XD9242/XD9243 Series

ETR05065-002

2A Synchronous Step-Down DC/DC Converters

☆AEC-Q100 Grade3
☆GreenOperation Compatible

The XD9242/XD9243 series is a group of synchronous-rectification step-down DC/DC converters with a built-in 0.11Ω(TYP.) P-channel MOS driver transistor and 0.12Ω(TYP.) N-channel MOS switching transistor, designed to allow the use of ceramic capacitors. The small on-resistances of these two internal driver transistors enable a high efficiency, stable power supply with an output current up to 2A. The XD9242/XD9243 series has operating voltage range of 2.7V~6.0V and a 0.8V (±2.0%) reference voltage, and using externally connected resistors, the output voltage can be set freely from 0.9V. With an internal switching frequency of 1.2MHz or 2.4MHz, small external components can be used.

The XD9242 series is PWM control, and the XD9243 series is PWM/PFM, which automatically switches from PWM to PFM during light loads and provides high efficiency, high load response, low voltage ripple, can be achieved over a wide range of load conditions. The series have a high speed soft-start as fast as 1ms in typical for quick turn-on. It's suitable for large-current application due to limit current is configured 4.0A in typical. During stand-by, all circuits are shutdown to reduce current consumption to as low as 1.0μA or less. The integrated C_L discharge function which enables the electric charge at the output capacitor C_L to be discharged via the internal discharge switch located between the L_X and V_{SS} pins. Due to C_L discharge function, malfunction on L_X is prevented when Stand-by mode. With the built-in UVLO (Under Voltage Lock Out) function, the internal P-channel driver transistor is forced OFF when input voltage becomes 2.5V or lower.

■APPLICATIONS

- ●Car navigation systems
- ●Car audios
- ●Automotive Camera
- ●Other automotive equipment

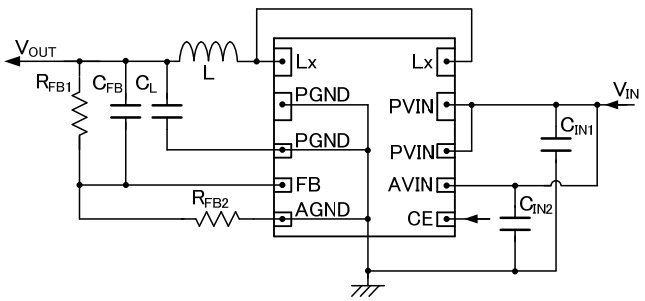
■FEATURES

Driver Transistor	:	0.11Ω P-ch Driver Transistor 0.12Ω N-ch Switching Transistor
Input Voltage Range	:	2.7V～6.0V
Output Voltage Setting	:	0.9V～V_{IN}
FB Voltage	:	0.8V±2.0%
High Efficiency	:	95%(TYP.)*
Output Current	:	2.0A
Oscillation Frequency	:	1.2MHz±15%, 2.4MHz±15%
Maximum Duty Cycle	:	100%
Functions	:	Soft-Start Circuit Built-In C_L Discharge Current Limit Circuit（automatic return） Thermal Shutdown UVLO
Output Capacitor	:	Low ESR Ceramic Capacitor
Control Methods	:	PWM control (XD9242) PWM/PFM Auto (XD9243)
Operating Ambient Temperature	:	-40℃ ~ +85℃
Packages	:	USP-10B
Environmentally Friendly	:	EU RoHS Compliant, Pb Free

* Performance depends on external components and wiring on the PCB.

