XC9246/XC9247 Series

ETR05024-005a

16V Driver Transistor Built-In Step-Down DC/DC Converters

☆GreenOperation-compatible

■GENERAL DESCRIPTION

XC9246/XC9247 series is a 16V step-down DC/DC converter with a built-in driver transistor. The series provides high efficiency, and a stable power supply with output currents up to 1A. The series is designed for use with small ceramic capacitors.

The series has a 1.0V reference voltage, and using externally connected resistors, the output voltage can be set freely. With an internal switching frequency of 1.2MHz, small external components can be used. The soft-start time is internally set to 1.5ms (TYP.), but can be adjusted to set a longer time using an external resistor and capacitor.

As for operation mode, the XC9246 series is PWM control and the XC9247 series is automatic PWM/PFM switching control.

In PWM/PFM switching control mode, provides fast response, low ripple and high efficiency over the full range of loads (from light load to heavy load).

With the UVLO (Under Voltage Lock Out) function, the internal driver transistor is forced OFF when input voltage becomes lower than detect voltage. The series includes current limit, thermal shutdown, and short-circuit protection.

Two types of package SOT-26W and USP-6C are available.

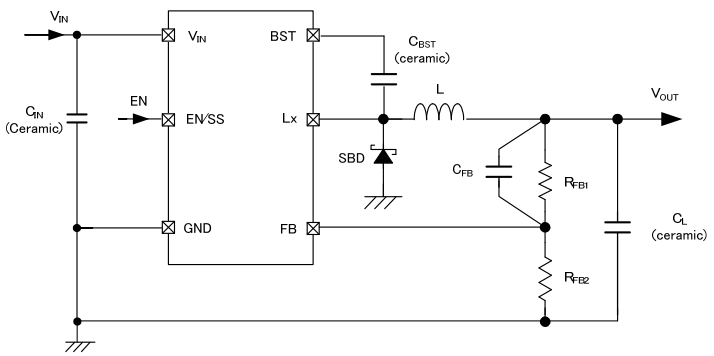
■APPLICATIONS

- LCD-TVs
- BD/HDD recorders
- Set top box
- Home video game consoles
- Multifunction printers

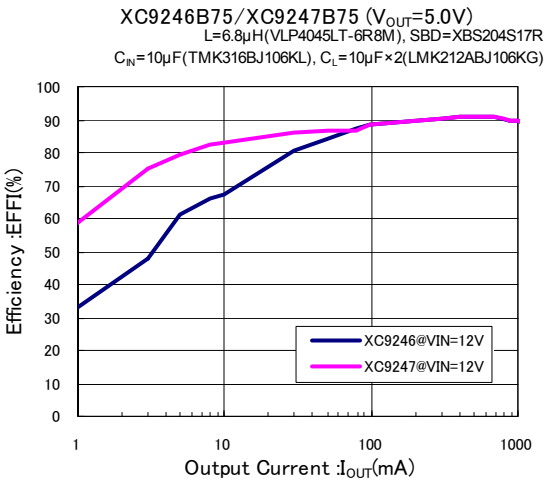
■FEATURES

Input Voltage	:	4.5V～16V (The V_{IN} range depends on the product)
Output Voltage Range	:	1.2V～5.6V (V_{FB}=1.0V) (The V_{OUT} range depends on the product)
Output Current	:	1A (V_{IN}≧6V and V_{OUT}/V_{IN}≦50%) 1A (V_{IN}＜6V and V_{OUT}/V_{IN}≦40%)
Efficiency	:	90%(V_{IN}=12V, V_{OUT}=5V, I_{OUT}=200mA)
Oscillation Frequency	:	1.2MHz
Maximum Duty Cycle	:	80%
Soft-start Time	:	Internally fixed 1.5ms Adjustable by RC
Control Methods	:	PWM Control (XC9246) PWM/PFM Automatic switching control (XC9247)
Protection Circuits	:	Current limiter (Integral Latching) Thermal shutdown Short-circuit protection
UVLO	:	4.15V, 5.65V, 7.65V
Output Capacitor	:	Ceramic Capacitor Compatible
Operating Ambient Temperature	:	-40℃～+85℃
Packages	:	USP-6C, SOT-26W
Environmentally Friendly	:	EU RoHS Compliant, Pb Free

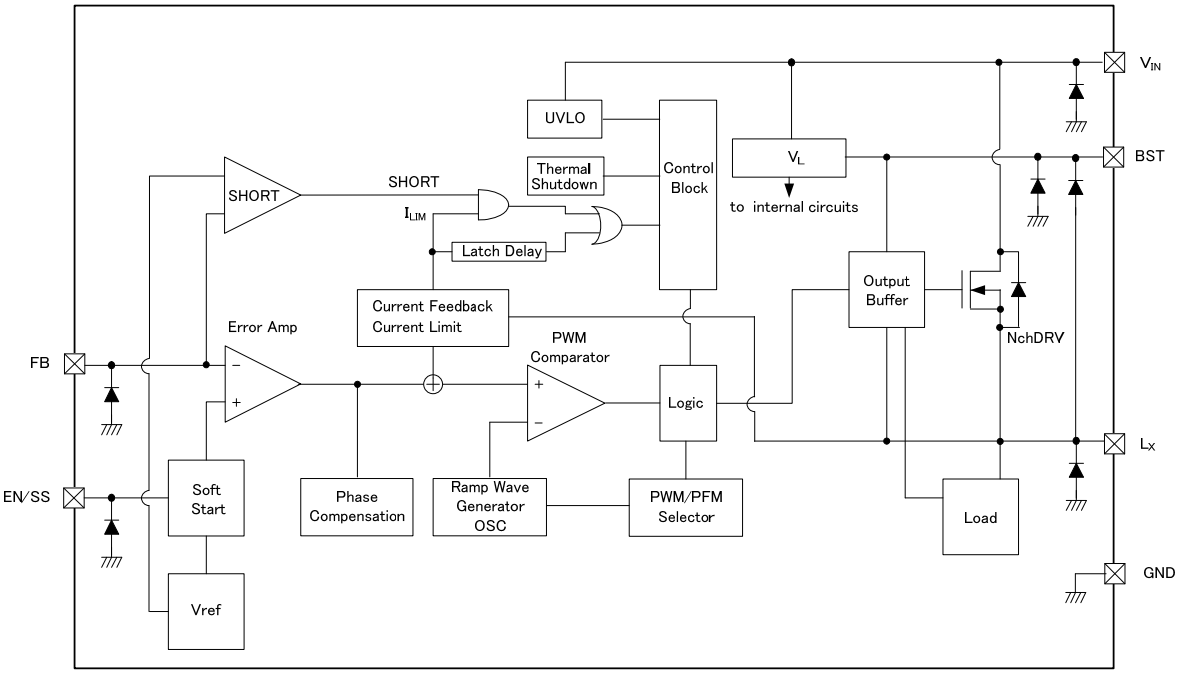
■TYPICAL APPLICATION CIRCUIT



■TYPICAL PERFORMANCE CHARACTERISTICS



■BLOCK DIAGRAM(*1) (*2) (*3)



(*1) Diodes inside the circuit are an ESD protection diode and a parasitic diode.
(*2) The XC9246 offers a fixed PWM control, a Control Logic to PWM/PFM Selector is fixed internally.
(*3) The XC9247 control scheme is a fixed PWM/PFM automatic switching, a Control Logic to PWM/PFM Selector is fixed internally.

■PRODUCT CLASSIFICATION

●Ordering Information

XC9246B①②③④⑤-⑥ PWM Control
XC9247B①②③④⑤-⑥ PWM/PFM Automatic switching control

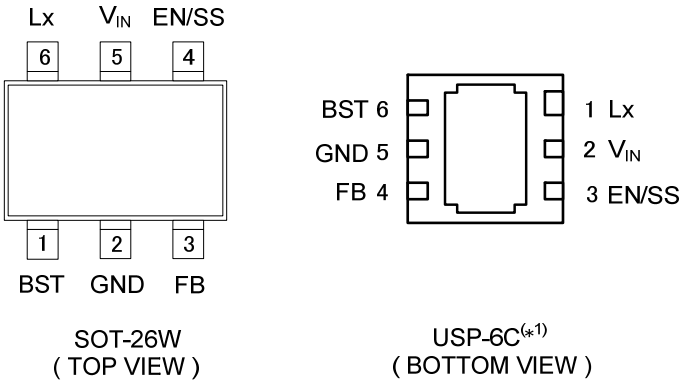
DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①②	UVLO Release Voltage	42	4.15V (1.2V≦V_{OUT}≦2.7V)
		65	5.65V (1.2V≦V_{OUT}≦3.8V)
		75	7.65V (XC9246: 1.5V≦V_{OUT}≦5.0V) (XC9247: 1.5V≦V_{OUT}≦5.6V)
③	Oscillation Frequency	C	1.2MHz
④⑤-⑥ (*1)	Packages (Order Unit)	ER-G	USP-6C (3,000/Reel)
		MR-G	SOT-26W (3,000/Reel)

(*1) The "-G" suffix denotes Halogen and Antimony free as well as being fully RoHS compliant.

●Selection Guide

TYPE	EN/SS	CURRENT LIMIT	LATCH	UVLO	THERMAL SHUTDOWN
B	Yes	Yes	Yes	Yes	Yes

■PIN CONFIGURATION



SOT-26W
(TOP VIEW)

USP-6C(*1)
(BOTTOM VIEW)

(*1) The dissipation pad for the USP-6C 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. 5) pin.

■PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTIONS
SOT-26W	USP-6C		
1	6	BST	Pre Driver Supply
2	5	GND	Ground
3	4	FB	Output Voltage Monitor
4	3	EN/SS	Enable Soft-start
5	2	V_{IN}	Power Input
6	1	Lx	Switching Output

■FUNCTION

PIN NAME	SIGNAL	STATUS
EN/SS(*1)	L	Stand-by
	H	Active

(*1) Please do not leave the EN/SS pin open.

■ABSOLUTE MAXIMUM RATINGS

Ta=25℃

PARAMETER		SYMBOL	RATINGS	UNITS
V_{IN} Pin Voltage		V_{IN}	-0.3～+22.0	V
BST Pin Voltage		V_{BST}	-0.3～+22.0 and Lx-0.3～Lx+6.0	V
FB Pin Voltage		V_{FB}	-0.3～+6.0	V
EN/SS Pin Voltage		$V_{EN/SS}$	-0.3～+22.0	V
Lx Pin Voltage		V_{LX}	-0.3～V_{IN}+0.3 or V_{BST}+0.3 or 22.0 (*1)	V
Lx Pin Current		I_{LX}	4000	mA
Power Dissipation	SOT-26W	Pd	250	mW
	USP-6C		120	
Operating Ambient Temperature		Topr	-40～+85	℃
Storage Temperature		Tstg	-55～+125	℃

All voltages are described based on the AGND and PGND pin.

(*1) The maximum value is the lowest one among V_{IN}+0.3V, V_{BST} + 0.3V or +22V.

