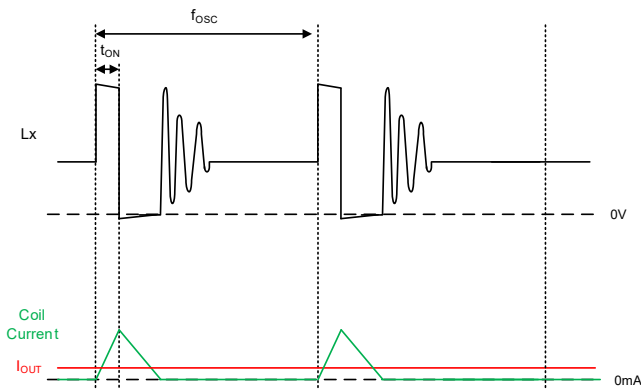
XCL230 series: Example of light load operation
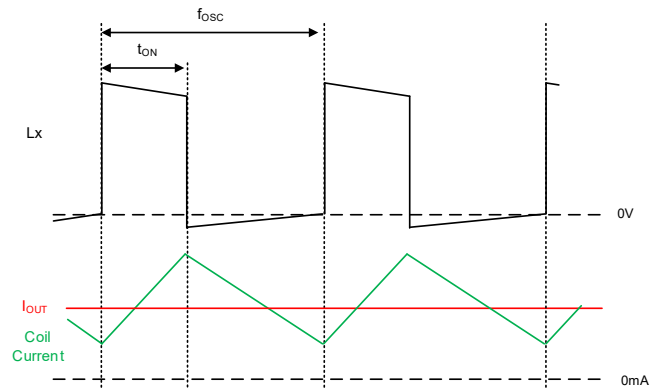
XCL230 series: Example of heavy load operation

XCL231 Series

The XCL231 Series (PWM/PFM automatic switching control) lowers the switching frequency during light loads by turning on the High side driver FET when the coil current reaches the PFM current (I_{PFM}). This operation reduces the loss during light loads and achieves high efficiency from light to heavy loads. As the output current increases, the switching frequency increases proportional to the output current, and when the switching frequency increases f_{OSC}, the circuit switches from PFM control to PWM control and the switching frequency becomes fixed.
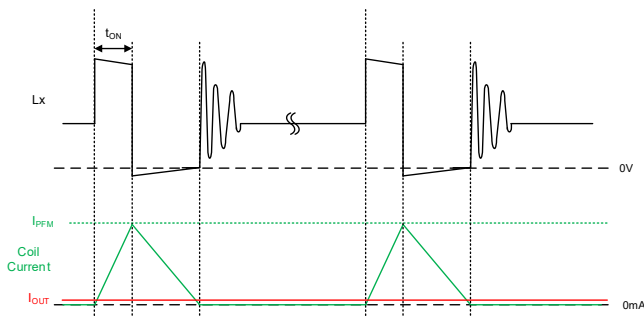
XCL231 series: Example of light load operation
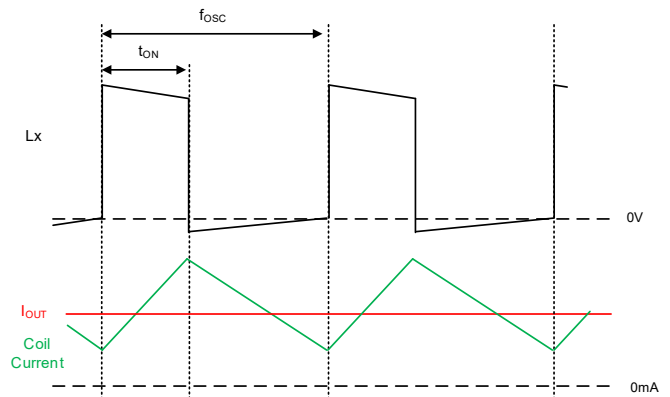
XCL231 series: Example of heavy load operation

< 100% Duty Cycle Mode >

When the dropout voltage is low or there is a transient response, the circuit might change to the 100% Duty cycle mode where the High side driver FET is continuously on.

The 100% Duty cycle mode operation makes it possible to maintain the output current even when the dropout voltage is low such as when the input voltage declines due to cranking, etc.

■OPERATIONAL EXPLANATION (Continued)

< CE Function >

When an "H" voltage ($V_{EN/SSH}$) is input to the EN/SS pin, normal operation is performed after the output voltage is started up by the soft start function, normal operation is performed. When the "L" voltage ($V_{EN/SSL}$) is input to the EN/SS pin, the circuit enters the standby state, the supply current is suppressed to the standby current I_{STB} (TYP. 1.65μA), and the High side driver FET and Low side driver FET are turned off.

< Soft Start Function >

This function gradually starts up the output voltage to suppress the inrush current.

The soft start time is the time until the output voltage from $V_{EN/SSH}$ reaches 90% of the output voltage set value, and when the output voltage increases further, the soft start function is cancelled to switch to normal operation.

Internal Soft Start Time

The internal soft start time (t_{SS1}) is configured so that after the "H" voltage ($V_{EN/SSH}$) is input to the EN/SS pin, the standard voltage connected to the error amplifier increases linearly during the soft-start period. This causes the output voltage to increase proportionally to the standard voltage increase. This operation suppresses the inrush current and smoothly increases the output voltage.
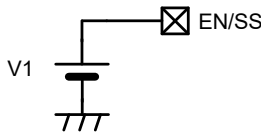
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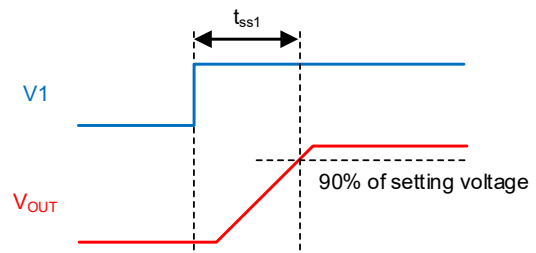
< Overview of internal soft start >

External Setting Soft Start Time

The external setting soft start time (t_{SS2}) can adjust the increase speed of the standard voltage in the IC by adjusting the EN/SS pin voltage inclination during startup using externally connected component R_{SS} and C_{SS}. This makes it possible to externally adjust the soft start time.

Soft start time (t_{SS2}) is approximated by the equation below according to values of V1, R_{SS}, and C_{SS}
When t_{SS2} is shorter than t_{SS1}, the output voltage rises at the internal soft start time.

$$t_{SS2} = C_{SS} \times R_{SS} \times \ln (V1 / (V1-1.45V))$$

【Setting Example】
C_{SS} = 0.47μF, R_{SS} = 430kΩ, V1 = 12V
t_{SS2} = 0.47μF x 430kΩ x (ln (12V/(12V-1.45V)) = 26ms
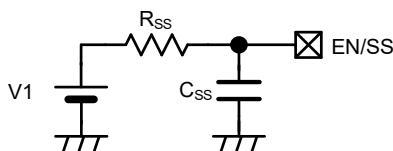
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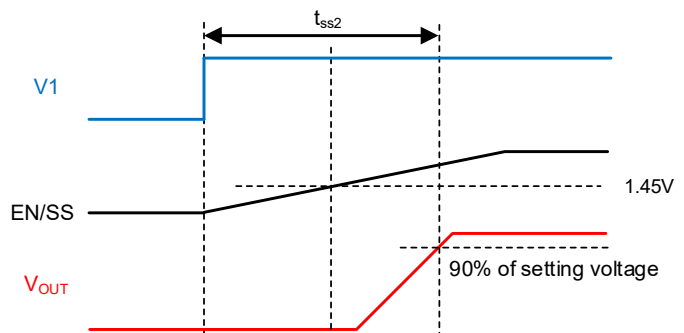
< Overview of external soft start >

■OPERATIONAL EXPLANATION (Continued)

< Power Good >

The output state can be monitored using the power good function. The PG pin is an Nch open drain output, therefore a pull-up resistor (approx. 100kΩ) must be connected to the PG pin.

The pull-up voltage should be 5.5V or less. When not using the power good function, connect the PG terminal to GND or leave it open.

CONDITION		SIGNAL
EN/SS = H	$V_{FB} > V_{PGDET}$	H (High impedance)
	$V_{FB} \leqq V_{PGDET}$	L (Low impedance)
	Thermal Shutdown	L (Low impedance)
	UVLO ($V_{IN} < V_{UVLOD}$)	Undefined State
EN/SS = L	Stand-by	L (Low impedance)

< UVLO Function >

When the V_{IN} pin voltage falls below V_{UVLOD} (TYP. 2.7V), the high side driver FET and low side driver FET are forcibly turned off to prevent false pulse output due to instable operation of the internal circuits. When the V_{IN} pin voltage rises above V_{UVLOR} (TYP. 2.8V), the UVLO function is released, the soft start function activates, and output start operation begins. Stopping by UVLO is not shutdown; only pulse output is stopped and the internal circuits continue to operate.