■TYPICAL APPLICATION CIRCUIT

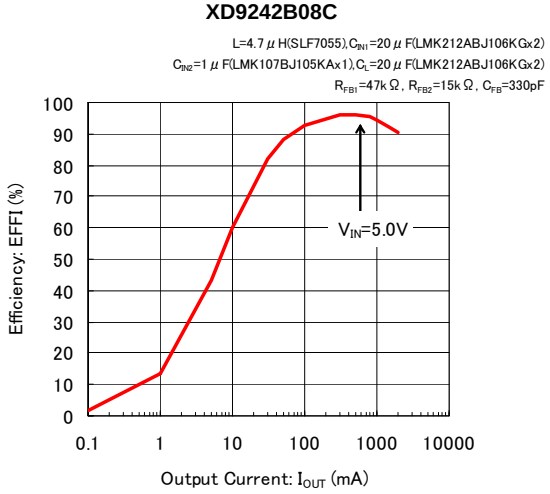
● XD9242/XD9243 Series (FB Type)



■TYPICAL PERFORMANCE CHARACTERISTICS

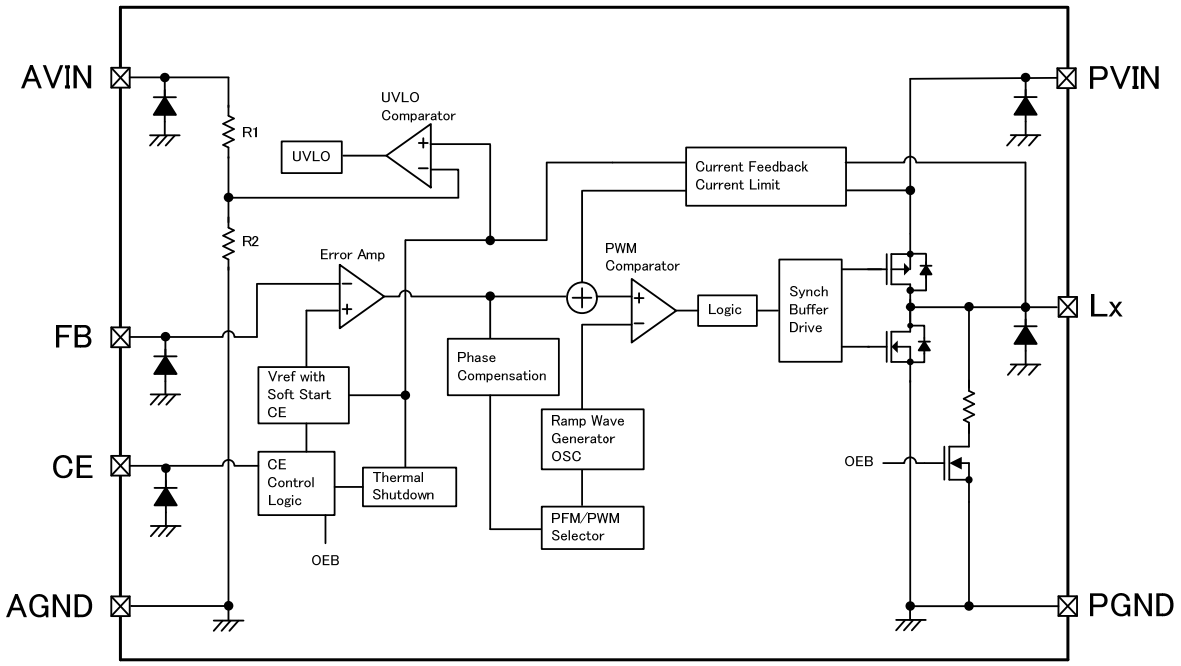
●Efficiency vs. Output Current (fosc=1.2MHz, V_{OUT}=3.3V)

XD9242B08C



■BLOCK DIAGRAM

1) XD9242/XD9243 Series



* Diodes inside the circuits are ESD protection diodes and parasitic diodes.

■ PRODUCT CLASSIFICATION

1) Ordering Information

XD9242①②③④⑤⑥-⑦(*1) Fixed PWM control

XD9243①②③④⑤⑥-⑦(*1) PWM / PFM automatic switching control

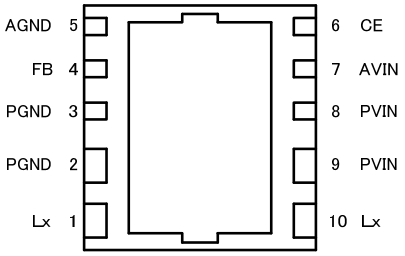
DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Type	B	Refer to Selection Guide
②③	Reference Voltage	08	Reference Voltage is fixed at 0.8V
④	Oscillation Frequency	C	1.2MHz
		D	2.4MHz
⑤⑥-⑦	Packages	DR-Q	USP-10B (*2)

(*1) The “-Q” suffix denotes “AEC-Q100” and “Halogen and Antimony free” as well as being fully EU RoHS compliant.
(*2) The USP-10B reels are shipped in a moisture-proof packing.