■ELECTRICAL CHARACTERISTICS

XC9246/XC9247 Series

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
FB Voltage	V_{FB}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=0.9V→1.1V Voltage to start oscillation while		D1 (*1)		V	②
Operating Voltage Range	V_{IN}	-		D2 (*1)		V	①
Maximum Output Current	I_{OUTMAX}	-	1000	-	-	mA	①
UVLO Detection Voltage	V_{UVLOD}	$V_{EN/SS}$=5V, V_{FB}=0.9V Voltage which Lx pin holding "L" level (*6)		D3 (*1)		V	②
UVLO Release Voltage	V_{UVLOR}	$V_{EN/SS}$=5V, V_{FB}=0.9V Voltage to start oscillation while		D4 (*1)		V	②
UVLO Hysteresis Voltage	$V_{UVLOHYS}$	-		D5 (*1)		V	-
Supply Current	I_q	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=1.1V	-	150	300	μA	③
Stand-by Current	I_{STB}	V_{IN}=16V, $V_{EN/SS}$=0V	-	6	15	μA	③
Oscillation Frequency	f_{OSC}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=0.9V	1020	1200	1380	kHz	②
Maximum Duty Cycle	D_{MAX}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=0.9V	72	80	88	%	②
Minimum Duty Cycle	D_{MIN}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=1.1V	-	-	0	%	②
PFM Switch Current (*2)	I_{PFM}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{OUT}=3.3V, I_{OUT}=10mA When connected to external components	-	300	-	mA	①
PFM Duty Limit (*2)	DTY_{LIMIT_PFM}	-	-	200	-	%	①
Lx SW ON Resistance	R_{Lx}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=0.9V	-	0.35 (*4)	0.5 (*4)	Ω	-
Current Limit (*5)	I_{LIM}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=0.9V	1600	2500	-	mA	②
Integral Latch Time	t_{LAT}	V_{IN}=12V, $V_{EN/SS}$=5V, V_{FB}=0.9V	0.75	1.5	3	ms	②
Short Detect Voltage	V_{SHORT}	Sweeping V_{FB}, V_{IN}=12V, $V_{EN/SS}$=5V, Short V_{OUT} at1ΩResistance, V_{FB} voltage which Lx becomes "L" level within 300μs	0.3	0.5	0.7	V	④
Internal Soft-start Time	$t_{SS}1$	V_{IN}=12V, $V_{EN/SS}$=0V→5V,V_{FB}=0.9V	0.75	1.5	3	ms	②
External Soft-start Time	$t_{SS}2$	V_{IN}=12V, $V_{EN/SS}$=0V→5V, V_{FB}=0.9V R_{SS}=120KΩ, C_{SS}=0.47μF When connected to external components	18	26	35	ms	⑤
Efficiency	EFFI	Target Output Voltage=5.0V V_{IN}=12V, I_{OUT}=200mA (*3)	-	90	-	%	①
Output Voltage Temperature Characteristics	ΔV_{OUT}/ (V_{OUT}・ΔTopr)	I_{OUT}=100mA -40℃≦Topr≦85℃	-	±100	-	ppm/℃	①
Thermal Shutdown Temperature	T_{TSD}	-	-	150	-	℃	-
Hysteresis Width	T_{HYS}	-	-	20	-	℃	-
EN/SS "H" Voltage	$V_{EN/SSH}$	V_{IN}=12V, V_{FB}=$V_{FB(E)}$-10mV (*7), $V_{EN/SS}$=5V→1V, Voltage to stop oscillation while	-	2.0	2.5	V	②
EN/SS "L" Voltage	$V_{EN/SSL}$	V_{IN}=12V, V_{FB}=0V $V_{EN/SS}$=5V→0V, Voltage to stop oscillation while	0.4	-	-	V	②
EN/SS "H" Current	$I_{EN/SSH}$	V_{IN}=$V_{EN/SS}$=16V	-	7	15	μA	⑥
EN/SS "L" Current	$I_{EN/SSL}$	V_{IN}=12V, $V_{EN/SS}$=0V	-0.1	-	0.1	μA	⑥
FB "H" Current	I_{FBH}	V_{IN}=12V, $V_{EN/SS}$=0V, V_{FB}=5.5V	-0.1	-	0.1	μA	⑥
FB "L" Current	I_{FBL}	V_{IN}=12V, $V_{EN/SS}$=0V, V_{FB}=0V	-0.1	-	0.1	μA	⑥
Lx "L" Current	I_{LXL}	V_{IN}=16V, $V_{EN/SS}$=5V, V_{FB}=1.1V, V_{LX}=0V	-7.5	-4	-	μA	⑦

Unless otherwise stated, V_{IN}=12V, $V_{EN/SS}$=5V

(*1) Please refer to SPEC Table below.

(*2) As the XC9246 series work in the PWM control operation only, I_{PFM} and DTY_{LIMIT_PFM} are not for XC9246 series.

(*3) EFFI=[(output voltage x output current)÷(input voltage x input current)]×100

(*4) Design value

(*5) Current limit denotes the level of detection at peak of coil current.

(*6) "H"=V_{IN}～V_{IN}-1.2V , "L"=+0.1V～-0.1V

(*7) $V_{FB(E)}$ is effective value of FB voltage.

■ELECTRICAL CHARACTERISTICS (Continued)

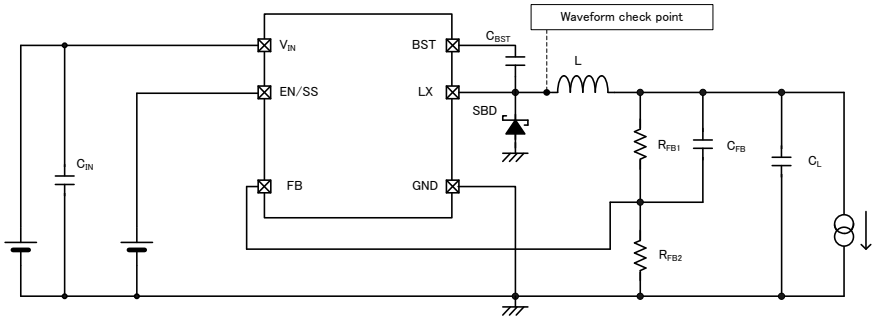
SPEC Table

No.	PARAMETER	SYNBOL	SOT-26W			USP-6C			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
D1	FB Voltage	V_{FB}	0.985	1.000	1.015	0.98	1.00	1.02	V

No.	PARAMETER	SYNBOL	XC9246B42/XC9247B42			XC9246B65/XC9247B65			XC9246B75/XC9247B75			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
D2	Operating Voltage Range	V_{IN}	4.5	-	16.0	6.0	-	16.0	8.0	-	16.0	V
D3	UVLO Detection Voltage	V_{UVLOD}	3.7	4.0	-	4.8	5.5	-	6.9	7.4	-	V
D4	UVLO Release Voltage	V_{UVLOR}	-	4.15	4.48	-	5.65	5.98	-	7.65	7.98	V
D5	UVLO Hysteresis Voltage	$V_{UVLOHYS}$	-	0.12	-	-	0.15	-	-	0.25	-	V

■TEST CIRCUITS

<Circuit No.①>



＊External components
C_{IN}:10μF(ceramic)
C_L:22μF(ceramic)
C_L:47μF(ceramic)(*1)
C_{BST}:0.22μF(ceramic)
L:4.7μH
SBD:XBS204S17R-G
(*1) Output Voltage Temperature Characteristics

Target Output Voltage=3.3V
R_{FB1}:62kΩ
R_{FB2}:27kΩ
C_{FB}:130pF

Target Output Voltage=5.0V
R_{FB1}:30kΩ
R_{FB2}:7.5kΩ
C_{FB}:270pF

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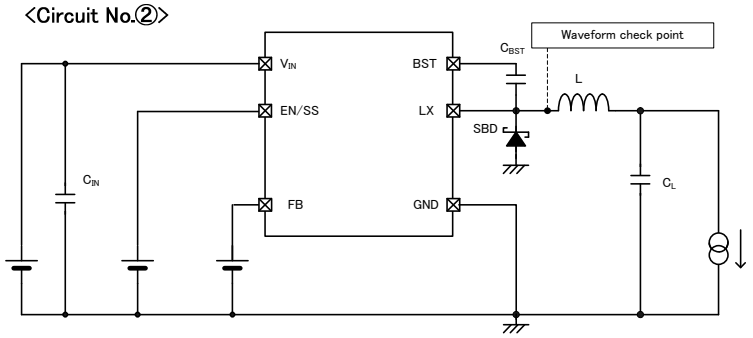

＊External components
C_{IN}:10μF(ceramic)
C_L:22μF(ceramic)
C_{BST}:0.22μF(ceramic)
L:4.7μH
SBD:XBS204S17R-G

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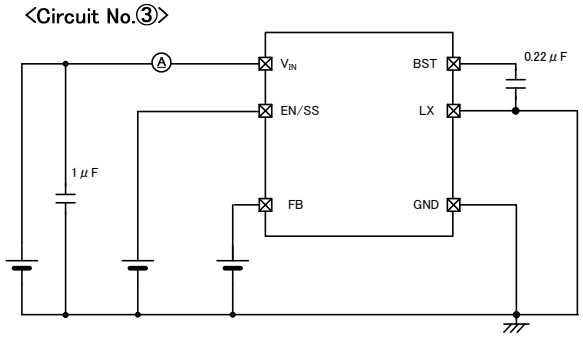

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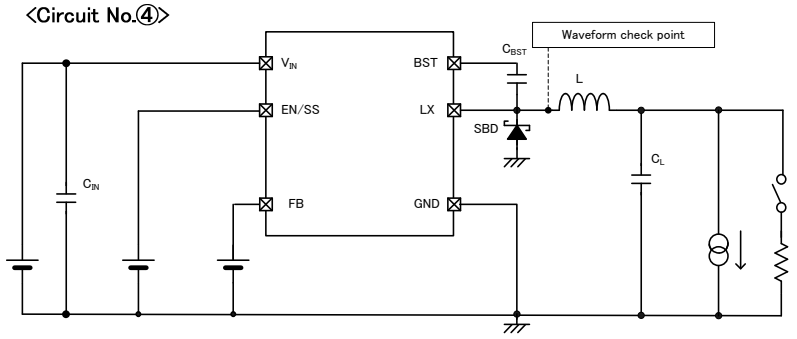
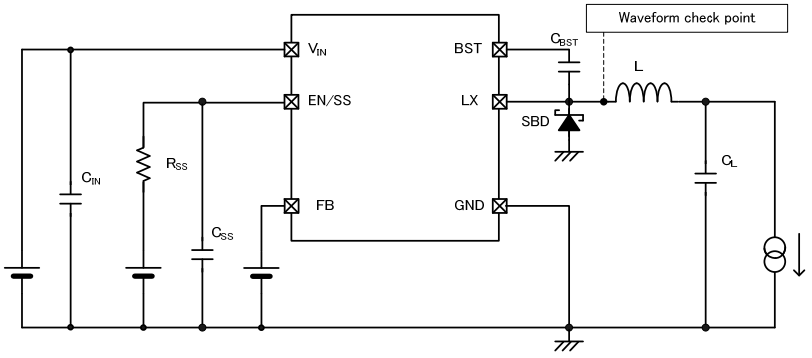


＊External components
C_{IN}:10μF(ceramic)
C_L:22μF(ceramic)
C_{BST}:0.22μF(ceramic)
L:4.7μH
SBD:XBS204S17R-G

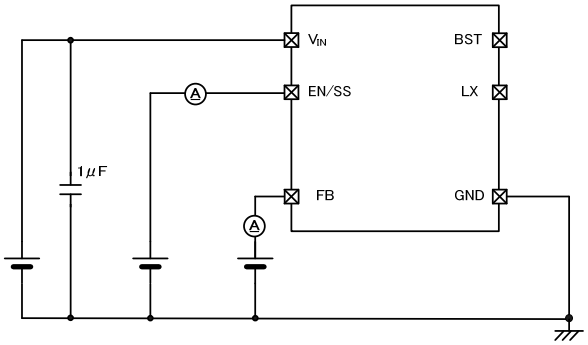
■TEST CIRCUITS (Continued)

<Circuit No.⑤>



＊External components
C_{IN}:10μF(ceramic)
C_L:22μF(ceramic)
C_{BST}:0.22μF(ceramic)
L:4.7μH
SBD:XBS204S17R-G
R_{SS}:120kΩ
C_{SS}:0.47μF

<Circuit No.⑥>



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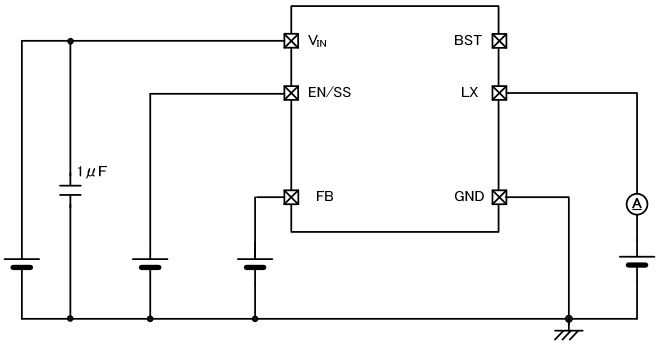
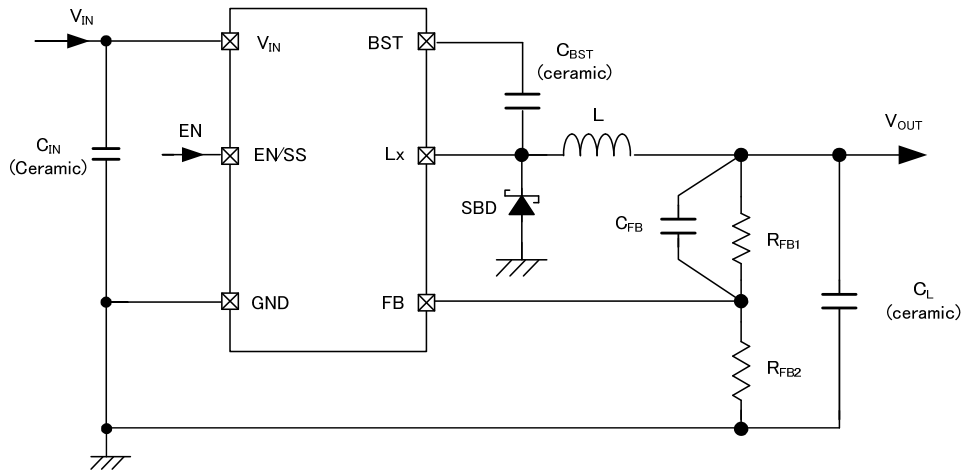


■TYPICAL APPLICATION CIRCUIT



【Typical Examples】

	MANUFACTURER	PRODUCT NUMBER	VALUE
L	Coilcraft	XFL4020-332MEB	3.3μH
	Coilcraft	XFL4020-472MEB	4.7μH
	TDK	VLP4045LT-4R7M	4.7μH
	TDK	VLP4045LT-6R8M	6.8μH
SBD (*1)	TOREX	XBS204S17R	VF=0.42V(1A)
	TOREX	XBS203V17R	VF=0.305V(1A)
	SHINDENGEN	D1FJ4	VF=0.48V(1A)
	VISHAY	SS2P3L	VF=0.45V(2A)
	TOSHIBA	CMS17	VF=0.42V(1A)
C_{IN}	TDK	C2012X5R1E106K	10μF/25V
	TAIYO YUDEN	TMK316BJ106KL	10μF/25V
C_L	TDK	C2012X5R1A106K	10μF/10V 2parallel
	TAIYO YUDEN	LMK212ABJ106KG	10μF/10V 2parallel
C_{BST}			0.22μF/10V

(*1) The Inter-Terminal Capacitance of the schottky barrier diode should be around 180pF.
Ct Test Conditions: f=1MHz, V_R=1V

【Recommended L Value and V_{OUT} Range】

V_{OUT}	Recommended L Value (*1)	
1.2V≦V_{OUT}≦3.5V	3.3μH	4.7μH
3.5V＜V_{OUT}≦4.0V	-	4.7μH
4.0V＜V_{OUT}≦5.6V	-	6.8μH

(*1) For the coil value (L), use a component with 20% accuracy or less.