< Thermal Shutdown Function >

A thermal shutdown (TSD) function is built in for protection from overheating. When the junction temperature reaches the thermal shutdown detection temperature T_{TSD}, the High side driver FET and Low side driver FET are compulsorily turned off.

If the driver FET continues in the off state, the junction temperature declines, and when the junction temperature falls to the thermal shutdown cancel temperature, the thermal shutdown function is cancelled and the soft-start function operates to start up the output voltage.

■OPERATIONAL EXPLANATION (Continued)

< Current Limit Function >
The current limiting circuit of the XCL230/XCL231 series monitors the current that flows through the High side driver FET and Low side driver FET, and when over current is detected, the current limiting function activates.

① High side driver FET current limiting
The current in the High side driver FET is detected to equivalently monitor the peak value of the coil current. The High side driver FET current limiting function forcibly turns off the High side driver FET when the peak value of the coil current reaches the High side driver current limit value I_{LIMH}.

High side driver FET current limit value I_{LIMH}=1.3A (TYP.)

② Low side driver FET current limiting
The current in the Low side driver FET is detected to equivalently monitor the bottom value of the coil current. The Low side driver FET current limiting function operates when the High side driver FET current limiting value reaches I_{LIMH}. The Low side driver FET current limiting function prohibits the High side driver FET from turning on in an over current state where the bottom value of the coil current is higher than the Low side driver FET current limit value I_{LIML}.

Low side driver FET current limit value I_{LIML}=0.9A (TYP.)

When the output current increases and reaches the current limit value, the current foldback circuit operates and lowers the output voltage and FB voltage. The I_{LIMH} and I_{LIML} decline accompanying the FB voltage decrease to restrict the output current.
When the overcurrent state is removed, the foldback circuit operation increases the I_{LIMH} and I_{LIML} together with output voltage to return the output to the output voltage set value.
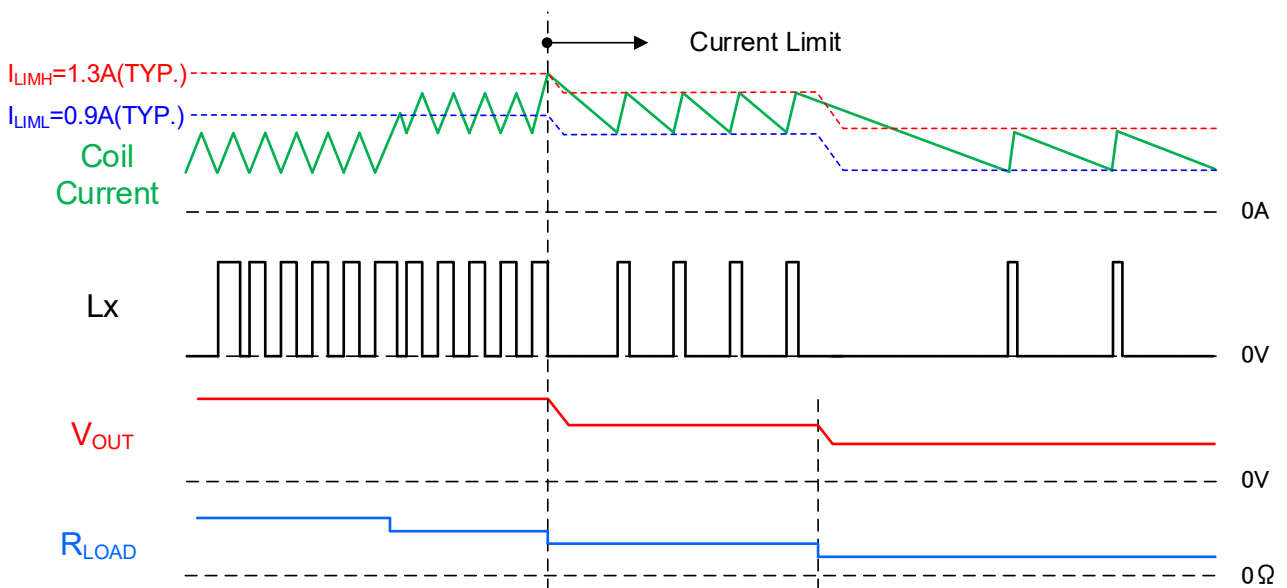
■NOTES ON USE

1) In the case of a temporary and transient voltage drop or voltage rise.
   If the absolute maximum ratings are exceeded, the IC may deteriorate or be destroyed.

   If a voltage exceeding the absolute maximum voltage is applied to the IC due to chattering caused by a mechanical switch or an external surge voltage, please use a protection element such as a TVS and a protection circuit as a countermeasure.
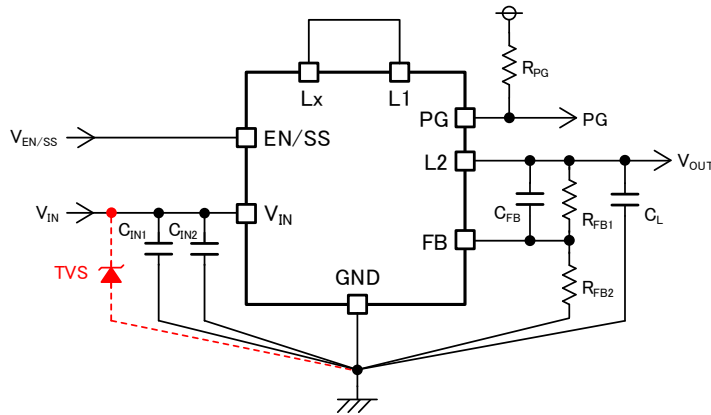
When the input voltage decreases below the output voltage, there is a possibility that an overcurrent will flow in the IC's internal parasitic diode and Lx pin. If the current is pulled into the input side by the low impedance between V_{IN}-GND, then countermeasures, such as adding an SBD between V_{OUT}-$V_{IN},$ should be taken.
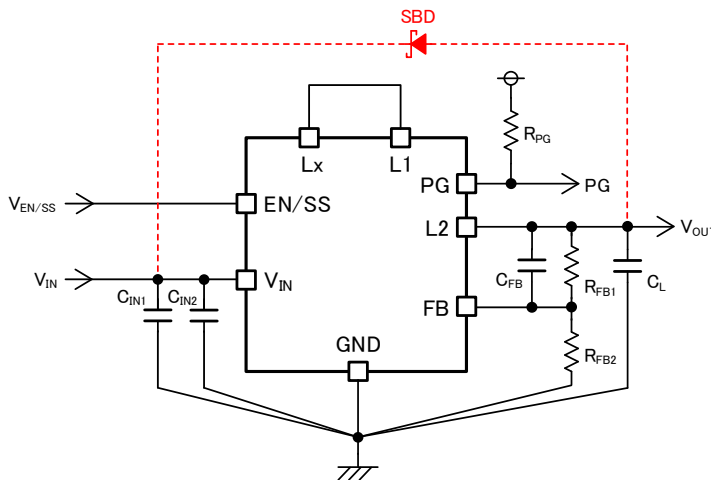
When a negative voltage is applied to the input voltage by a reverse connection or chattering, an overcurrent could flow in the IC's parasitic diode and damage the IC. Take countermeasures, such as adding a reverse touching protection diode.
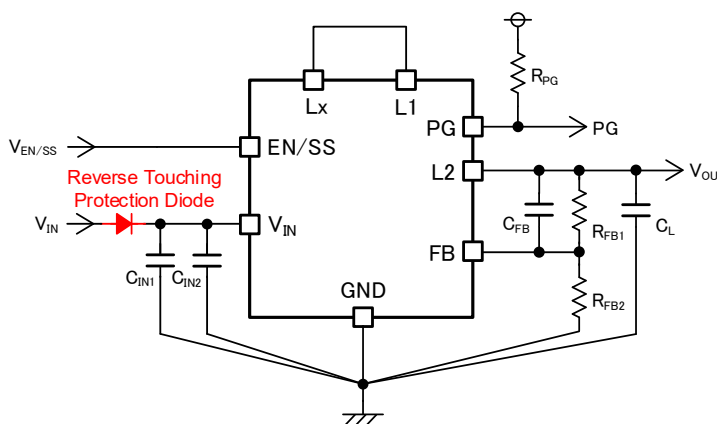
■NOTES ON USE (Continued)

2)   Make sure that the absolute maximum ratings of the external components and of this IC are not exceeded.