2) Selection Guide

TYPE	SOFT-START TIME	CHIP ENABLE	CURRENT LIMITER	THERMAL SHUTDOWN	UVLO	C_L AUTO-DISCHARGE
B	Fixed	Yes	Yes	Yes	Yes	Yes

■ PIN CONFIGURATION



USP-10B
(BOTTOM VIEW)

USP-10B
* Please connect the power input pins (No.8 and No.9) and analog input pin (No.7) when operating.
* Please connect the two Lx pins (No.1 and 10).
* Please connect the power ground pins (No.2 and 3) and analog ground pin (No.5) when operating.
* It is recommended that the heat dissipation pad of the USP-10B package is soldered by using the reference mount pattern and metal mask pattern for mounting strength. The mount pattern should be electrically opened or connected to AGND pin (No.5) and PGND pin (No.2, and 3).

■ PIN ASSIGNMENT

PIN NUMBER USP-10B	PIN NAME	FUNCTIONS
1,10	Lx	Switching Output
2,3	PGND	Power Ground
4	FB	Output Voltage Monitor
5	AGND	Analog Ground
6	CE	Chip Enable
7	AVIN	Analog Input
8,9	PVIN	Power Input

■ CE PIN FUNCTION

PIN NAME	SIGNAL	STATUS
CE	H	Active
	L	Stand-by

* Please do not leave the CE pin open.

■ ABSOLUTE MAXIMUM RATINGS

Ta=25℃

PARAMETER	SYMBOL	RATINGS	UNIT
PVIN Pin Voltage	V_{PVIN}	-0.3 ~ +7.0(*1)	V
AVIN Pin Voltage	V_{AVIN}		
CE Pin Voltage	V_{CE}	-0.3 ~ +7.0	V
FB Pin Voltage	V_{FB}	-0.3 ~ +7.0	V
Lx Pin Voltage	V_{Lx}	-0.3 ~ +7.0 or V_{PVIN} +0.3(*2)	V
Lx Pin Current	I_{Lx}	±6.0(*3)	A
Power Dissipation USP-10B	Pd	150	mW
Operating Ambient Temperature	Topr	-40 ~ +85	℃
Storage Temperature	T_{stg}	-55 ~ +125	℃

All voltages are described based on the ground voltage of AGND and PGND.

(*1) Please connect PVIN pin and AVIN pin for use.

(*2) The maximum value should be either +7.0 or V_{PVIN}+0.3 in the lowest.

(*3) It is measured when the two Lx pins (USP-10B No.1 and 10) are tied up to each other.