■TYPICAL APPLICATION CIRCUIT (Continued)

<Output Voltage Setting>

The output voltage can be set by connecting external dividing resistors. The output voltage is determined by the values of R_{FB1} and R_{FB2} as given in the equation below. The total of R_{FB1} and R_{FB2} should be less than 100kΩ or less. Output voltage range can be set freely from 1.2V to 5.6V with a 1.0V reference voltage. (The step down ratio is determined based on the version. Refer to the "Output voltage range classified by product" graph below.) However, it should be noted that the output voltage can not be stable when V_{IN}=16V and V_{OUT}=1.2V so please set the step down ration under the condition of V_{OUT}/V_{IN} x 100≧18%

$$V_{OUT}=1.0\times(R_{FB1}+R_{FB2})/R_{FB2}$$

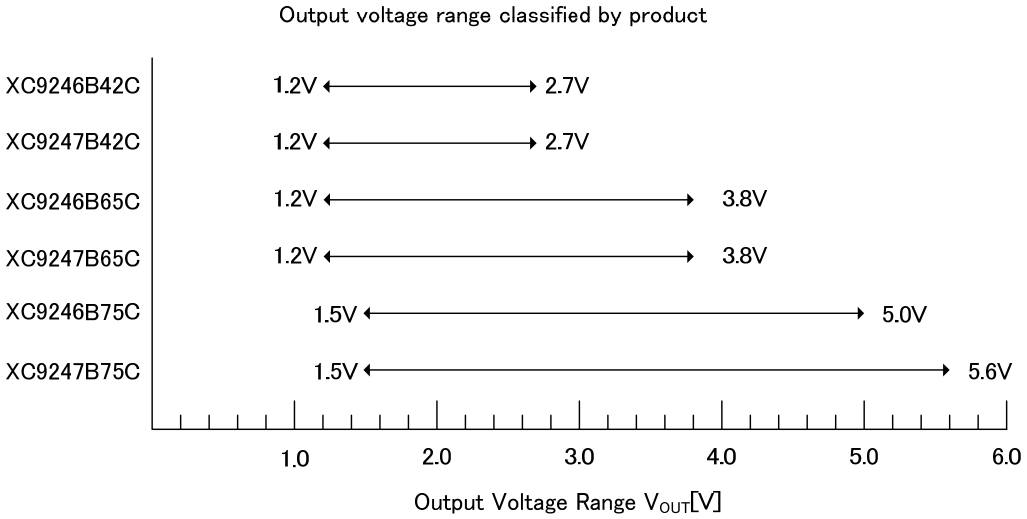
Adjust the value of the phase compensation speed-up capacitor C_{FB} so that $f_{zfp}=1 / (2 \times \pi \times C_{FB} \times R_{FB1})$ is about 20kHz. Adjustments are required from 10kHz to 50kHz depending on the application, value of inductance (L), and value of load capacitance (C_L).

【Examples】

When R_{FB1}=30kΩ and R_{FB2}=7.5kΩ, $V_{OUT}=1.0\times(30k\Omega+7.5k\Omega) / 7.5k\Omega =5V$
When C_{FB}=270pF, $fzfb= 1/(2\times\pi\times270pF\times30k\Omega) =19.65kHz$

【Typical Examples】

V_{OUT} (V)	R_{FB1}(kΩ)	R_{FB2}(kΩ)	C_{FB}(pF)	V_{OUT}(V)	R_{FB1}(kΩ)	R_{FB2}(kΩ)	C_{FB}(pF)
1.2	15	75	510	2.5	36	24	220
1.5	18	36	430	3.0	36	18	220
1.8	24	30	330	3.3	62	27	130
2.0	47	47	160	5.0	30	7.5	270



■TYPICAL APPLICATION CIRCUIT (Continued)

<C_{BST} Setting>

0.22μF is recommended for the C_{BST} capacitance when C_L=22μF. Do not fix it at C_{BST}=0.22μF for all conditions but rather change it depending on the C_L capacitance (*1).

As a guideline, make it about C_L:C_{BST}=100:1.

(*1) Think of the C_L capacitance as the total capacitance connected to the V_{OUT} of XC9246/XC9247.

【CBST Optimum Settings】

C_L(μF)	C_{BST}(μF)
$C_L \leqq 22$	0.22
$22 < C_L \leqq 47$	0.47
$47 < C_L \leqq 100$	1
$100 < C_L \leqq 220$	2.2

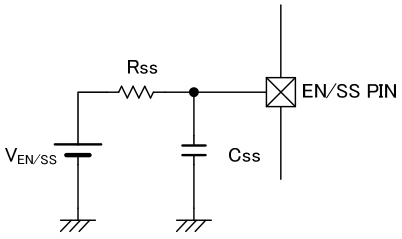
<Soft-start Time Setting>

The Vref voltage applied to the error amplifier is restricted by the start-up voltage of the EN/SS pin. This ensures that the error amplifier operates with its two inputs in balance, thereby preventing ON-time signal from becoming longer than necessary. Therefore, start-up time of the EN/ESS pin becomes the set-time of soft-start. The soft-start time can be adjusted by adding a capacitor and a resistor to the EN/SS pin. If the EN/SS pin voltage rises steeply without connecting C_{SS} and R_{SS} (R_{SS}=0Ω), Output rises with taking the soft-start time of 1.5ms (TYP.) which is fixed internally. The soft-start function operates when the voltage at the EN/SS pin is between 0.4V to 2.5V. If the voltage at the EN/SS pin does not start from 0V but from a mid level voltage when the power is switched on, the soft-start function will become ineffective and the possibilities of large inrush currents and ripple voltages occurring will be increased. Soft-start time is approximated by the equation below according to values of V_{EN}, R_{SS}, and C_{SS}.

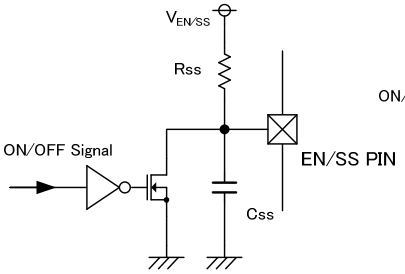
$$tss = -Css \times Rss \times In\{(V_{EN/SS} - 2) / V_{EN/SS}\}$$

Example: When Css=0.47μF, Rss=120kΩ and $V_{EN/SS}$=5V, $t_{SS} = -0.47x10^{-6} \times 120x10^{3} \times In((5-2)/5) = 29ms$ (Approx.)

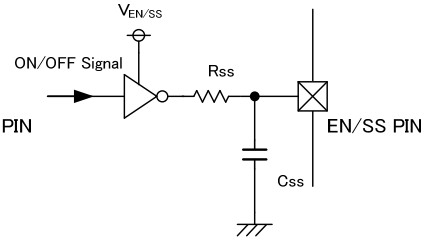
* When R_{SS}=0Ω and C_{SS}=0F, the soft-start time is 1.5ms (TYP.) and it's set internally.



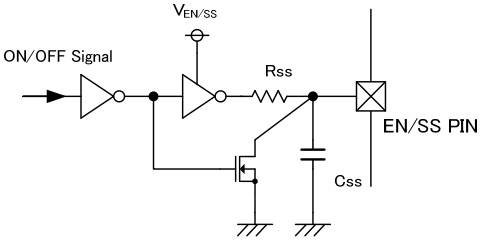
> Circuit Example1 : N-ch Open Drain



> Circuit Examle2 : CMOS logic (low current dissipation)



> Cicuit Examle3 : CMOS logic (low current dissipation, quick off)

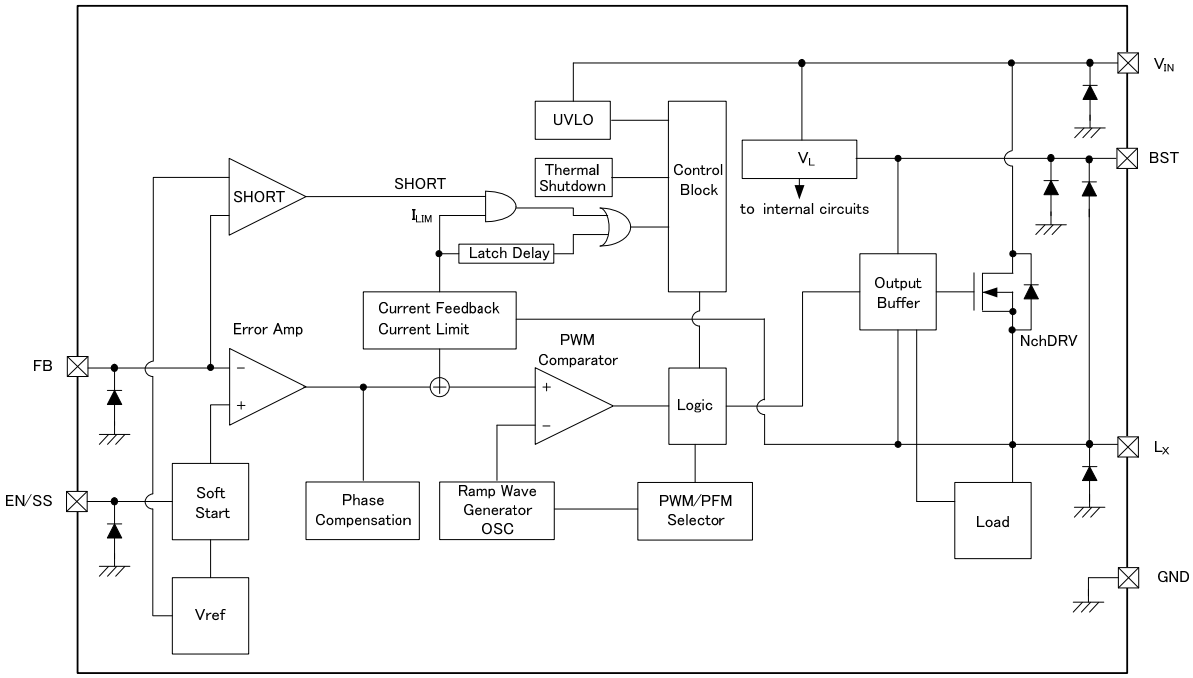


■OPERATIONAL EXPLANATION

The XC9246/XC9247 series consists of a reference voltage source (Vref), an internal reference voltage source (V_L), ramp wave circuit, error amplifier, PWM comparator, phase compensation circuit, N-ch MOS driver transistor, current limiter circuit, short protection circuit, UVLO circuit, thermal shutdown circuit, over voltage protection, load disconnect control and others. (See the BLOCK DIAGRAM below.)

By using the error amplifier, the FB pin voltage is compared with the reference voltage. The error amplifier output is sent to the PWM comparator in order to determine the duty cycle of PWM switching. The signal from the error amplifier is compared with the ramp wave from the ramp wave circuit, and the resulting output is delivered to the buffer driver circuit to provide on-time of the duty cycle at the LX pin. This process is continuously performed to ensure stable output voltage.

The current feedback circuit monitors the N-ch MOS driver transistor current for each switching operation, and modulates the error amplifier output signal to provide multiple feedback signals. This enables a stable feedback loop even when using a low ESR capacitor such as ceramic, which results in ensuring stable output voltage.



BLOCK DIAGRAM

<Reference Voltage Source>

The reference voltage source (Vref voltage) provides the reference voltage to ensure stable output voltage of the DC/DC converter.

<Ramp Wave Circuit>

The ramp wave circuit determines switching frequency. The frequency is fixed 1.2MHz internally. Clock pulses generated in this circuit are used to produce ramp waveforms needed for PWM operation, and to synchronize all the internal circuits.

<Error Amplifier>

The error amplifier is designed to monitor output voltage. The amplifier compares the reference voltage with the feedback voltage. When a voltage lower than the reference voltage is fed back, the output voltage of the error amplifier increases. The gain and frequency characteristics of the error amplifier output are fixed internally to deliver an optimized signal to the mixer. The error amplifier output signal optimized in the mixer is modulated with the current feedback signal. This signal is delivered to the PWM comparator.