3)   The DC/DC converter characteristics depend greatly on the externally connected components as well as on the characteristics of this IC, so refer to the specifications and standard circuit examples of each component when carefully considering which components to select.
 Be especially careful of the capacitor characteristics and use X7R or X5R (EIA standard) ceramic capacitors.
The capacitance decrease caused by the bias voltage may become large depending on the external size of the capacitor.

4)   The current limit value is the coil current peak value when switching is not conducted.
 The coil current peak value when the actual current limit function begins to operate may exceed the current limit of the electrical characteristics due to the effect of the propagation delay inside the circuit.

5)   When the On time is less than the Min On Time (t_{ONMIN}) and the dropout voltage is large or the load is low, the PWM control operates intermittently and the ripple voltage may become large or the output voltage may become unstable.

6)   The ripple voltage could be increased when switching from discontinuous conduction mode to continuous conduction mode and when switching to 100% Duty cycle.

7)   The PWM/PFM auto series may cause superimposed ripple voltage by continuous pulses if used in high temperature and no load conditions. It is necessary to set an idle current of higher than 100μA from V_{OUT} if used at no load.
 It can have the same effect as when R_{FB2} is lower than 7.5kΩ. Please refer to the
 < Output Voltage Setting Value V_{OUTSET} Setting > section under TYPICAL APPLICATION CIRCUIT.

8)   If the voltage at the EN/SS Pin does not start from 0V but is at the midpoint potential when the power is switched on, the soft start function may not work properly and it may cause larger inrush current and bigger ripple voltages.

9)   Torex places an importance on improving our products and their reliability. We request that users incorporate fail safe designs and post aging protection treatment when using Torex products in their systems.

■NOTES ON USE (Continued)

10)   Pattern Layout Instructions

(1)   The operation may become unstable due to noise and/or phase lag from the output current when the wire impedance is high. Please place the input capacitor (C_{IN1}, C_{IN2}) and the output capacitor (C_L) as close to the IC as possible.

(2)   In order to stabilize the V_{IN} voltage level, we recommend that a bypass capacitor (C_{IN1}, C_{IN2}) be connected as close as possible to the V_{IN} and GND pins.

(3)   Please mount each external component as close to the IC as possible.

(4)   Wire external components as close to the IC as possible and use thick, short connecting traces to reduce the circuit impedance.

(5)   Make sure that the GND traces are as thick as possible, as variations in ground potential caused by high ground currents at the time of switching may result in instability of the IC.

(6)   This product has a built in driver FET, which causes heat generation from the on resistance, so take measures to dissipate the heat when necessary.

< Reference Pattern Layout >
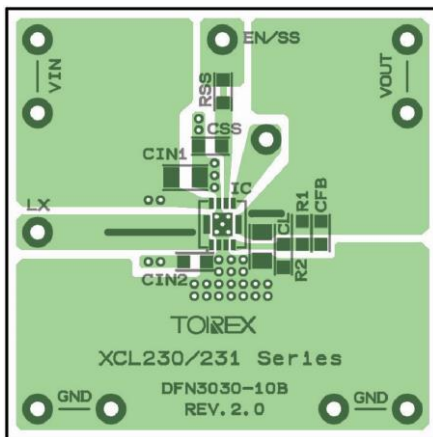
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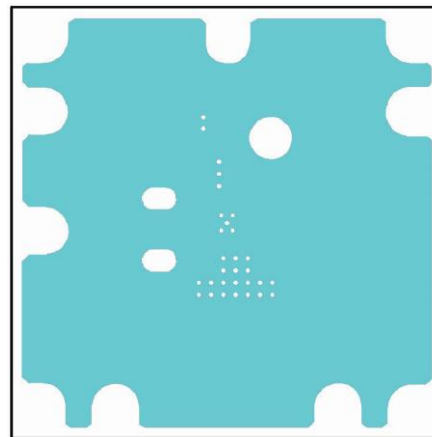
< Layer2 >
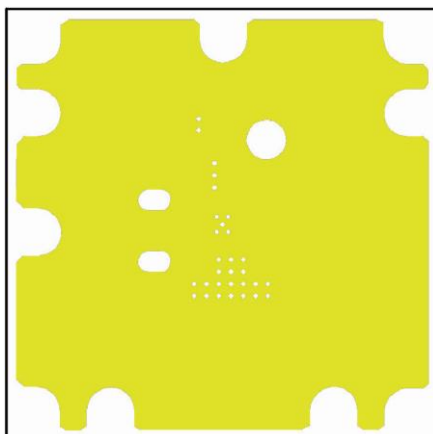
< Layer3 >
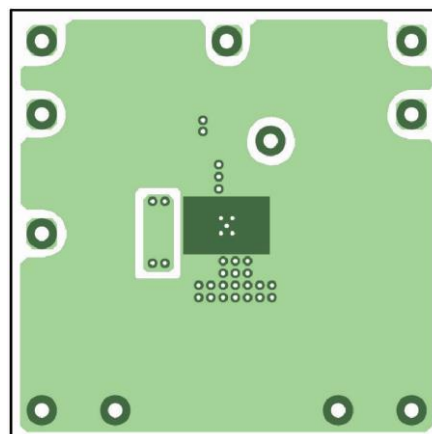
< Layer4 >

■HANDLING OF THIS PRODUCT

(1) The coil complies with the general surface-mounted type chip coil (inductor) specifications and could have scratches, be dirty with flux, etc.

(2) Please do not use this product in the following environments:
Areas where it could come in to contact with water or salt water. Areas where it could be affected by condensation.
Areas where it could come in contact with toxic gases (Hydrogen Sulfide, Sulfurous Acid, Chlorine, Ammonia, etc.)

(3) This product should not be washed in a solvent.

■ABOUT IMPLEMENTATION

(1) This product is only suitable for reflow soldering (it is not suitable for flow soldering).

(2) This product uses solder to mount the coil on top of the package. This is no problem for regular circuit board mounted reflow, but if excessive impact is applied during reflow, the mounted coil could be moved out of position or the coil could fall off. Be careful not to strike the circuit board during circuit board mounting reflow.

■TYPICAL PERFORMANCE CHARACTERISTICS

(1) Efficiency vs. Output Current

XCL230B0K1H2
(V_{IN}=12V, V_{OUT}=3.3V)

C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

XCL230B0K1H2
(V_{IN}=12V, V_{OUT}=5V)

C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

XCL231B0K1H2
(V_{IN}=12V, V_{OUT}=3.3V)

C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

XCL231B0K1H2
(V_{IN}=12V, V_{OUT}=5V)

C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

TOREX
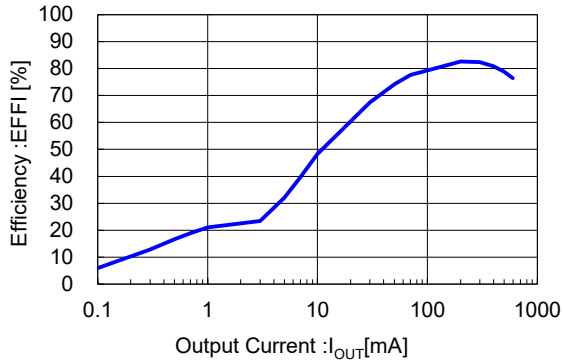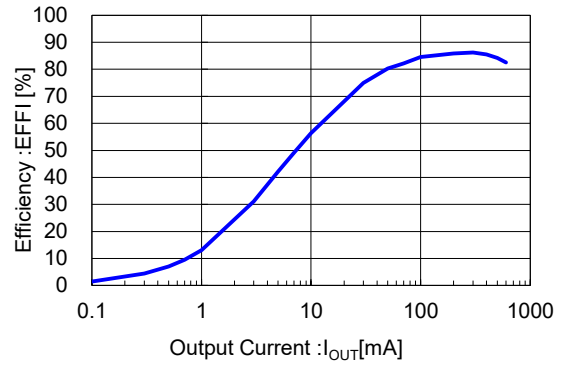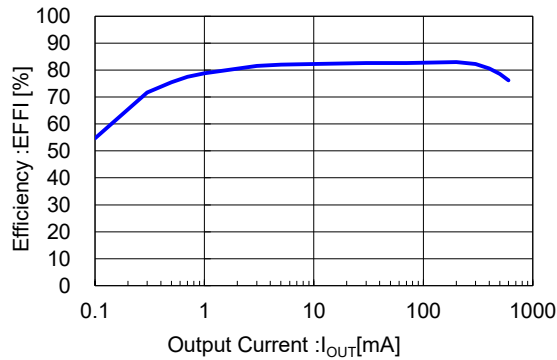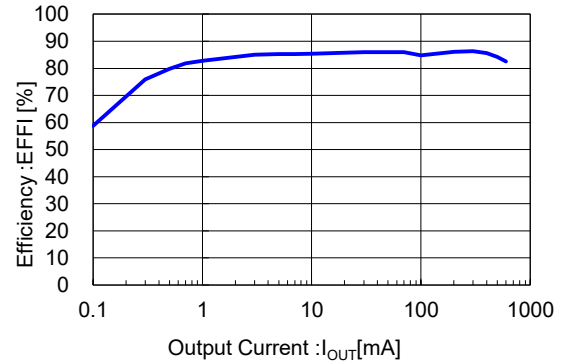
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Output Current