■ ELECTRICAL CHARACTERISTICS

●XD9242/XD9343, f_{OSC}=1.2MHz Ta=25℃

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP.	MAX.	UNIT	CIRCUIT
FB Voltage	V_{FB}	V_{IN}=5.0V, V_{CE}=5.0V, Voltage to start oscillation while		0.784	0.800	0.816	V	③
		V_{FB}=0.72V → 0.88V	-40℃≦Ta≦85℃	0.768	0.800	0.832		
Operating Voltage Range	V_{IN}	When connected to external components	-40℃≦Ta≦85℃	2.7	-	6.0	V	①
Maximum Output Current	I_{OUTMAX}	V_{IN}=V_{CE}=5.0V (*1,*2) When connected to external components		2.0	-	-	A	①
UVLO Voltage	V_{UVLO}	V_{CE}=5.0V, V_{FB}=0.72V Voltage which Lx pin holding "L" level(*3)		2.00	-	2.68	V	③
Quiescent Current	I_q	V_{IN}=V_{CE}=5.0V, V_{FB}=0.88V		-	41	78	μA	②
			-40℃≦Ta≦85℃	-	41	164		
Stand-by Current	I_{STB}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0.88V		-	0.01	1.00	μA	②
Oscillation Frequency	f_{OSC}	V_{IN}=V_{CE}=5.0V, I_{OUT}=300mA,		1020	1200	1380	kHz	①
		When connected to external components	-40℃≦Ta≦85℃	816	1200	1656		
PFM Switch Current (*4)	I_{PFM}	V_{IN}=V_{CE}=4.0V, I_{OUT}=1mA When connected to external components		-	280	-	mA	①
PFM Duty Limit (*4)	DTY_{LIMIT_PFM}	V_{IN}=V_{CE}=2.7V, I_{OUT}=1mA When connected to external components		-	180	250	%	①
Maximum Duty Limit	D_{MAX}	V_{IN}=V_{CE}=5.0V, V_{FB}=0.72V	-40℃≦Ta≦85℃	100	-	-	%	③
Minimum Duty Limit	D_{MIN}	V_{IN}=V_{CE}=5.0V, V_{FB}=0.88V	-40℃≦Ta≦85℃	-	-	0	%	③
Efficiency	EFFI	V_{IN}=V_{CE}=5.0V, I_{OUT}=500mA (*5) R_{FB1}=47kΩ, R_{FB2}=15kΩ, C_{FB}=330pF		-	95	-	%	①
LXSW"H"ON Resistance	R_{LxH}	V_{IN}=V_{CE}=4.0V, V_{FB}=0.72V (*6)		-	0.11	0.21	Ω	④
LXSW"L"ON Resistance	R_{LxL}			-	0.12	0.30(*7)	Ω	–
LXSW"H" Leakage Current	I_{LeakH}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0.88V, V_{Lx}=0V		-	0.01	1.00(*8)	μA	⑤
Current Limit	I_{LIM}	V_{IN}=V_{CE}=5.0V, V_{FB}=0.72V (*9)		-	4.0	-	A	④

NOTE:
External Components: C_{IN1}=20μF(ceramic), C_{IN2}=1μF(ceramic), L=4.7μH, C_L=20μF(ceramic)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF
Condition: Unless otherwise stated, "H"=V_{IN} ~ V_{IN} - 1.2V, "L"=+ 0.1V ~ -0.1V
The ambient temperature range (-40℃≦Ta≦85℃) is design Value.
(*1) Mount conditions affect heat dissipation. Maximum output current is not guaranteed when T_{TSD} starts to operate earlier.
(*2) When the difference between the input and the output is small, some cycles may be skipped completely before current maximizes. If current is further pulled from this state, output voltage will decrease because of P-ch driver ON resistance.
(*3) These values include UVLO detect voltage, UVLO release voltage and hysteresis operating voltage range. UVLO release voltage is defined as the V_{IN} voltage which makes Lx pin "H".
(*4) XD9242 series exclude I_{PFM} and DTY_{LIMIT_PFM} because those are only for the PFM control's functions.
(*5) EFFI = { (output voltage × output current) ／ (input voltage × input current) } × 100
(*6) On resistance = (V_{IN} – Lx pin measurement voltage) / 100mA
(*7) Design value.
(*8) When temperature is high, a current of approximately 20μA (maximum) may leak.
(*9) Current limit denotes the level of detection at peak of coil current.