■OPERATIONAL EXPLANATION (Continued)

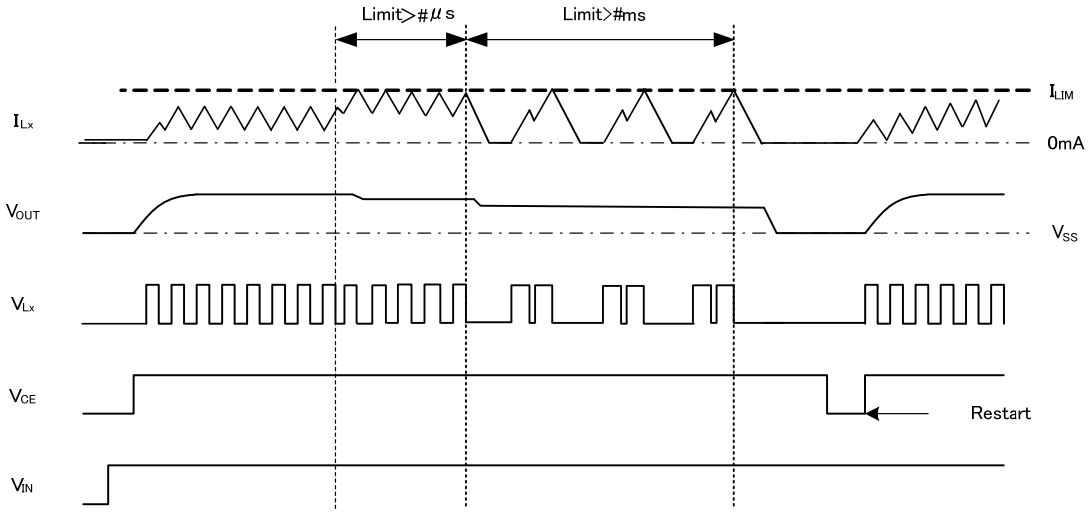
<Current Limit>

The current limit circuit monitors the current flowing through the N-ch MOS driver transistor, and features a combination of the current limit mode and the operation suspension mode.

① When the driver current is greater than a specific level, the current limit operates to turn off the pulses from the LX pin at any given timing.
② When the N-ch MOS driver transistor is turned off, the limiter circuit is then released from the current limit detection state.
③ At the next pulse, the N-ch MOS driver transistor is turned on. However, the N-ch MOS transistor is immediately turned off in the case of an over current state.
④ When the over current state is eliminated, the IC resumes its normal operation.

As ① to ③ are repeated and an over-current state continues for about 20μs, the off period of the N-ch MOS driver Tr. will be longer to prevent from DC overlapping of the coil current. The over-current state continues for several ms. and as ① to ③ are repeated, the off state of the N-ch MOS driver will be latched and IC will be stopped. Once IC is in the state, operation can be resumed by feeding H-level to EN/SS pin after L-level is fed to the pin, or by turning the VIN power off and turning it on again. Under the function-stop state, clock is stopped, however it is not the shutdown state. So the internal circuitries operate. The current limiting value is 2500mA typically.

The latch time may be longer than spec., or the latch situation may not happen in spite of the over-current condition due to the ambient noise or the allocation of external components on PCB. Putting the input capacitor to IC as close as possible is recommended.



<Thermal Shutdown>

For protection against heat damage of the ICs, thermal shutdown function monitors chip temperature. The thermal shutdown circuit starts operating and the N-ch MOS driver transistor will be turned off when the chip's temperature reaches 150℃. When the temperature drops to 130℃ or less after shutting of the current flow, the IC performs the soft-start function to initiate output startup operation.

<UVLO Circuit>

When the V_{IN} voltage becomes 4.0V (XC9246B42 / XC9247B42) either 5.5V (9246B65 / XC9247B65) and 7.4V (9246B75 / XC9247B75) or lower, the N-ch MOS driver transistor is forced OFF to prevent false pulse output caused by unstable operation of the internal circuitry. When the V_{IN} voltage becomes 4.15V (TYP.) either 5.65V (TYP.) and 7.65V (TYP.) or higher, switching operation takes place. By releasing the UVLO function, the IC performs the soft-start function to initiate output startup operation. The soft-start function operates even when the V_{IN} voltage falls momentarily below the UVLO detect voltage. The UVLO circuit does not cause a complete shutdown of the IC, but causes pulse output to be suspended; therefore, the internal circuitry remains in operation.

<Boot Strap Method>

An N-ch MOS driver transistor is used in the high side driver, so a voltage higher than the V_{IN} voltage is required in order to turned the driver on. Therefore, the boot strap method is used to generate a voltage that is higher than the V_{IN} voltage. The boot strap method is connecting the C_{BST} capacitor between the BST-L_X to cause the V_{Lx} to be lower than the V_L (V_L voltage = 4V), which is the internal power supply, so that the V_L charges the C_{BST}. Charging the C_{BST} requires more than a certain time when V_{LX} is 0V or less. If the load current is below several mA, sufficient time to charge the C_{BST} cannot be obtained, so oscillation might stop, but the product compulsorily increases the load current to provide stable operation even at light loads.

■OPERATIONAL EXPLANATION (Continued)

<Short-Circuit Protection>

V_{OUT} voltage is observed with the voltage at FB pin(hence FB voltage) and the voltage is produced by RFB1 and RFB2 which are connected between V_{OUT} and GND. And in the event that V_{OUT} is shorted to GND accidentally, the FB voltage drops to one half of the reference voltage or less, and if a current which is greater than I_{LIM} flows to the driver, the short-circuit protection is activated instantaneously and turns off the driver and the driver latches. Once IC is in the latch state, operation can be resumed by feeding H-level to EN/SS pin after L-level is fed to the pin, or by turning the V_{IN} power off and turning it on again. In this case, V_{IN} should go down to lower voltage than UVLO detect voltage, and after that V_{IN} should go up to higher voltage than UVLO release voltage.

<PFM Switch Current> (*1)

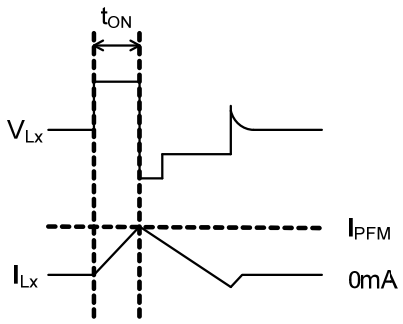
In PFM control operation, until coil current reaches to a specified level (I_{PFM}), the IC keeps the N-ch MOS driver transistor on. In this case, time that the N-ch MOS driver transistor is kept on (t_{ON}) can be given by the following formula. →I_{PFM}①

$$t_{ON} = L \times I_{PFM} / (V_{IN} - V_{OUT})$$

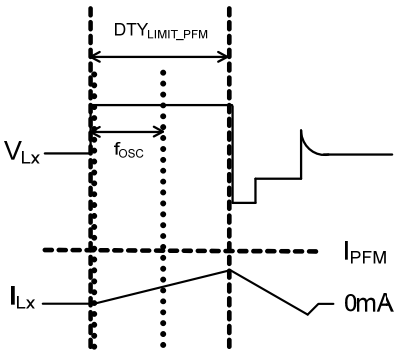
< PFM Duty Limit > (*1)

In the PFM control operation, the PFM Duty Limit (DTY_{LIMIT_PFM}) is set to 200% (TYP.). Therefore, under the condition that the duty increases (e.g. the condition that the step-down ratio is small), it's possible for N-ch MOS driver transistor to be turned off even when coil current does not reach to I_{PFM}. →I_{PFM}②

(*1) XC9246 series excluded.



I_{PFM}①



I_{PFM}②

■NOTE ON USE

1. For the phenomenon of temporal and transitional voltage decrease or voltage increase, the IC may be damaged or deteriorated if IC is used beyond the absolute MAX. specifications.

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 B characteristics (JIS standard) or X7R, X5R (EIA standard) ceramic capacitors.

4. If there is a large dropout voltage, then a stable output voltage will not always be supplied under all conditions. Please use it under the condition of $V_{OUT}/V_{IN}\times100 \geqq 18\%$. The operation might become unstable if used under 18%.

5. If there is a large dropout voltage, then there might be pulse-skip during light loads even with PWM control.

6. The DC/DC converter of this IC uses a current-limiting circuit to monitor the coil peak current. If the potential dropout voltage is large or the load current is large, the peak current will increase, which makes it easier for current limitation to be applied which in turn could cause the operation to become unstable. When the peak current becomes large, adjust the coil inductance and sufficiently check the operation. The following formula is used to show the peak current.

$$Peak\ Current:\ Ipk = (V_{IN} - V_{OUT}) \times OnDuty / (2 \times L \times f_{OSC}) + I_{OUT}$$

L: Coil Inductance
f_{OSC}: Oscillation Frequency

7. If an over-current (peak current) that exceeds the current limitation flows for a set time, N-ch MOS driver transistor is turned off (integral latch circuit). The current limited portion of the current will flow during the time from when the over-current is detected until N-ch MOS driver transistor is turned off, so be careful about the coil ratings.

8. If there is a large dropout voltage, a circuit delay could create the ramp-up of coil current with staircase waveform exceeding the current limit.

9. When the over-current state continues for 20μs, the driver off time is lengthened to prevent superimposing of the coil current. The lengthened driver off time causes the V_{OUT} to lower and thus triggering the short circuit protection without waiting for the integral latch time.

10. If a steep load change occurs, the voltage drop of the V_{OUT} voltage is directly transmitted to the FB via the C_{FB}, so the short circuit protection is triggered when the voltage is more than half the V_{OUT} voltage.

11. The ripple current might rise during light loads. This is done to charge the C_{BST} to ensure normal operation. Although it depends on the input and output conditions, this can be improved by pulling a load of several mA.

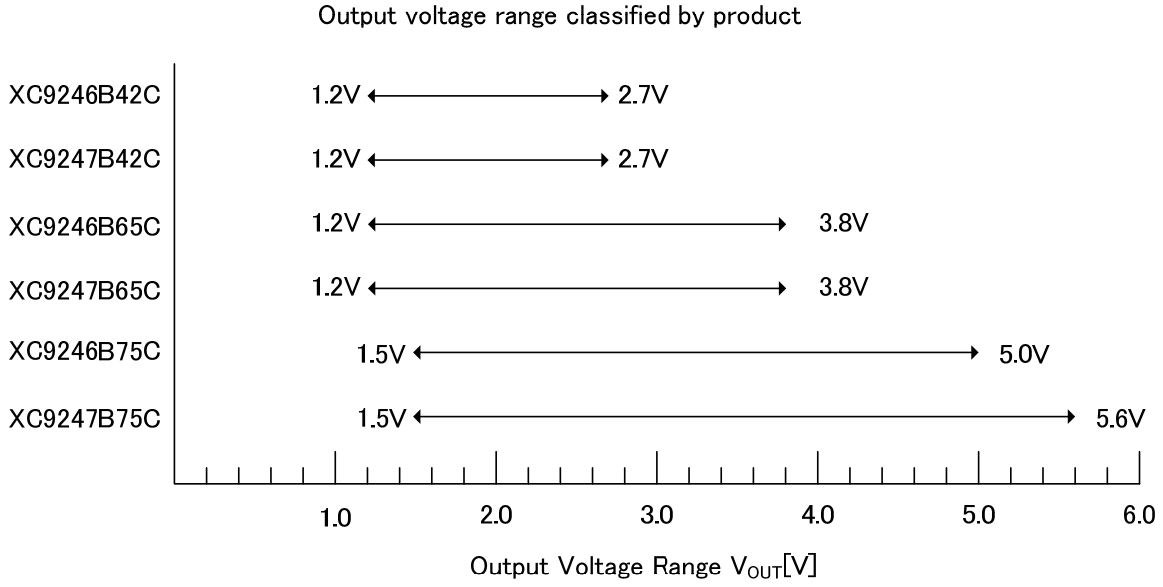
12. When using C_L=22μF or above, also correspondingly increase the C_{BST} capacitance. When not using the specified capacitance, the oscillation stops and the output voltage may become unstable.

【CBST Optimum Settings】

C_L(μF)	C_{BST}(μF)
$C_L \leqq 22$	0.22
$22 < C_L \leqq 47$	0.47
$47 < C_L \leqq 100$	1.0
$100 < C_L \leqq 220$	2.2

■NOTE ON USE (Continued)

13. When the voltage difference between input and output is small and the load is light, the voltage between the BST-L_X will lower and prevent driver on/off control, which could cause oscillation to stop and the output voltage to become unstable. Use the specified input-output voltage range and set to the recommended coil inductance each.
Also use about 180pF for the capacitance between SBD terminals. Using a large capacitance between terminals could cause oscillation stop.



【Recommended L Value and V_{OUT} Range】

V_{OUT}	Recommended L Value	
1.2V≦V_{OUT}≦3.5V	3.3μH	4.7μH
3.5V＜V_{OUT}≦4.0V	-	4.7μH
4.0V＜V_{OUT}≦5.6V	-	6.8μH

14. When the input voltage is high and the load is light, the V_{OUT} could rise above the set voltage. Use the recommended coil inductance specified for each set voltage. Also please use the SBD which has inter-terminal capacitance of approx. 180pF. The over voltage situation may be caused at the output if the SBD with smaller inter-terminal capacitance than 180pF is used.