XCL230B0K1H2
(V_{IN}=12V, V_{OUT}=3.3V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)
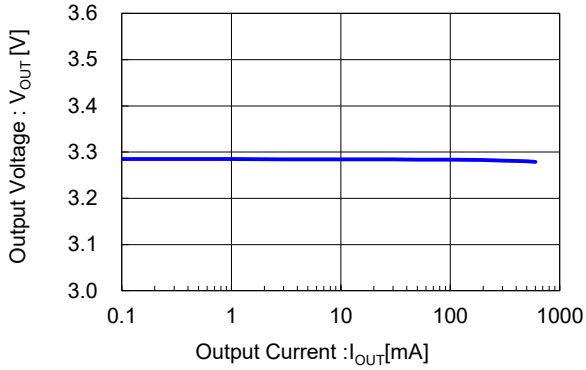
XCL230B0K1H2
(V_{IN}=12V, V_{OUT}=5V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)
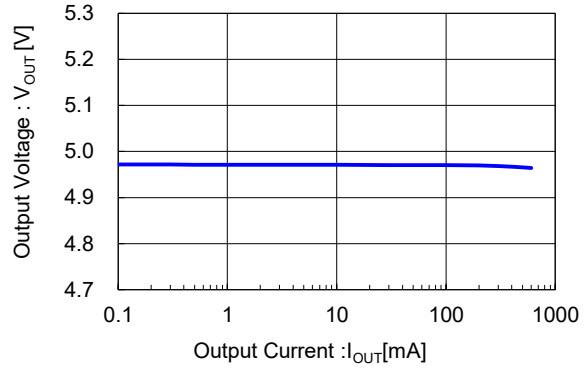
XCL231B0K1H2
(V_{IN}=12V, V_{OUT}=3.3V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)
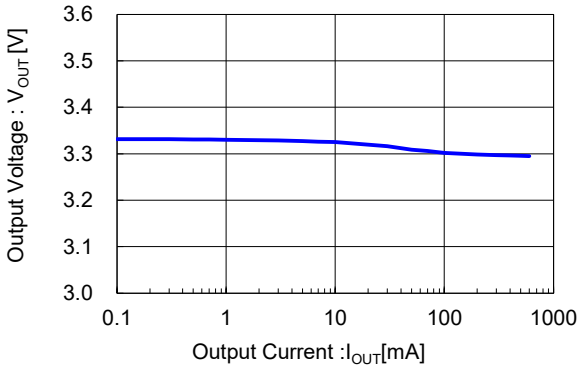
XCL231B0K1H2
(V_{IN}=12V, V_{OUT}=5V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)
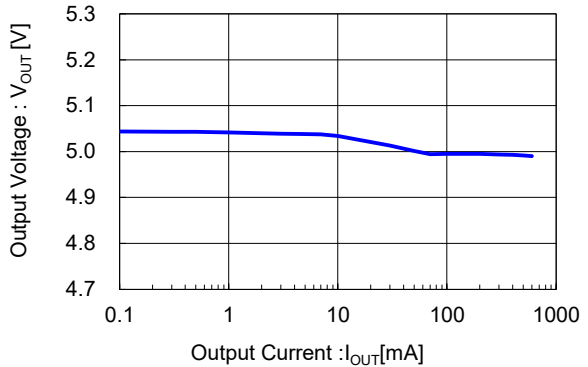
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Ripple Voltage vs. Output Current

XCL230B0K1H2
(V_{IN}=12V, V_{OUT}=3.3V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL230B0K1H2
(V_{IN}=12V, V_{OUT}=5V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
(V_{IN}=12V, V_{OUT}=3.3V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
(V_{IN}=12V, V_{OUT}=5V)

C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

TOREX
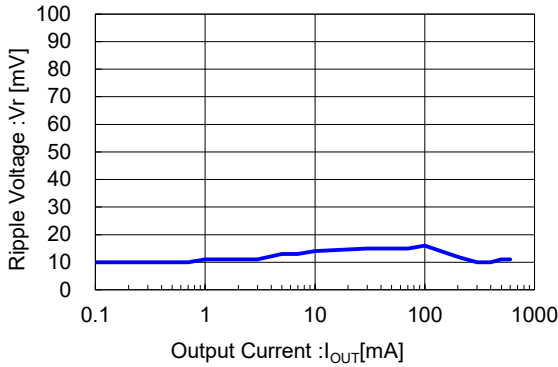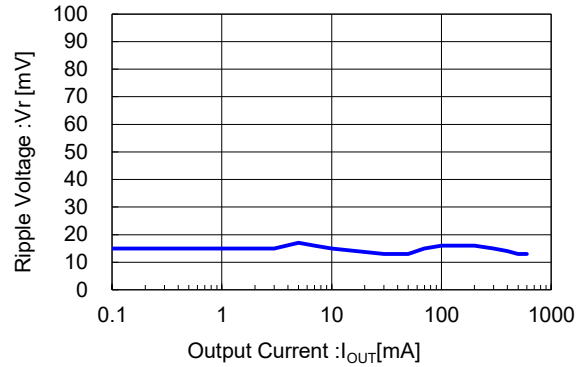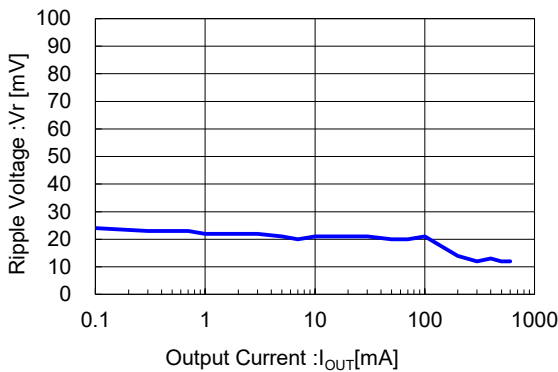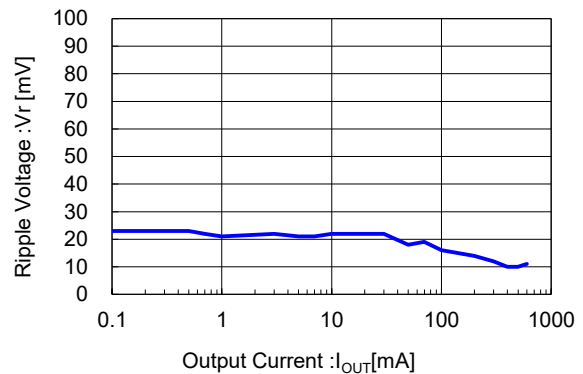
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(4) FB Voltage vs. Ambient Temperature

XCL230/XCL231
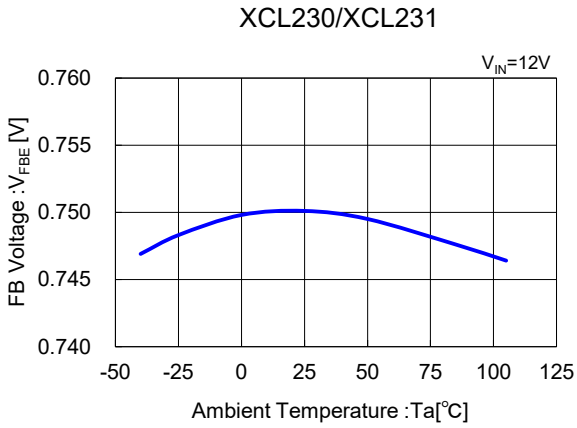
(5) UVLO Voltage vs. Ambient Temperature

XCL230/XCL231
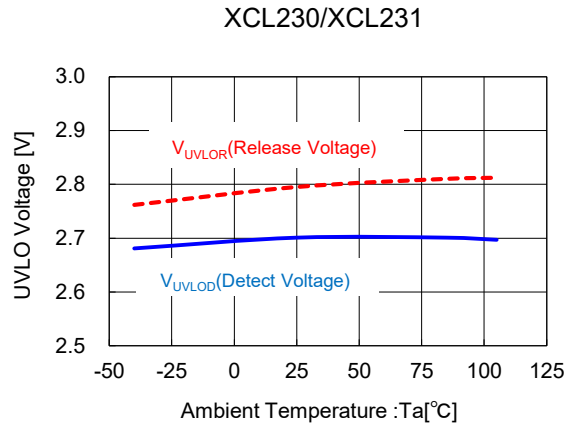
(6) Oscillation Frequency vs. Ambient Temperature