■ ELECTRICAL CHARACTERISTICS(Continued)

●XD9242/XD9343, f_{OSC}=1.2MHz

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP.	MAX.	UNIT	CIRCUIT
CE"H" Voltage	V_{CEH}	V_{IN}=5.0V, V_{FB}=0.72V Applied voltage to V_{CE} Voltage changes Lx to "H" level	-40℃≦Ta≦85℃	1.2	-	V_{IN}	V	③
CE"L" Voltage	V_{CEL}	V_{IN}=5.0V, V_{FB}=0.72V Applied to V_{CE} Voltage changes Lx to "L" level	-40℃≦Ta≦85℃	AGND	-	0.4	V	③
CE"H" Current	I_{CEH}	V_{IN}=5.0V, V_{CE}=5.0V, V_{FB}=0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
CE"L" Current	I_{CEL}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
FB"H" Current	I_{FBH}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=5.0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
FB"L" Current	I_{FBL}	VI_{N}=5.0V, V_{CE}=0V, V_{FB}=0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
Soft-Start Time	t_{SS}	V_{IN}=5.0V, V_{CE}=0V→5.0V, I_{OUT}=1mA When connected to external components		0.3	1.0	2.0	ms	①
Thermal Shutdown Temperature	T_{TSD}	-		-	150	-	℃	-
Hysteresis Width	T_{HYS}	-		-	20	-	℃	-
C_L Discharge	R_{DCHG}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0.72V, V_{Lx}=1.0V		80	130	160	Ω	⑥

NOTE:

External Components: C_{IN1}=20μF(ceramic), C_{IN2}=1μF(ceramic), L=4.7μH, C_L=20μF(ceramic)

R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF

Condition: Unless otherwise stated, "H"=V_{IN} ~ V_{IN} - 1.2V, "L"=+ 0.1V ~ -0.1V

The ambient temperature range (-40℃≦Ta≦85℃) is design Value.

■ ELECTRICAL CHARACTERISTICS (Continued)

XD9242/XD9343, f_{OSC}=2.4MHz

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP.	MAX.	UNIT	CIRCUIT
FB Voltage	V_{FB}	V_{IN}=5.0V, V_{CE}=5.0V, Voltage to start oscillation while		0.784	0.800	0.816	V	③
		V_{FB}=0.72V → 0.88V	-40℃≦Ta≦85℃	0.768	0.800	0.832		
Operating Voltage Range	V_{IN}	When connected to external components	-40℃≦Ta≦85℃	2.7	-	6.0	V	①
Maximum Output Current	I_{OUTMAX}	V_{IN}=V_{CE}=5.0V (*1,*2) When connected to external components		2.0	-	-	A	①
UVLO Voltage	V_{UVLO}	V_{CE}=5.0V, V_{FB}=0.72V Voltage which Lx pin holding "L" level(*3)		2.00	-	2.68	V	③
Quiescent Current	I_q	V_{IN}=V_{CE}=5.0V, V_{FB}=0.88V		-	53	92	μA	②
			-40℃≦Ta≦85℃	-	53	184		
Stand-by Current	I_{STB}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0.88V		-	0.01	1.00	μA	②
Oscillation Frequency	f_{OSC}	V_{IN}=V_{CE}=5.0V, I_{OUT}=1000mA, When connected to external components		2040	2400	2760	kHz	①
			-40℃≦Ta≦85℃	1632	2400	3312		
PFM Switch Current (*4)	I_{PFM}	V_{IN}=V_{CE}=6.0V, I_{OUT}=1mA When connected to external components		-	680	-	mA	①
PFM Duty Limit (*4)	DTY_{LIMIT_PFM}	V_{IN}=V_{CE}=2.7V, I_{OUT}=1mA When connected to external components		-	180	250	%	①
Maximum Duty Limit	D_{MAX}	V_{IN}=V_{CE}=5.0V, V_{FB}=0.72V	-40℃≦Ta≦85℃	100	-	-	%	③
Minimum Duty Limit	D_{MIN}	V_{IN}=V_{CE}=5.0V, V_{FB}=0.88V	-40℃≦Ta≦85℃	-	-	0	%	③
Efficiency	EFFI	V_{IN}=V_{CE}=5.0V, I_{OUT}=500mA (*5) R_{FB1}=47kΩ, R_{FB2}=15kΩ, C_{FB}=330pF		-	95	-	%	①
LXSW"H"ON Resistance	R_{LxH}	V_{IN}=V_{CE}=4.0V, V_{FB}=0.72V (*6)		-	0.11	0.21	Ω	④
LXSW"L"ON Resistance	R_{LxL}			-	0.12	0.30(*7)	Ω	-
LXSW"H" Leakage Current	I_{LeakH}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0.88V, V_{Lx}=0V		-	0.01	1.00(*8)	μA	⑤
Current Limit	I_{LIM}	V_{IN}=V_{CE}=5.0V, V_{FB}=0.72V (*9)		-	4.0	-	A	④