15. When using the EN/SS pin to switch between enable status and disable status, switch to the enable status after the V_{OUT} voltage has become 1V or less. When switching to enable status when the V_{OUT} is over 1V, sufficient voltage will not be applied between the BST-L_X, which could cause oscillation stop and the output voltage to become unstable.

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

17. When using at an ambient temperature of -30ºC or less, use C_L=47μF or higher. Abnormal oscillation may occur at C_L=22μF.

18. The ripple voltage could be increased when switching from discontinuous conduction mode to Continuous conduction mode.

19. For the XC9246B42 and XC9247B42, when the IC is operated under V_{IN}=5.0V, the efficiency may get lower significantly in the discontinuous conduction mode.

20. There is the possibility to get the ripple voltage larger in case the peak current is unstable at the light current load in PFM control operation.

21. 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.

■NOTE ON USE (Continued)

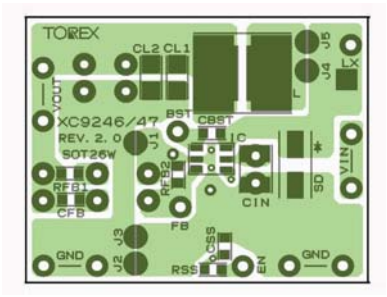
The operation may become unstable due to noise and/or phase lag from the output current when the wire impedance is high, please place the input capacitor(C_{IN}) and the output capacitor (C_L) as close to the IC as possible.

●Instructions of pattern layouts

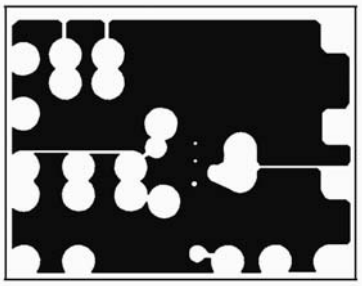
(1) In order to stabilize V_{IN} voltage level, we recommend that a by-pass capacitor (C_{IN}) be connected as close as possible to the V_{IN} and GND pins.
(2) Please mount each external component as close to the IC as possible.
(3) Wire external components as close to the IC as possible and use thick, short connecting traces to reduce the circuit impedance.
(4) 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.
(5) Please note that internal driver transistors bring on heat because of the load current and ON resistance of the N-ch MOS driver transistors.

Recommended Pattern Layout (SOT-26W)

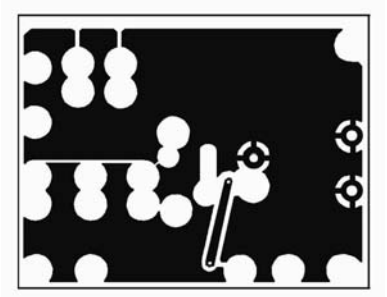
1st Layer



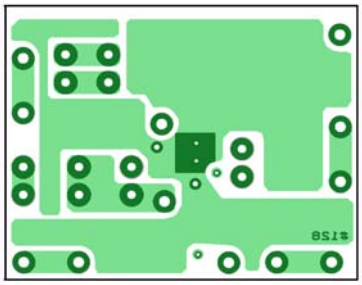
2nd Layer



3rd Layer

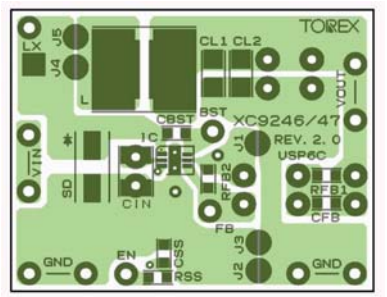


4th Layer

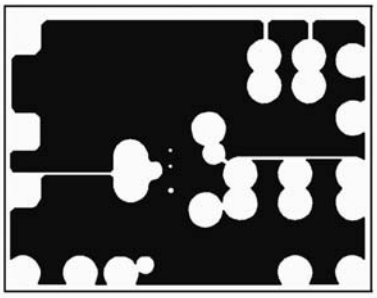


Recommended Pattern Layout (USP-6C)

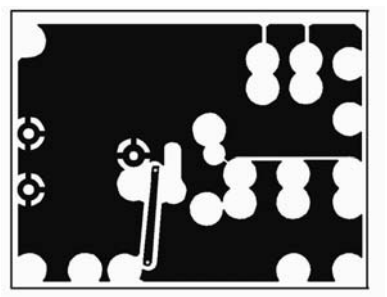
1st Layer



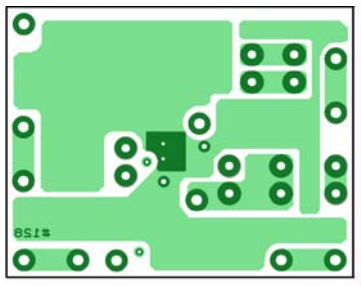
2nd Layer



3rd Layer

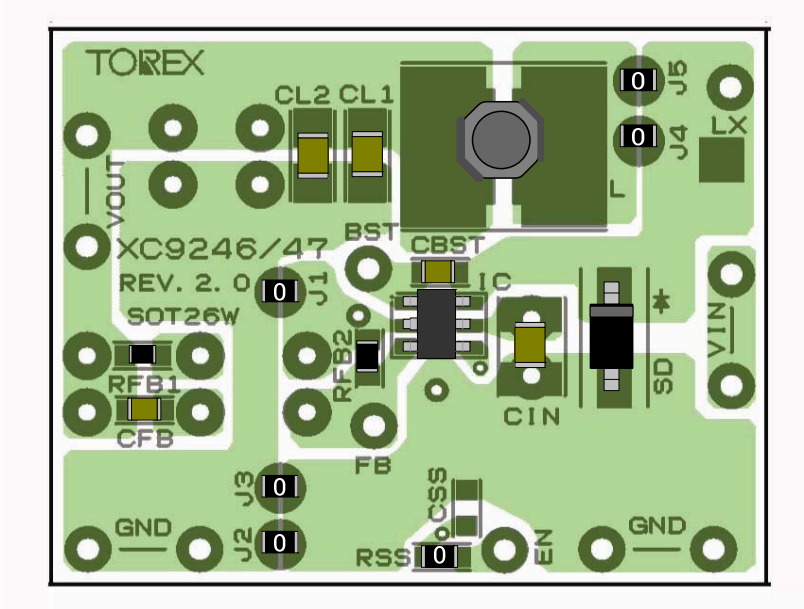


4th Layer

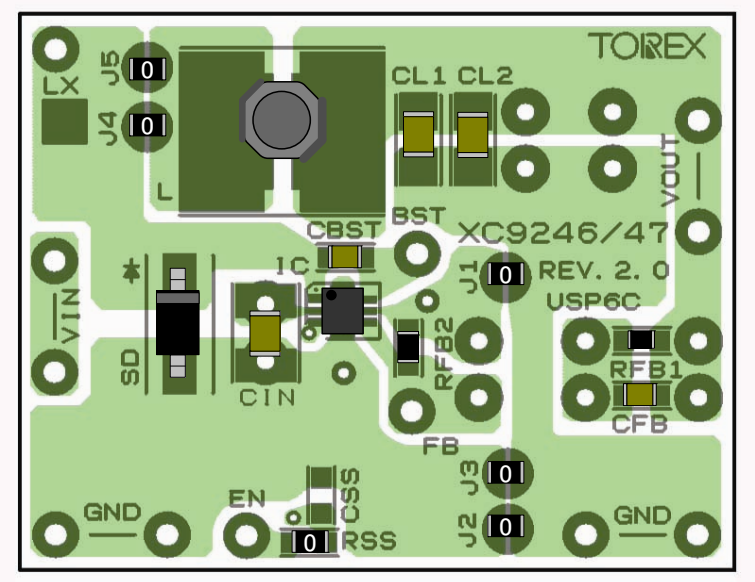


■NOTE ON USE (Continued)

PCB mounted (SOT-26W)



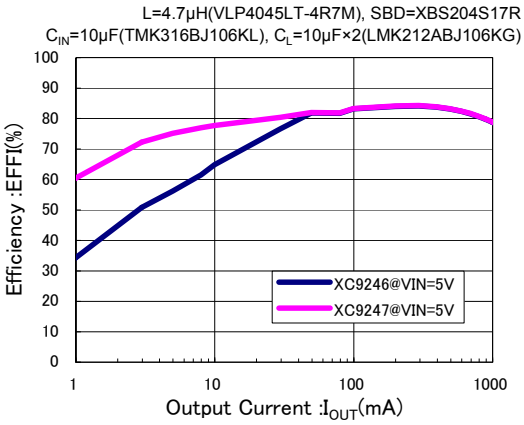
PCB mounted (USP-6C)



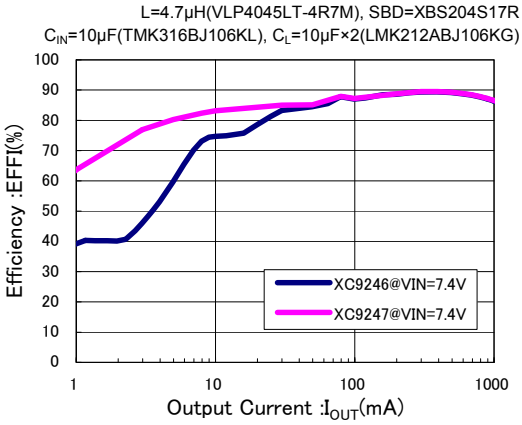
■TYPICAL PERFORMANCE CHARACTERISTICS

(1) Efficiency vs. Output Current

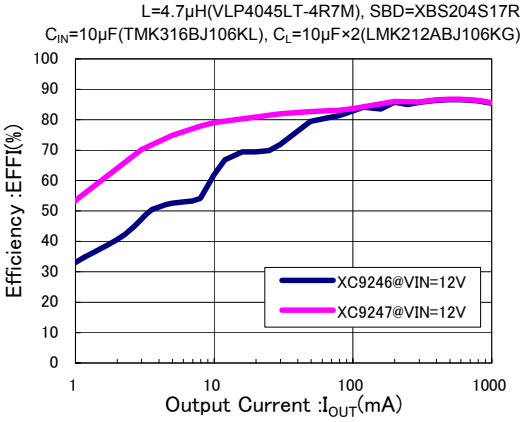
XC9246B42/XC9247B42 (V_{OUT}=1.8V)



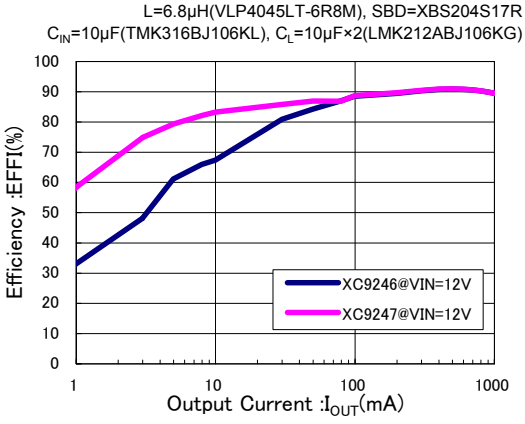
XC9246B65/XC9247B65 (V_{OUT}=3.3V)



XC9246B75/XC9247B75 (V_{OUT}=3.3V)

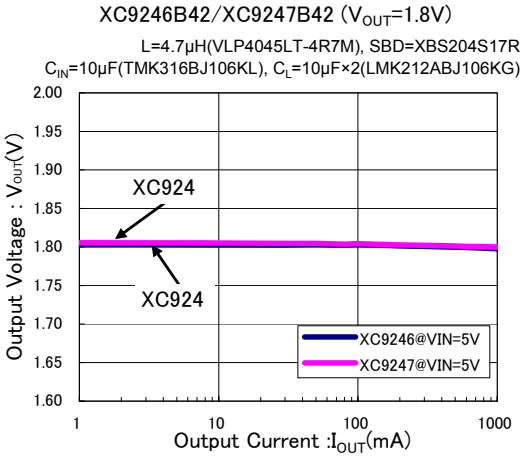


XC9246B75/XC9247B75 (V_{OUT}=5.0V)

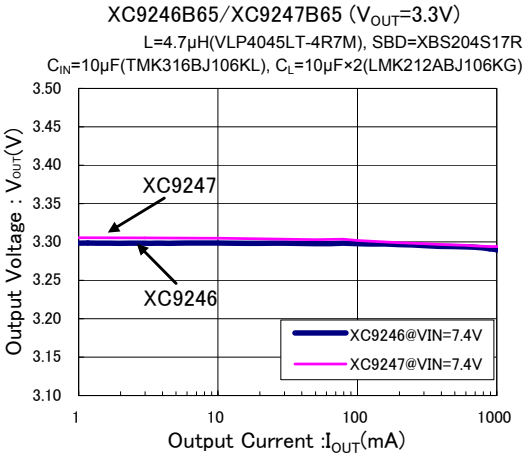


(2) Output Voltage vs. Output Current

XC9246B42/XC9247B42 (V_{OUT}=1.8V)



XC9246B65/XC9247B65 (V_{OUT}=3.3V)