XCL230/XCL231
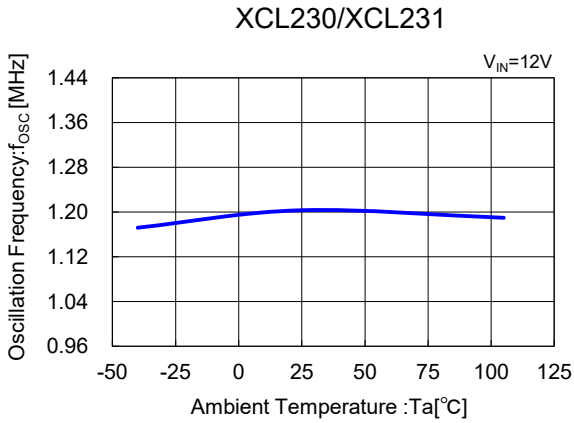
(7) Lx SW On Resistance vs. Ambient Temperature

XCL230/XCL231
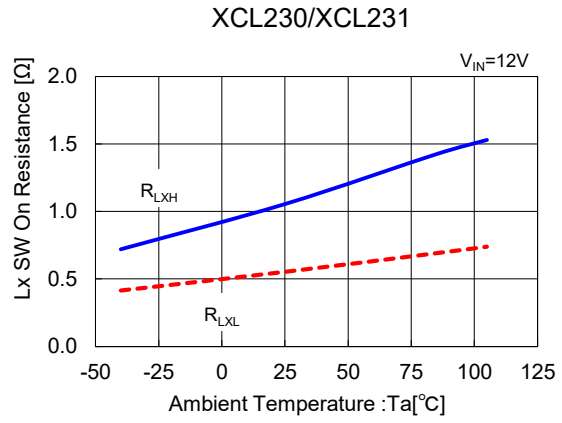
(8) Quiescent Current vs. Ambient Temperature

XCL230B0K1H2

XCL231B0K1H2
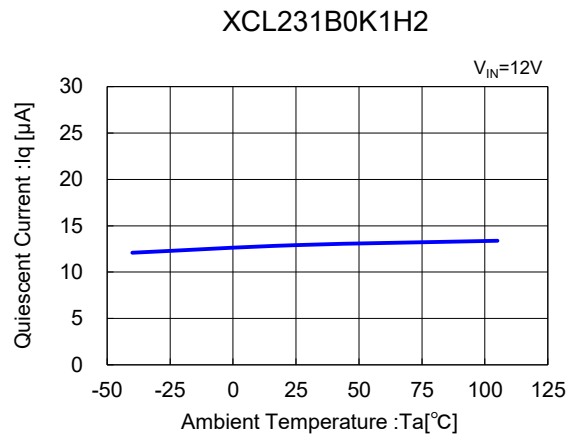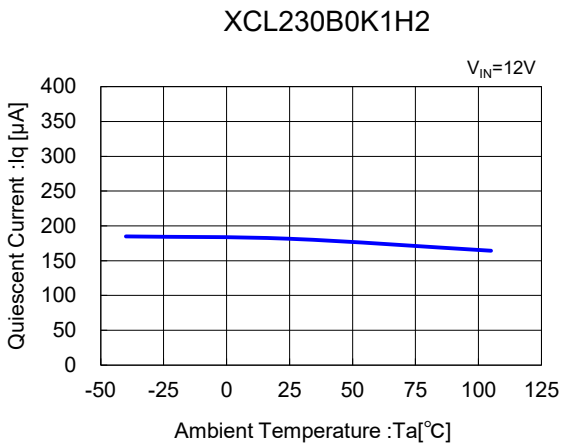
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Stand-by Current vs. Ambient Temperature
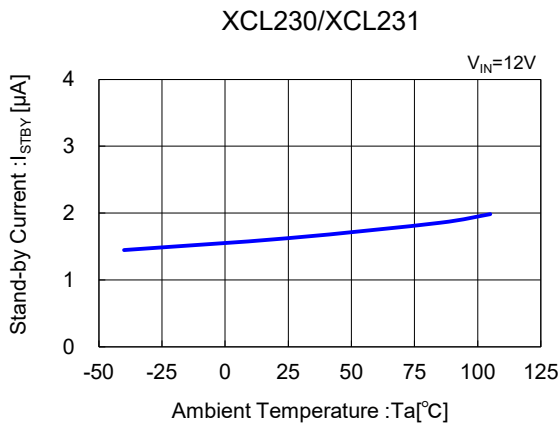
(10) EN/SS Voltage vs. Ambient Temperature

XCL230/XCL231

V_{IN}=12V

XCL230/XCL231

V_{IN}=12V

EN/SS"H"
EN/SS"L"
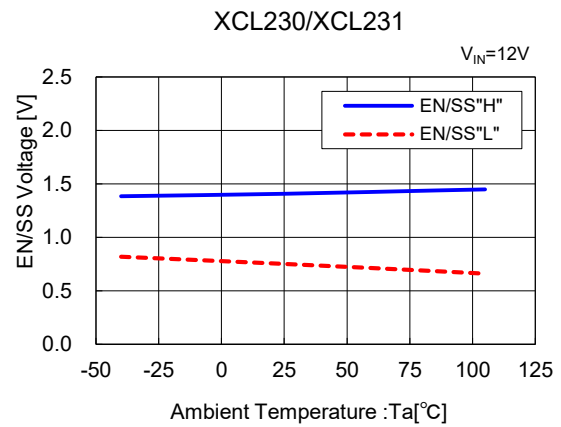
(11) Internal Soft-Start Time vs. Ambient Temperature

(12) External Soft-Start Time vs. Ambient Temperature

XCL230/XCL231

V_{IN}=12V

XCL230/XCL231

V_{IN}=12V, R_{SS}=430kΩ, C_{SS}=0.47μF
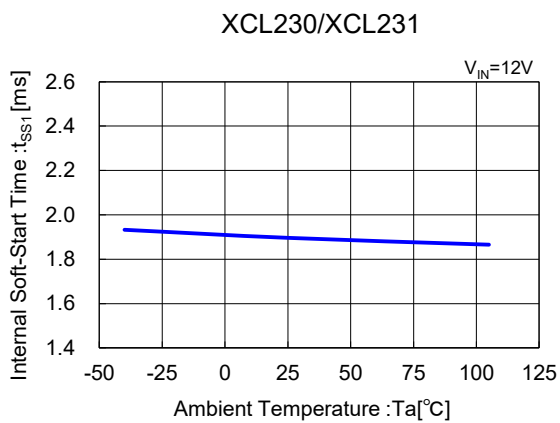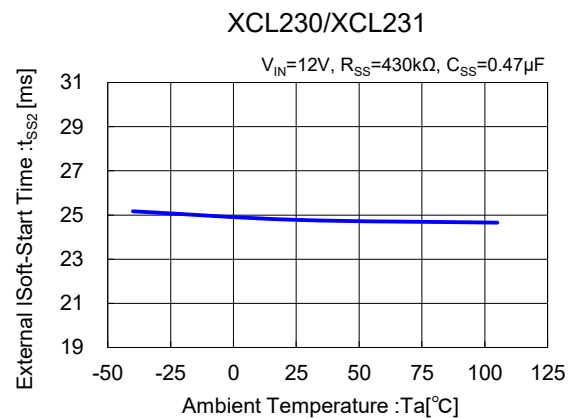
(13) PG Detect Voltage vs. Ambient Temperature
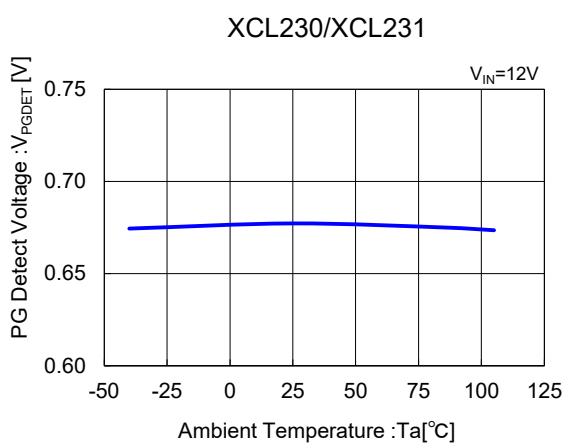
(14) PG Output Voltage vs. Ambient Temperature