NOTE:

External Components: C_{IN1}=20μF(ceramic), C_{IN2}=1μF(ceramic), L=2.2μH, C_L=20μF(ceramic)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF

Condition: Unless otherwise stated, "H"= V_{IN} ~ VI_N - 1.2V, "L"= + 0.1V ~ -0.1V

The ambient temperature range (-40℃≦Ta≦85℃) is design Value.

(*1) Mount conditions affect heat dissipation. Maximum output current is not guaranteed when T_{TSD} starts to operate earlier.

(*2) When the difference between the input and the output is small, some cycles may be skipped completely before current maximizes. If current is further pulled from this state, output voltage will decrease because of P-ch driver ON resistance.

(*3) These values include UVLO detect voltage, UVLO release voltage and hysteresis operating voltage range. UVLO release voltage is defined as the V_{IN} voltage which makes Lx pin "H".

(*4) XD9242 series exclude I_{PFM} and DTY_{LIMIT_PFM} because those are only for the PFM control's functions.

(*5) EFFI = { (output voltage × output current) ／ (input voltage × input current) } × 100

(*6) On resistance = (V_{IN} – Lx pin measurement voltage) / 100mA

(*7) Design value.

(*8) When temperature is high, a current of approximately 20μA (maximum) may leak.

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

■ ELECTRICAL CHARACTERISTICS (Continued)

XD9242/XD9343, f_{OSC}=2.4MHz

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP.	MAX.	UNIT	CIRCUIT
CE"H" Voltage	V_{CEH}	V_{IN}=5.0V, V_{FB}=0.72V Applied voltage to V_{CE} Voltage changes Lx to "H" level	-40℃≦Ta≦85℃	1.2	-	V_{IN}	V	③
CE"L" Voltage	V_{CEL}	V_{IN}=5.0V, V_{FB}=0.72V Applied to V_{CE} Voltage changes Lx to "L" level	-40℃≦Ta≦85℃	AGND	-	0.4	V	③
CE"H" Current	I_{CEH}	V_{IN}=5.0V, V_{CE}=5.0V, V_{FB}=0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
CE"L" Current	I_{CEL}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
FB"H" Current	I_{FBH}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=5.0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
FB"L" Current	I_{FBL}	VI_N=5.0V, V_{CE}=0V, V_{FB}=0V		-0.1	-	0.1	μA	②
			-40℃≦Ta≦85℃	-1	-	1		
Soft-Start Time	t_{SS}	V_{IN}=5.0V, V_{CE}=0V→5.0V, I_{OUT}=1mA When connected to external components		0.3	1.0	2.0	ms	①
Thermal Shutdown Temperature	T_{TSD}	-		-	150	-	℃	-
Hysteresis Width	T_{HYS}	-		-	20	-	℃	-
C_L Discharge	R_{DCHG}	V_{IN}=5.0V, V_{CE}=0V, V_{FB}=0.72V, V_{Lx}=1.0V		80	130	160	Ω	⑥

NOTE:

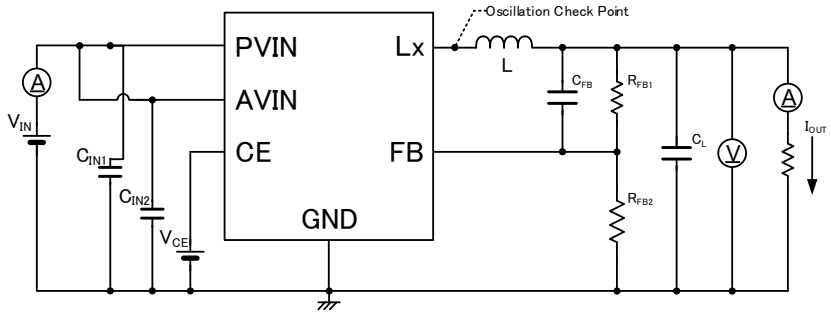
External Components: C_{IN1}=20μF(ceramic), C_{IN2}=1μF(ceramic), L=2.2μH, C_L=20μF(ceramic)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF