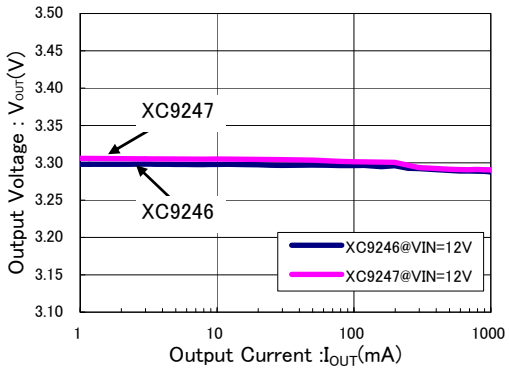
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Output Current (Continued)

XC9246B75/XC9247B75 (V_{OUT}=3.3V)

L=4.7μH(VLP4045LT-4R7M), SBD=XBS204S17R

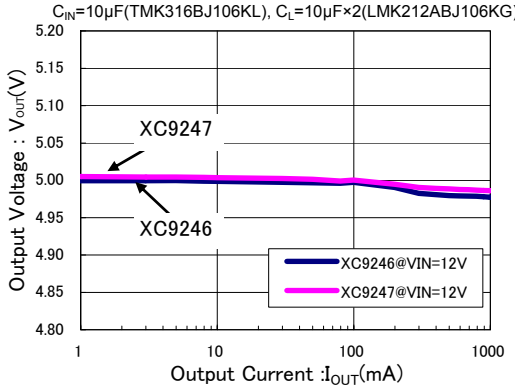
C_{IN}=10μF(TMK316BJ106KL), C_L=10μF×2(LMK212ABJ106KG)



XC9246B75/XC9247B75 (V_{OUT}=5.0V)

L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R

C_{IN}=10μF(TMK316BJ106KL), C_L=10μF×2(LMK212ABJ106KG)

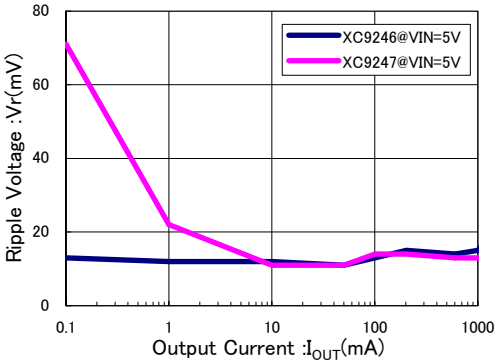


(3) Ripple Voltage vs. Output Current

XC9246B42/XC9247B42 (V_{OUT}=1.8V)

L=4.7μH(VLP4045LT-4R7M), SBD=XBS204S17R

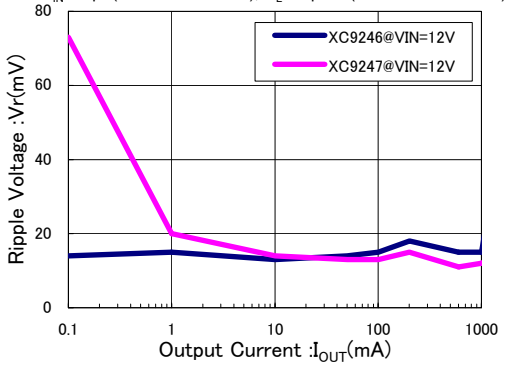
C_{IN}=10μF(TMK316BJ106KL), C_L=10μF×2(LMK212ABJ106KG)



XC9246B75/XC9247B75 (V_{OUT}=3.3V)

L=4.7μH(VLP4045LT-4R7M), SBD=XBS204S17R

C_{IN}=10μF(TMK316BJ106KL), C_L=10μF×2(LMK212ABJ106KG)

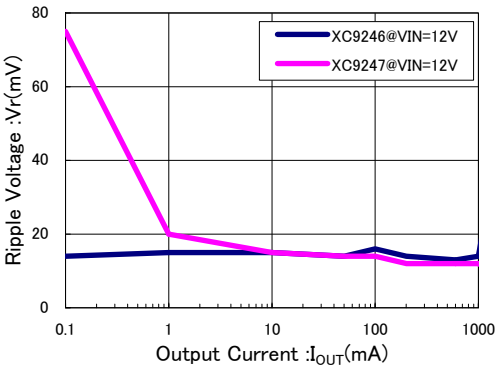


(3) Ripple Voltage vs. Output Current

XC9246B75/XC9247B75 (V_{OUT}=5.0V)

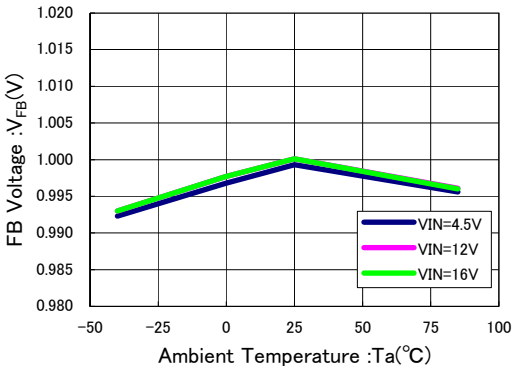
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R

C_{IN}=10μF(TMK316BJ106KL), C_L=10μF×2(LMK212ABJ106KG)



(4) FB Voltage vs. Ambient Temperature

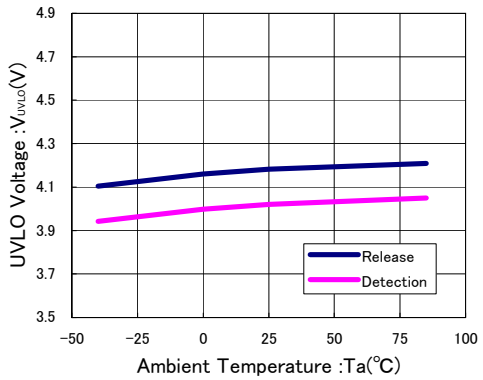
XC9246B/XC9247B



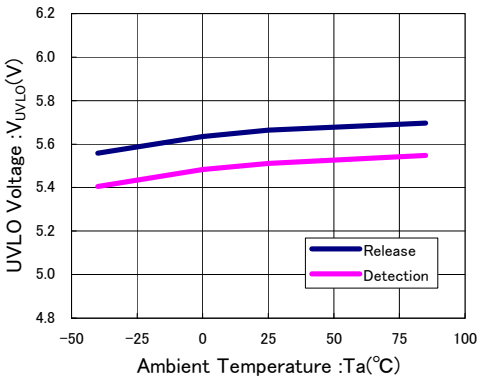
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(5) UVLO Voltage vs. Ambient Temperature

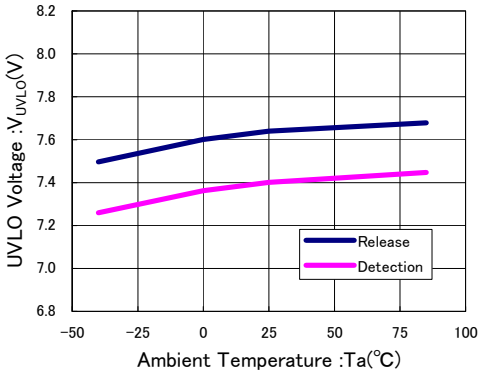
XC9246B42/XC9247B42



XC9246B65/XC9247B65

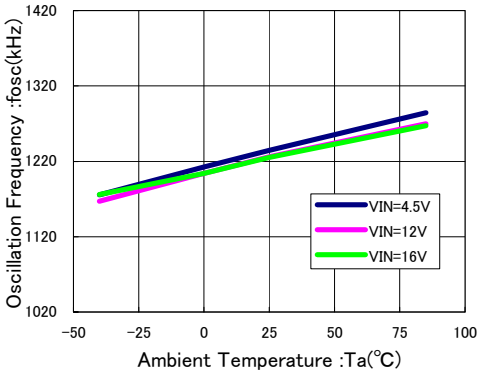


XC9246B75/XC9247B75



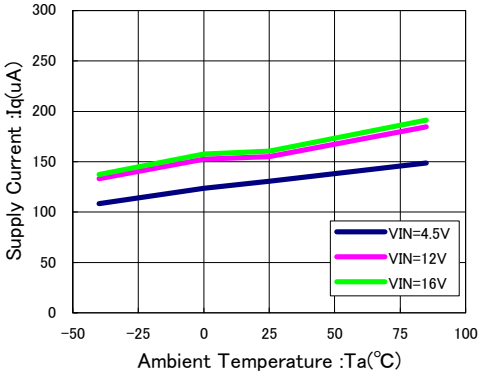
(6) Oscillation Frequency vs. Ambient Temperature

XC9246B



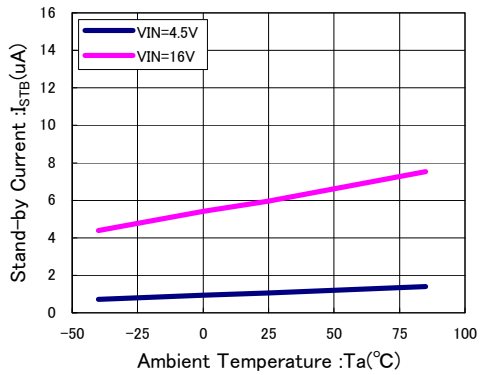
(7) Supply Current vs. Ambient Temperature

XC9246B/XC9247B



(8) Stand-by Current vs. Ambient Temperature

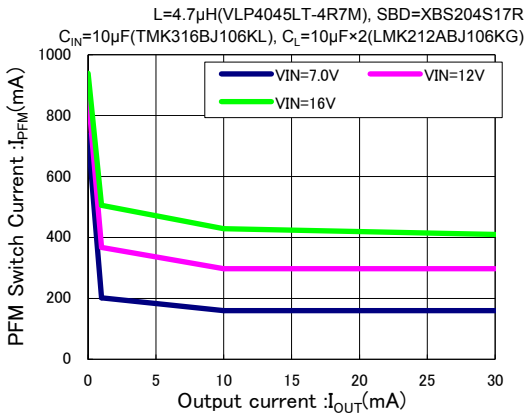
XC9246B/XC9247B



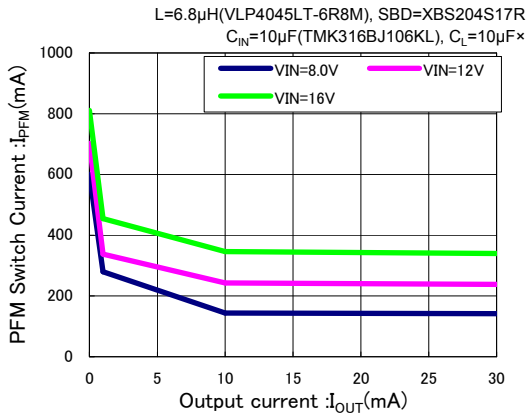
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) PFM Switch Current vs. Output current

XC9247B (V_{OUT}=3.3V)

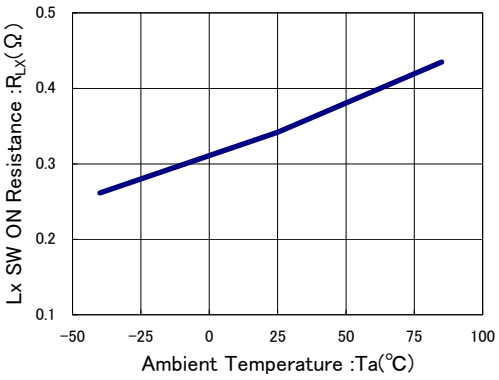


XC9247B (V_{OUT}=5.0V)



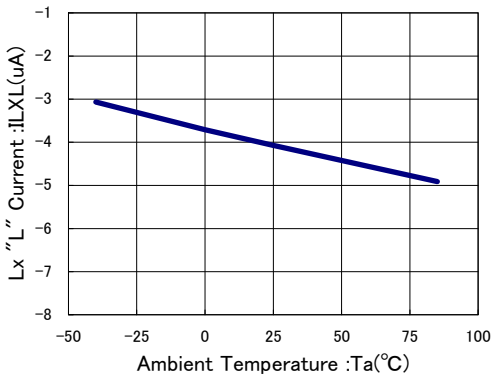
(10) Lx SW ON Resistance vs. Ambient Temperature

XC9246B/XC9247B



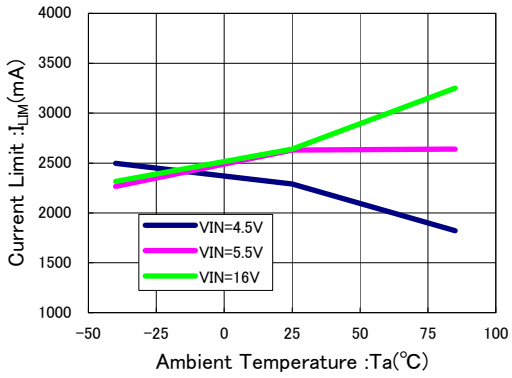
(11) Lx "L" Current vs. Ambient Temperature

XC9246B/XC9247B



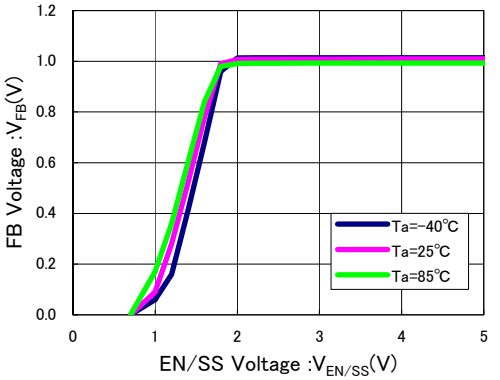
(12) Current Limit vs. Ambient Temperature