XCL230/XCL231

V_{IN}=12V

XCL230/XCL231

V_{IN}=12V, I_{PG}=1mA

TOREX
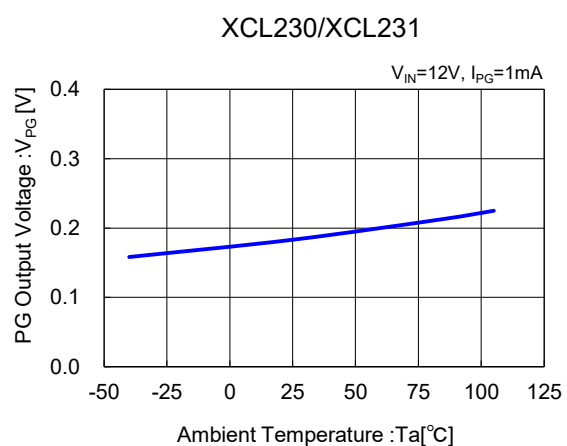
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(15) V_{IN}-V_{OUT} Operation Area

XCL230B0K1H2   XCL231B0K1H2
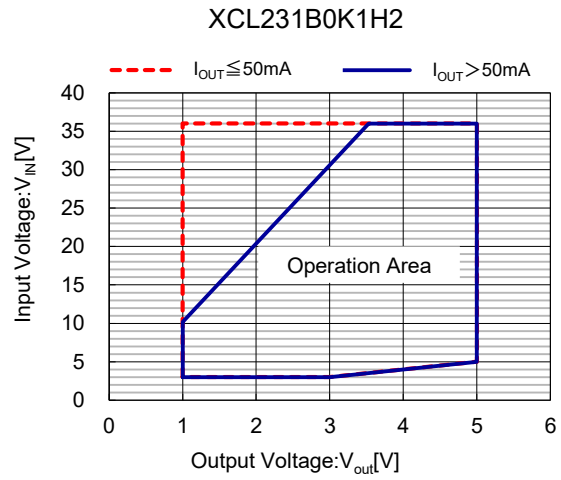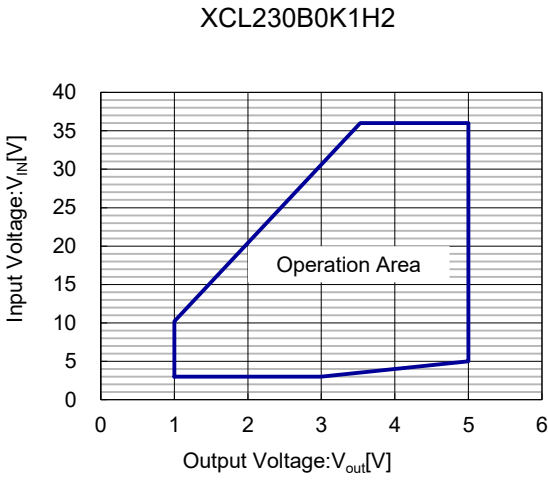
(16) Output Current Operation Area

XCL230/XCL231

V_{OUT}=5.0V, θja=50℃/W

XCL230/XCL231 Series is Discontinued.

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(17) Load Transient Response (XCL230)

XCL230B0K1H2
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=10mA⇔300mA (t_r, t_f=5µs)
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

XCL230B0K1H2
V_{IN}=24V, V_{OUT}=3.3V, I_{OUT}=10mA⇔300mA (t_r, t_f=5µs)
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

XCL230B0K1H2
V_{IN}=12V, V_{OUT}=5.0V, I_{OUT}=10mA⇔300mA (t_r, t_f=5µs)
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

XCL230B0K1H2
V_{IN}=24V, V_{OUT}=5.0V, I_{OUT}=10mA⇔300mA (t_r, t_f=5µs)
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)
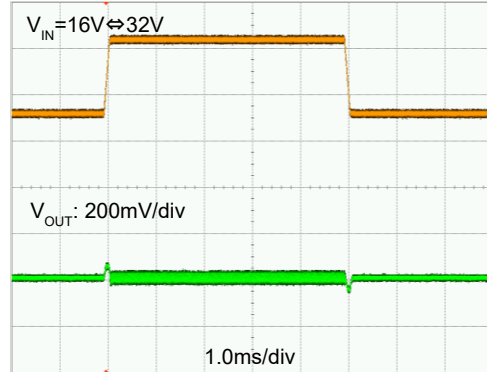
(17) Load Transient Response (XCL231)

XCL231B0K1H2

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=10mA⇔300mA (t_r, t_f=5μs)
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

I_{OUT}=10mA⇔300mA

V_{OUT}: 500mV/div

1.0ms/div

XCL231B0K1H2

V_{IN}=24V, V_{OUT}=3.3V, I_{OUT}=10mA⇔300mA (t_r, t_f=5μs)
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

I_{OUT}=10mA⇔300mA

V_{OUT}: 500mV/div

1.0ms/div

XCL231B0K1H2

V_{IN}=12V, V_{OUT}=5.0V, I_{OUT}=10mA⇔300mA (t_r, t_f=5μs)
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

I_{OUT}=10mA⇔300mA

V_{OUT}: 500mV/div

1.0ms/div

XCL231B0K1H2

V_{IN}=24V, V_{OUT}=5.0V, I_{OUT}=10mA⇔300mA (t_r, t_f=5μs)
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

I_{OUT}=10mA⇔300mA

V_{OUT}: 500mV/div

1.0ms/div

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) Input Transient Response (XCL230)

XCL230B0K1H2

V_{IN}=8V⇔16V (t_r, t_f=50µs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
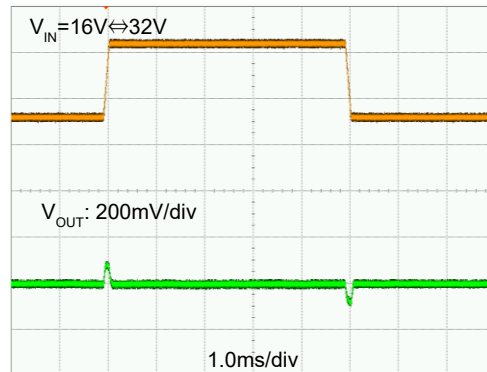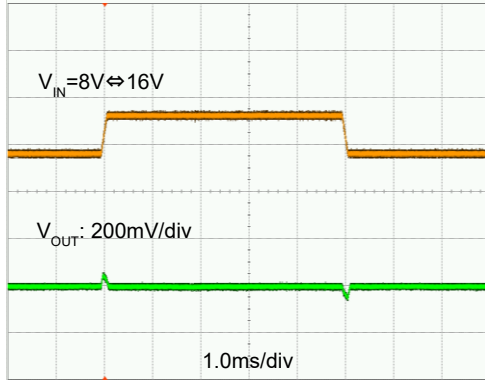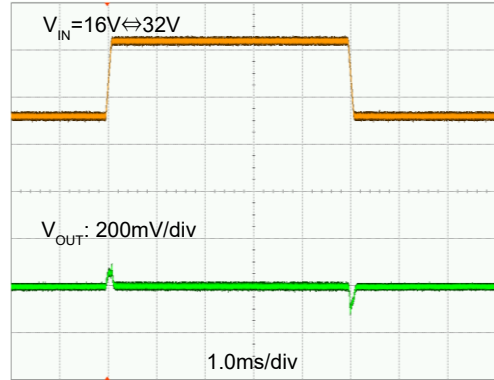C_L=22µF(TMK212BBJ226MG)

V_{IN}=8V⇔16V
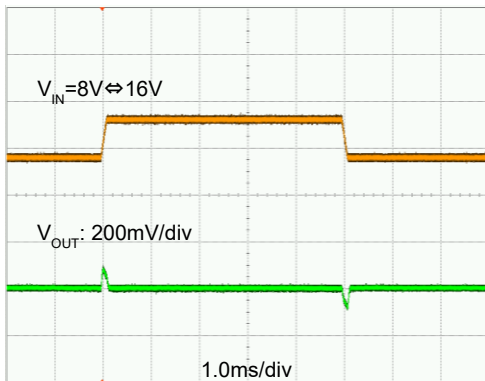
V_{OUT}: 200mV/div

1.0ms/div

XCL230B0K1H2

V_{IN}=16V⇔32V (t_r, t_f=50µs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
C_L=22µF(TMK212BBJ226MG)