Condition: Unless otherwise stated, "H"= V_{IN} ~ VI_N - 1.2V, "L"= + 0.1V ~ -0.1V

The ambient temperature range (-40℃≦Ta≦85℃) is design Value.

■TEST CIRCUITS

1) CIRCUIT ①

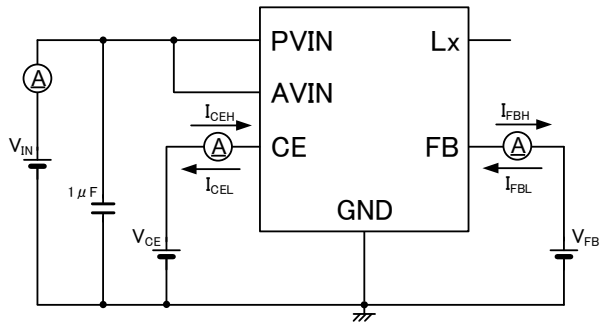


※External components
C_{IN1} : 20μF(ceramic)
C_{IN2} : 1μF(ceramic)
C_L : 20μF(ceramic)
R_{FB1} : 15kΩ
R_{FB2} : 30kΩ
C_{FB} : 1000pF

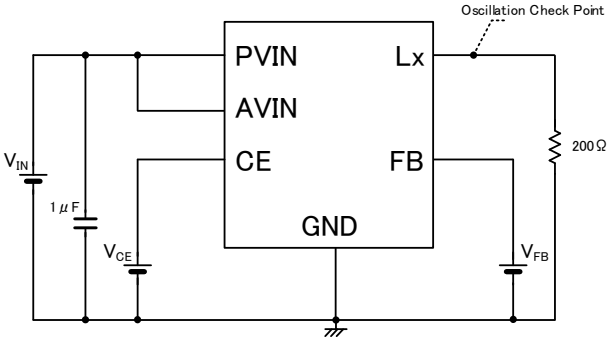
(*1)XD924xB08C TYPE
L : 4.7μH
XD924xB08D TYPE
L : 2.2μH