XC9246B/XC9247B



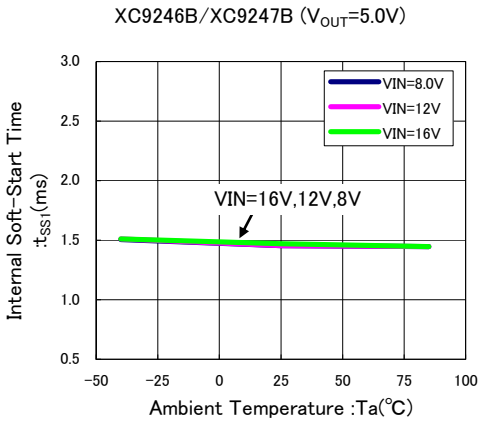
(13) FB Voltage vs. EN/SS Voltage

XC9246B/XC9247B

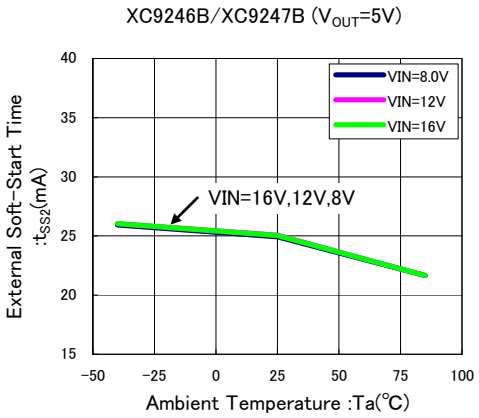


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(14) Internal Soft-Start Time vs. Ambient Temperature



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



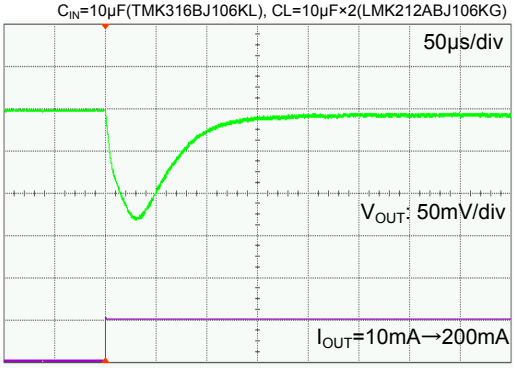
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(16) Load Transient Response

XC9246B

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=10mA→200mA

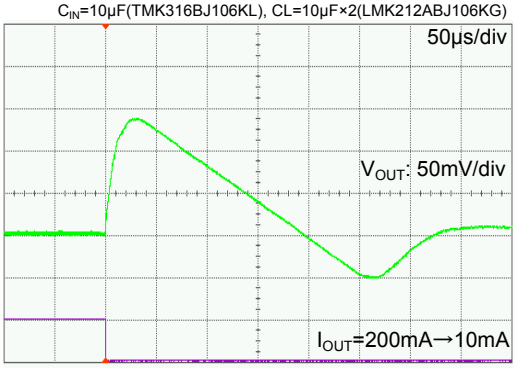
L=4.7μH(XFL4020-472MEB), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9246B

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=200mA→10mA

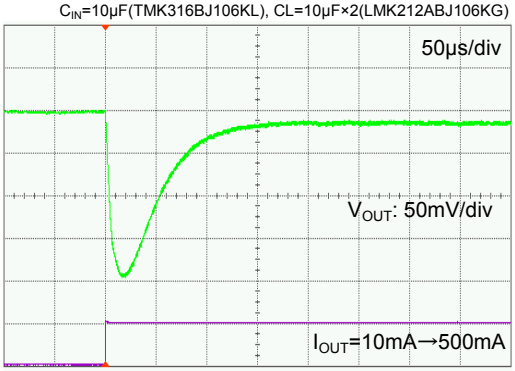
L=4.7μH(XFL4020-472MEB), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9246B

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=10mA→500mA

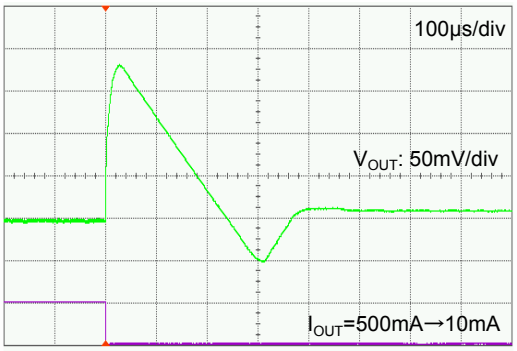
L=4.7μH(XFL4020-472MEB), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9246B

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=500mA→10mA

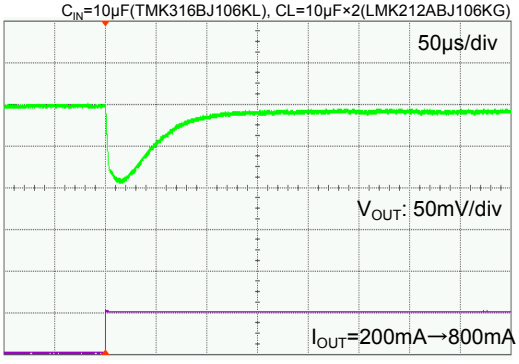
L=4.7μH(XFL4020-472MEB), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9246B

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=200mA→800mA

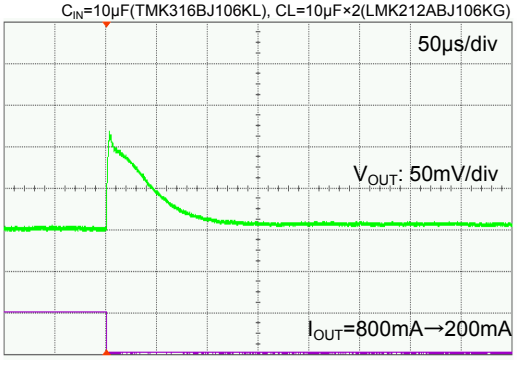
L=4.7μH(XFL4020-472MEB), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9246B

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=800mA→200mA

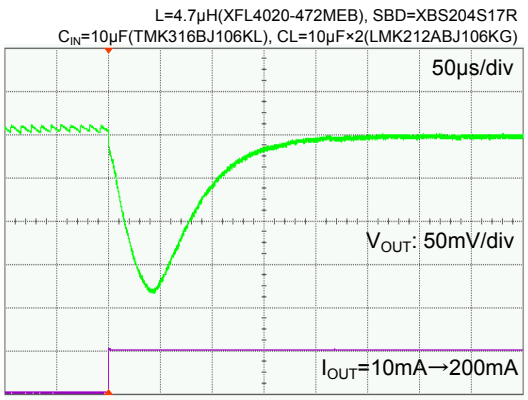
L=4.7μH(XFL4020-472MEB), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



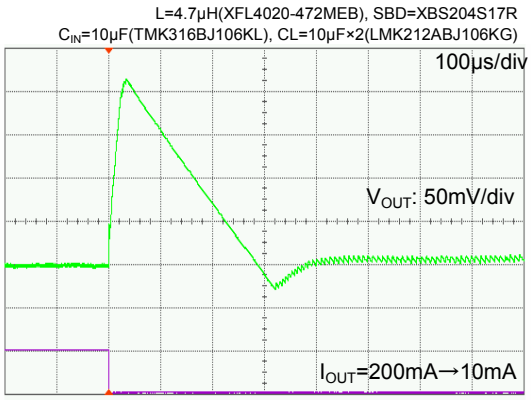
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(16) Load Transient Response (Continued)

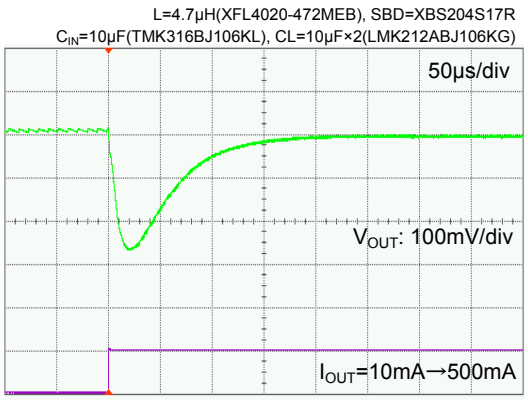
XC9247B
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=10mA→200mA



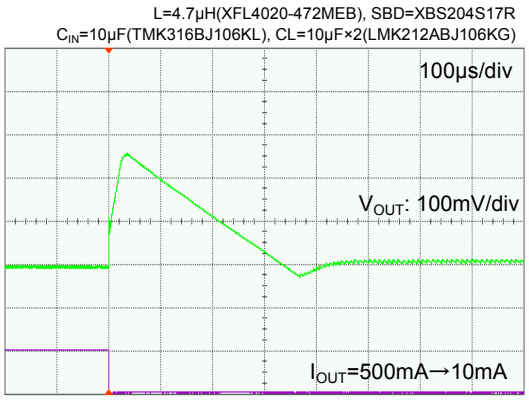
XC9247B
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=200mA→10mA



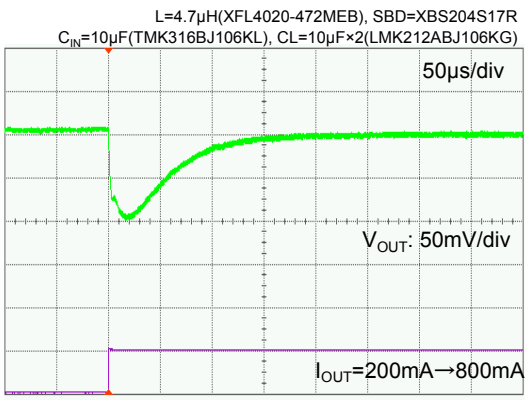
XC9247B
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=10mA→500mA



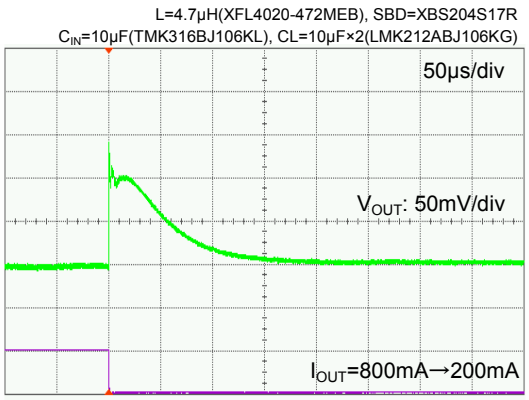
XC9247B
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=500mA→10mA



XC9247B
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=200mA→800mA



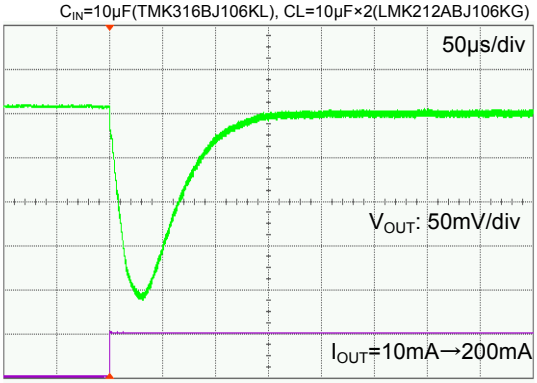
XC9247B
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=800mA→200mA



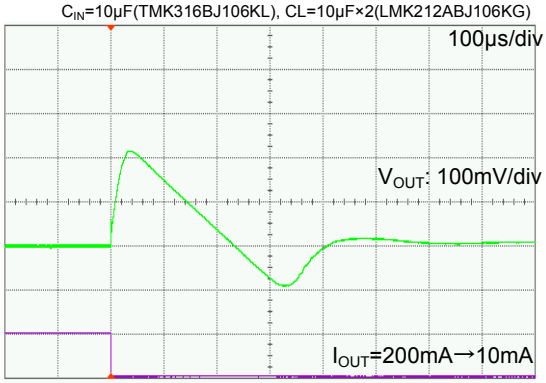
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(16) Load Transient Response (Continued)

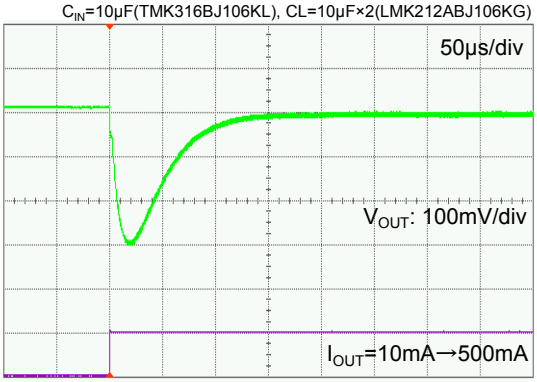
XC9246B
VIN=12V, VOUT=5.0V, IOUT=10mA→200mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