V_{IN}=16V⇔32V

V_{OUT}: 200mV/div

1.0ms/div

XCL230B0K1H2

V_{IN}=8V⇔16V (t_r, t_f=50µs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
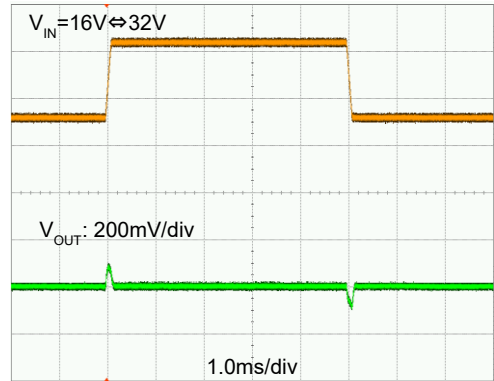C_L=22µF(TMK212BBJ226MG)

V_{IN}=8V⇔16V

V_{OUT}: 200mV/div

1.0ms/div

XCL230B0K1H2

V_{IN}=16V⇔32V (t_r, t_f=50µs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7µF(UMK212BBJ475KG), C_{IN2}=0.1µF(UMK107BJ104MAHT)
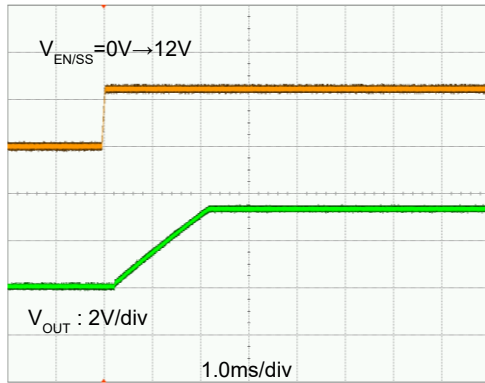C_L=22µF(TMK212BBJ226MG)

V_{IN}=16V⇔32V

V_{OUT}: 200mV/div

1.0ms/div

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) Input Transient Response (XCL231)

XCL231B0K1H2
V_{IN}=8V⇔16V (t_r, t_f=50μs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
V_{IN}=16V⇔32V (t_r, t_f=50μs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
V_{IN}=8V⇔16V (t_r, t_f=50μs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
V_{IN}=16V⇔32V (t_r, t_f=50μs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(19) EN/SS Rising Response (XCL230)

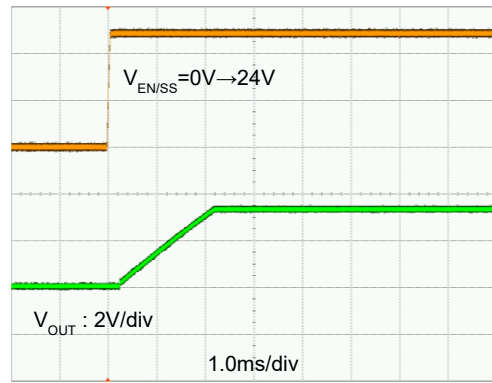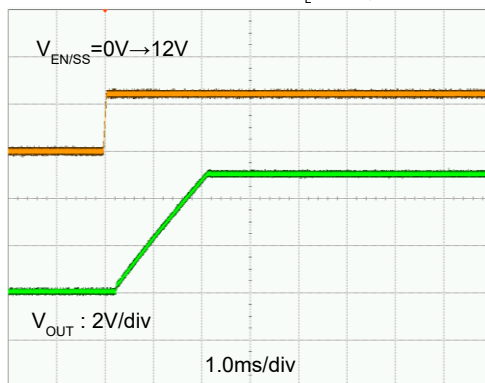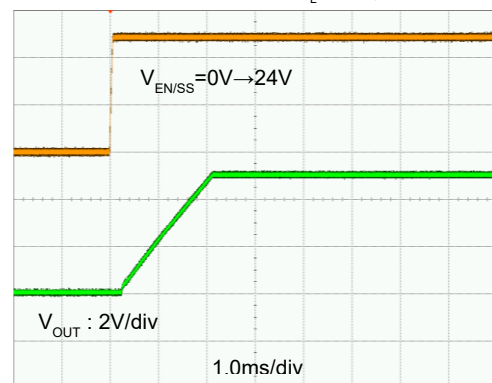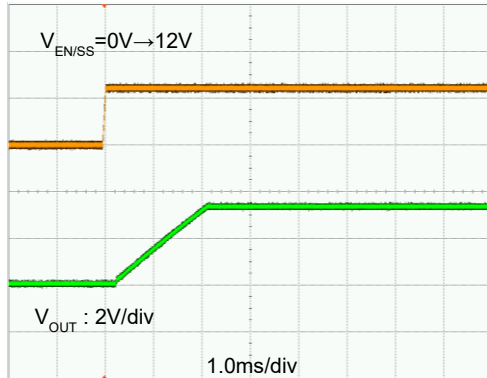### XCL230B0K1H2

V_{IN}=12V, $V_{EN/SS}$=0V→12V(tr=50μs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL230B0K1H2

V_{IN}=24V, $V_{EN/SS}$=0V→24V(tr=50μs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL230B0K1H2

V_{IN}=12V, $V_{EN/SS}$=0V→12V(tr=50μs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL230B0K1H2

V_{IN}=24V, $V_{EN/SS}$=0V→24V(tr=50μs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)
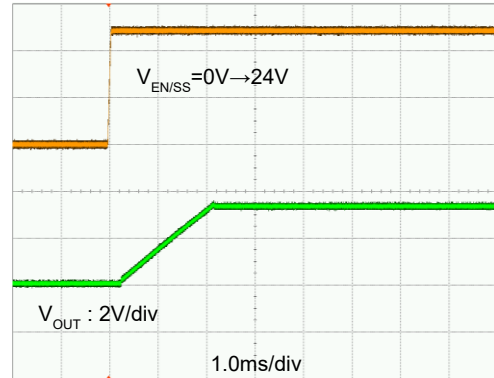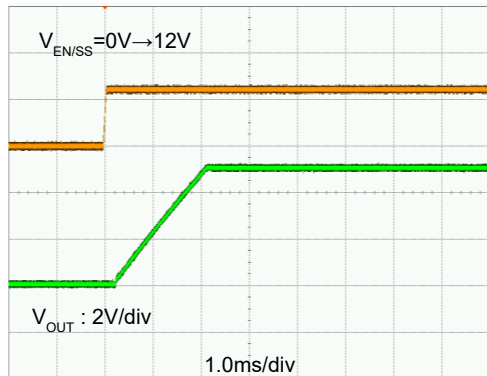
(19) EN/SS Rising Response (XCL231)

XCL231B0K1H2
V_{IN}=12V, $V_{EN/SS}$=0V→12V(tr=50μs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
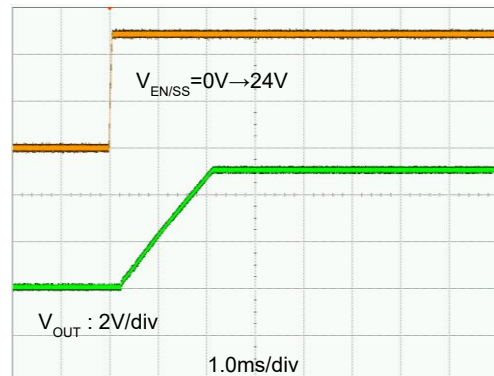V_{IN}=24V, $V_{EN/SS}$=0V→24V(tr=50μs), V_{OUT}=3.3V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
V_{IN}=12V, $V_{EN/SS}$=0V→12V(tr=50μs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

XCL231B0K1H2
V_{IN}=24V, $V_{EN/SS}$=0V→24V(tr=50μs), V_{OUT}=5.0V, I_{OUT}=300mA
C_{IN1}=4.7μF(UMK212BBJ475KG), C_{IN2}=0.1μF(UMK107BJ104MAHT)
C_L=22μF(TMK212BBJ226MG)

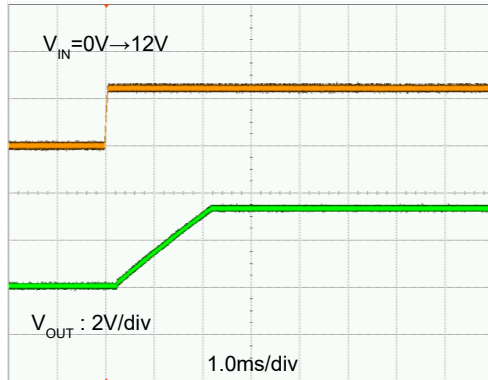# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(20) V$_{IN}$ Rising Response (XCL230)

XCL230B0K1H2

V$_{IN}$=0V→12V(tr=50μs),V$_{EN/SS}$=V$_{IN}$, V$_{OUT}$=3.3V, I$_{OUT}$=300mA
C$_{IN1}$=4.7μF(UMK212BBJ475KG), C$_{IN2}$=0.1μF(UMK107BJ104MAHT)
C$_L$=22μF(TMK212BBJ226MG)

XCL230B0K1H2

V$_{IN}$=0V→24V(tr=50μs), V$_{EN/SS}$=V$_{IN}$, V$_{OUT}$=3.3V, I$_{OUT}$=300mA
C$_{IN1}$=4.7μF(UMK212BBJ475KG), C$_{IN2}$=0.1μF(UMK107BJ104MAHT)
C$_L$=22μF(TMK212BBJ226MG)

XCL230B0K1H2

V$_{IN}$=0→12V(tr=50μs), V$_{EN/SS}$=V$_{IN}$, V$_{OUT}$=5.0V, I$_{OUT}$=300mA
C$_{IN1}$=4.7μF(UMK212BBJ475KG), C$_{IN2}$=0.1μF(UMK107BJ104MAHT)
C$_L$=22μF(TMK212BBJ226MG)

XCL230B0K1H2

V$_{IN}$=0→24V(tr=50μs), V$_{EN/SS}$=V$_{IN}$, V$_{OUT}$=5.0V, I$_{OUT}$=300mA
C$_{IN1}$=4.7μF(UMK212BBJ475KG), C$_{IN2}$=0.1μF(UMK107BJ104MAHT)
C$_L$=22μF(TMK212BBJ226MG)

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)
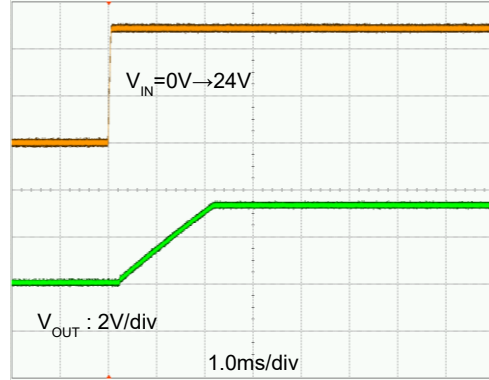
(20) V_{IN} Rising Response (XCL231)

XCL231B0K1H2

$V_{IN}=0\rightarrow12V(tr=50\mu s)$, $V_{EN/SS}=V_{IN}$, $V_{OUT}=3.3V$, $I_{OUT}=300mA$
$C_{IN1}=4.7\mu F(UMK212BBJ475KG)$, $C_{IN2}=0.1\mu F(UMK107BJ104MAHT)$
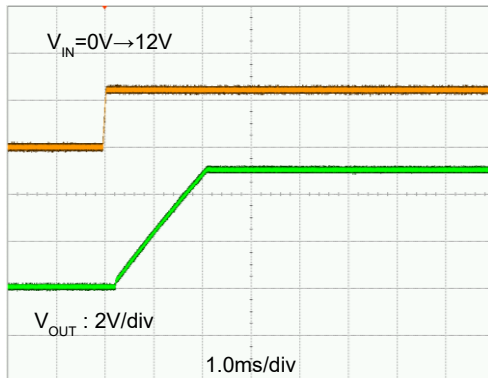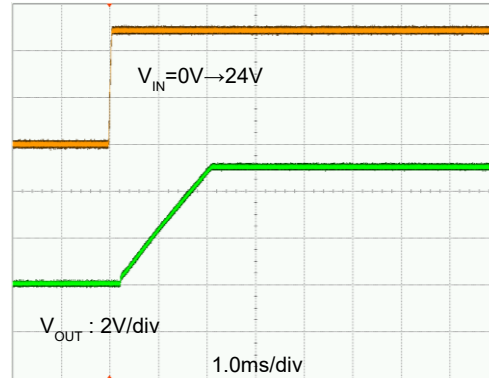$C_L=22\mu F(TMK212BBJ226MG)$

XCL231B0K1H2

$V_{IN}=0\rightarrow24V(tr=50\mu s)$, $V_{EN/SS}=V_{IN}$, $V_{OUT}=3.3V$, $I_{OUT}=300mA$
$C_{IN1}=4.7\mu F(UMK212BBJ475KG)$, $C_{IN2}=0.1\mu F(UMK107BJ104MAHT)$
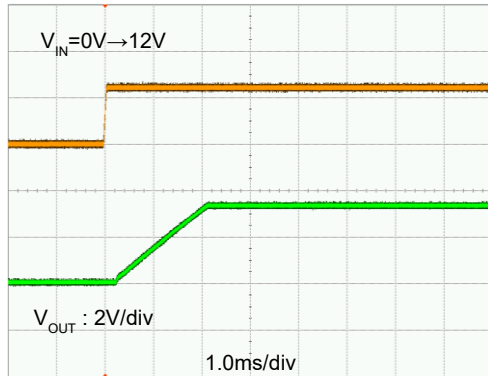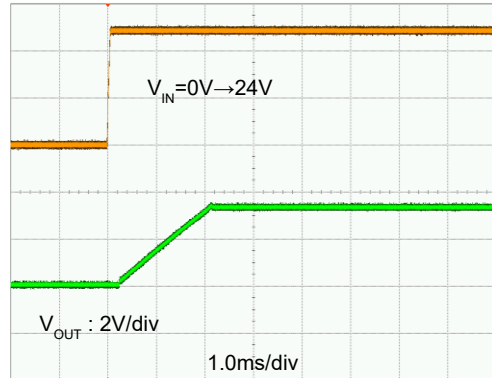$C_L=22\mu F(TMK212BBJ226MG)$

XCL231B0K1H2

$V_{IN}=0\rightarrow12V(tr=50\mu s)$, $V_{EN/SS}=V_{IN}$, $V_{OUT}=5.0V$, $I_{OUT}=300mA$
$C_{IN1}=4.7\mu F(UMK212BBJ475KG)$, $C_{IN2}=0.1\mu F(UMK107BJ104MAHT)$
$C_L=22\mu F(TMK212BBJ226MG)$

XCL231B0K1H2

$V_{IN}=0\rightarrow24V(tr=50\mu s)$, $V_{EN/SS}=V_{IN}$, $V_{OUT}=5.0V$, $I_{OUT}=300mA$
$C_{IN1}=4.7\mu F(UMK212BBJ475KG)$, $C_{IN2}=0.1\mu F(UMK107BJ104MAHT)$
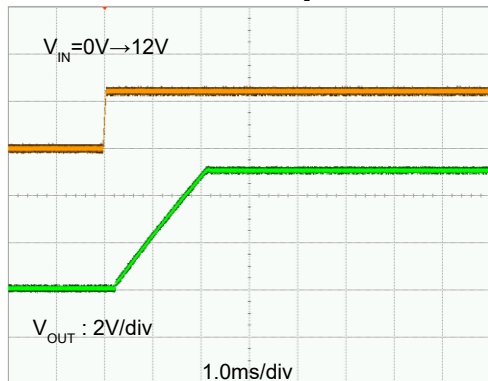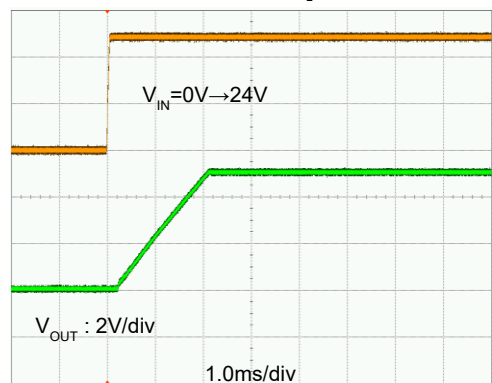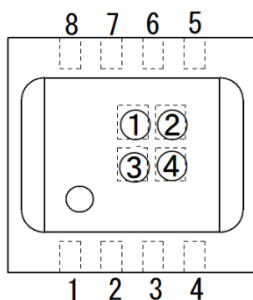$C_L=22\mu F(TMK212BBJ226MG)$

■PACKAGING INFORMATION

For the latest package information go to, www.torex.co.jp/technical-support/packages/

PACKAGE	OUTLINE / LAND PATTERN	THERMAL CHARACTERISTICS	
DFN3030-10B	DFN3030-10B PKG	JESD51-7 Board	DFN3030-10B Power Dissipation

■MARKING RULE

●DFN3030-10B

Mark ①,②, represents product series, products type.

SYMBOL		Product Number	Type	PRODUCT NAME
①	②			
T	N	XCL230	B	XCL230B0K1H2
T	T	XCL231	B	XCL231B0K1H2

Mark ③,④, represents production lot number.
01~09, 0A~0Z, 11~9Z, A1~A9, AA~B1~ZZ, repeated.
(G, I, J, O, Q, W excluded) No character inversion used.

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