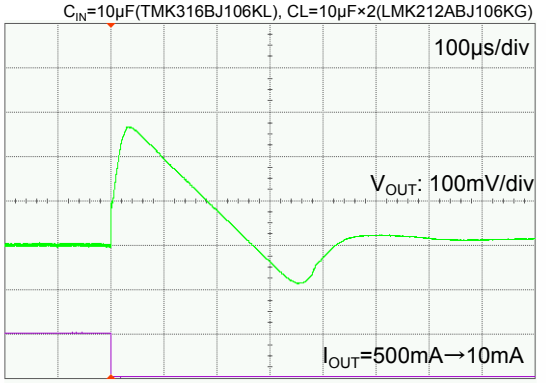
XC9246B
VIN=12V, VOUT=5.0V, IOUT=200mA→10mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



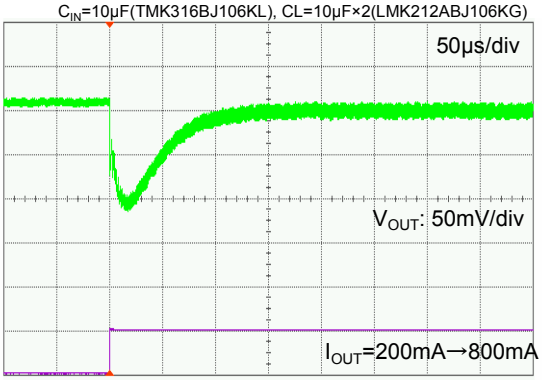
XC9246B
VIN=12V, VOUT=5.0V, IOUT=10mA→500mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



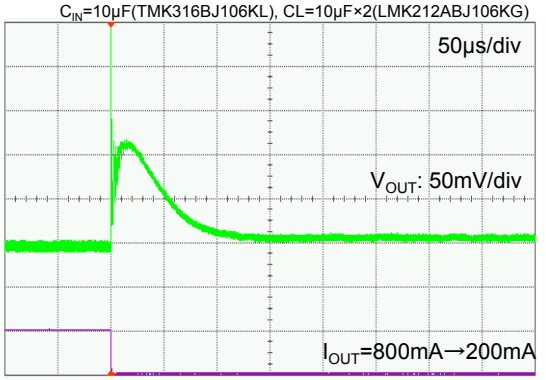
XC9246B
VIN=12V, VOUT=5.0V, IOUT=500mA→10mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9246B
VIN=12V, VOUT=5.0V, IOUT=200mA→800mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



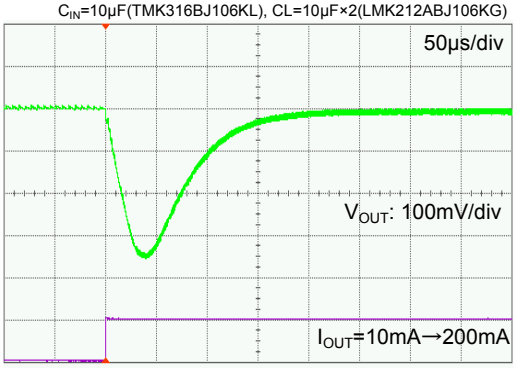
XC9246B
VIN=12V, VOUT=5.0V, IOUT=800mA→200mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



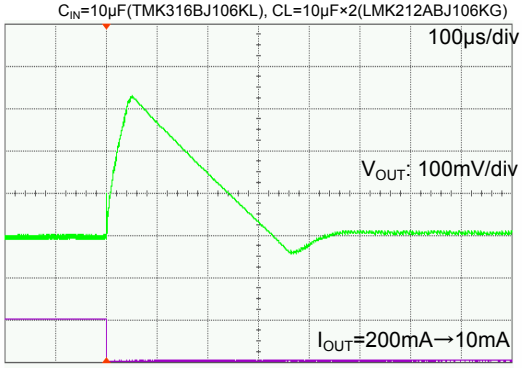
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(16) Load Transient Response (Continued)

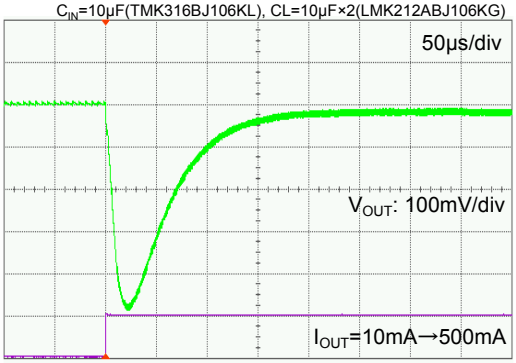
XC9247B
VIN=12V, VOUT=5.0V, IOUT=10mA→200mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



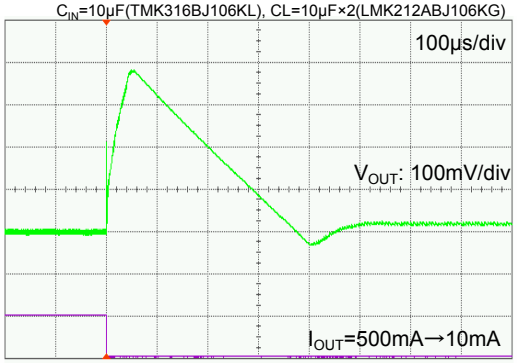
XC9247B
VIN=12V, VOUT=5.0V, IOUT=200mA→10mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



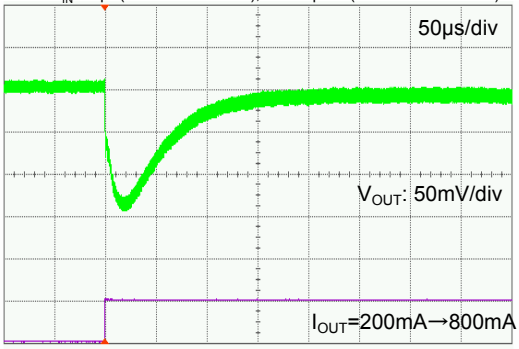
XC9247B
VIN=12V, VOUT=5.0V, IOUT=10mA→500mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



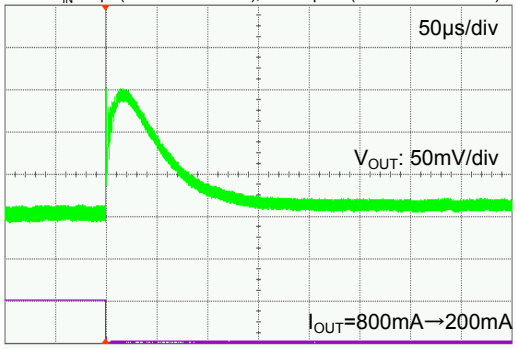
XC9247B
VIN=12V, VOUT=5.0V, IOUT=500mA→10mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



XC9247B
VIN=12V, VOUT=5.0V, IOUT=200mA→800mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



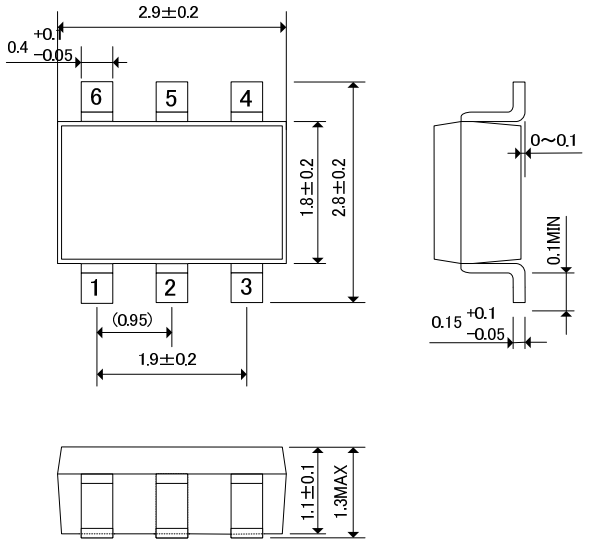
XC9247B
VIN=12V, VOUT=5.0V, IOUT=800mA→200mA
L=6.8μH(VLP4045LT-6R8M), SBD=XBS204S17R
C_{IN}=10μF(TMK316BJ106KL), CL=10μF×2(LMK212ABJ106KG)



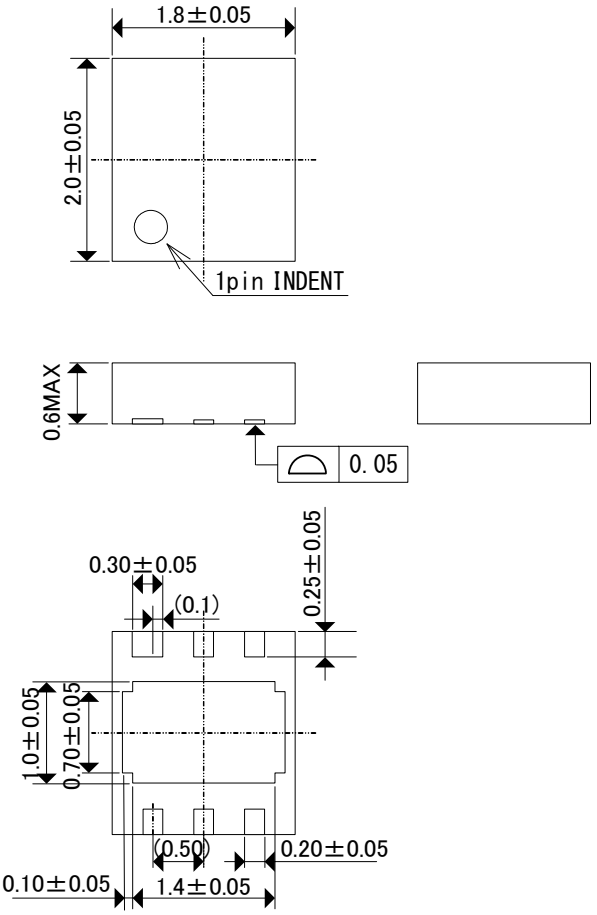
■PACKAGING INFORMATION

●SOT-26W (unit: mm)

(unit : mm)

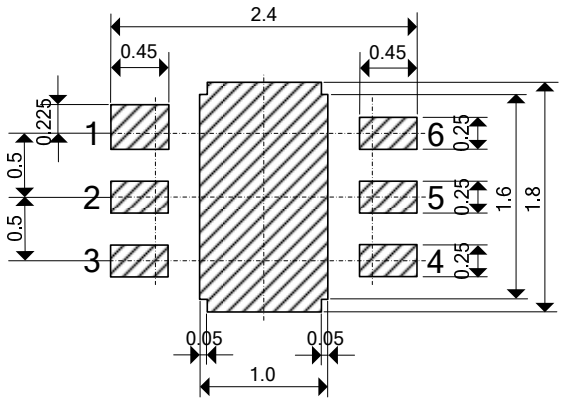


●USP-6C (unit: mm)

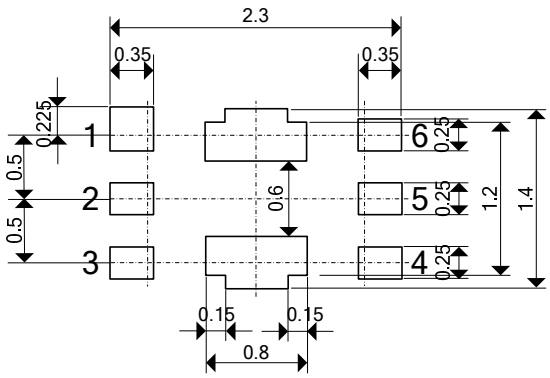


■PACKAGING INFORMATION (Continued)

●USP-6C Reference Pattern Layout (unit: mm)

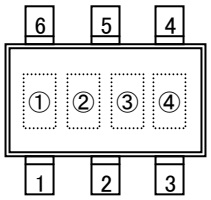


●USP-6C Reference Metal Mask Design (unit: mm)



■MARKING RULE

SOT-26W



① represents products series

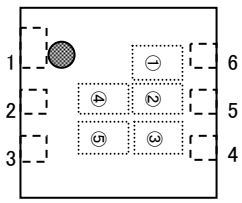
MARK	PRODUCT SERIES
6	XC9246B*****-G
7	XC9247B*****-G

② represents products type

MARK ②	TYPE	PRODUCT SERIES
4	UVLO Voltage=4.15V	XC9246B42***-G XC9247B42***-G
6	UVLO Voltage=5.65V	XC9246B65***-G XC9247B65***-G
7	UVLO Voltage=7.65V	XC9246B75***-G XC9247B75***-G

③④ represents production lot number
01～09, 0A～0Z, 11～9Z, A1～A9, AA～AZ, B1～ZZ in order.
(G, I, J, O, Q, W excluded)
* No character inversion used.

USP-6C



① represents products series

MARK	PRODUCT SERIES
6	XC9246B*****-G
7	XC9247B*****-G

②③ represents products type

MARK ②	MARK ③	TYPE	PRODUCT SERIES
4	2	UVLO Voltage=4.15V	XC9246B42***-G XC9247B42***-G
6	5	UVLO Voltage=5.65V	XC9246B65***-G XC9247B65***-G
7	5	UVLO Voltage=7.65V	XC9246B75***-G XC9247B75***-G

④⑤ represents production lot number
01～09, 0A～0Z, 11～9Z, A1～A9, AA～AZ, B1～ZZ in order.
(G, I, J, O, Q, W excluded)
* No character inversion used.

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