※The condtion to measure EFFI
R_{FB1} : 47kΩ
R_{FB2} : 15kΩ
C_{FB} : 330pF

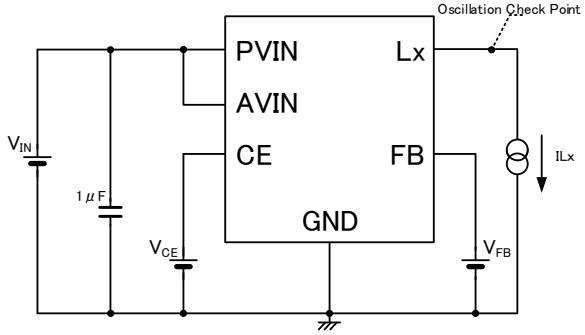
2) CIRCUIT ②



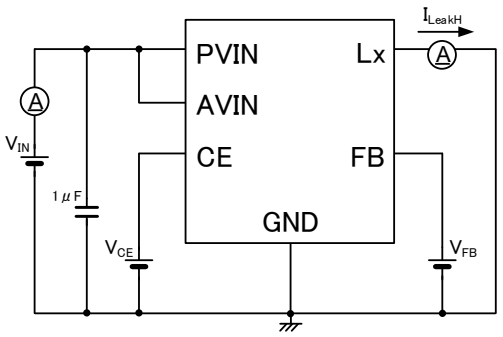
3) CIRCUIT ③



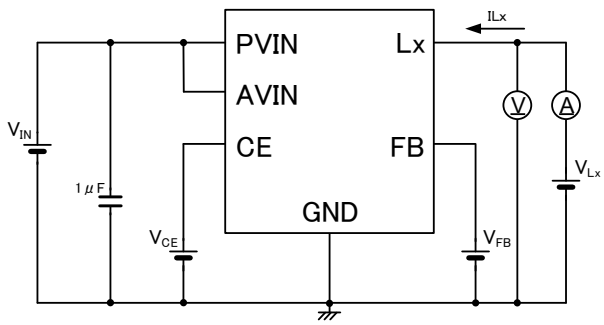
4) CIRCUIT ④



5) CIRCUIT ⑤

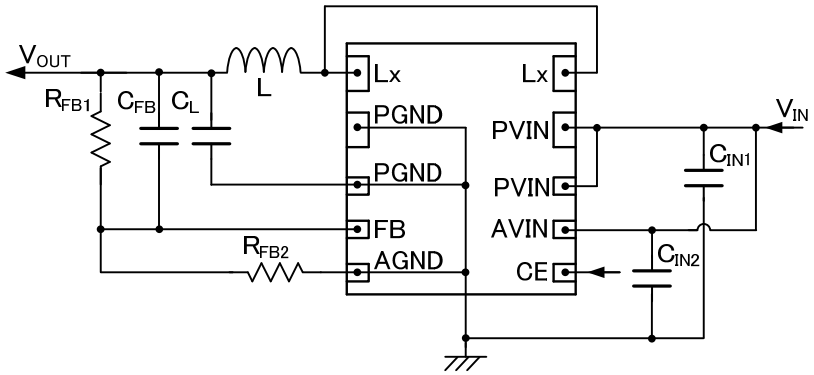


6) CIRCUIT ⑥



■TYPICAL APPLICATION CIRCUIT

●XD9242/XD9243 Series



External Components

【Typical Examples】f_{OSC}=1.2MHz

	MANUFACTURER	PRODUCT NUMBER	VALUE
L:	TDK	CLF7045NIT-4R7N-D(*1)	4.7μH
L:	TDK	SLF7055T-4R7	4.7μH
L:	TDK	SPM6530T-4R7	4.7μH

【Typical Examples】f_{OSC}=2.4MHz

	MANUFACTURER	PRODUCT NUMBER	VALUE
L:	TDK	CLF7045NIT-2R2N-D(*1)	2.2μH
L:	TDK	SLF7055T-2R2	2.2μH
L:	TDK	SPM6530T-2R2	2.2μH

【Typical Examples】 f_{OSC}=1.2MHz / 2.4MHz

	MANUFACTURER	PRODUCT NUMBER	VALUE
C_{IN1}:	TAIYO YUDEN	LMK212ABJ106KGHT(*1)	10V/10μF x 2
C_{IN2}	TAIYO YUDEN	LMK107BJ105KAHT(*1)	10V/1μF x 1
C_L:	TAIYO YUDEN	LMK212ABJ106KGHT(*1)	10V/10μF x 2

(*1) The products for Automotive Electronic Equipment.

<Output Voltage Setting>

Output voltage can be set by adding external split resistors. Output voltage is determined by the following equation, based on the values of RFB1 and RFB2. The sum of RFB1 and RFB2 should normally be 100kΩ or less. Output voltage range is 0.9V~5.5V by a 0.8V (±2.0%) reference voltage. When input voltage (V_{IN}) ≦setting output voltage, output voltage (V_{OUT}) can not output the power more than input voltage (V_{IN}).

The value of C_{FB}, speed-up capacitor for phase compensation, should be f_{ZFB}= *1 / (2 x π x CFB x RFB1)* which is equal to 10kHz. Adjustments are required from 1kHz to 10kHz depending on the application, value of inductance (L), and value of load capacitance (C_L).

[Example of calculation]

When R_{FB1}=47kΩ, R_{FB2}=15kΩ, V_{OUT}=0.8×(47kΩ+15kΩ) / 15kΩ =3.3V

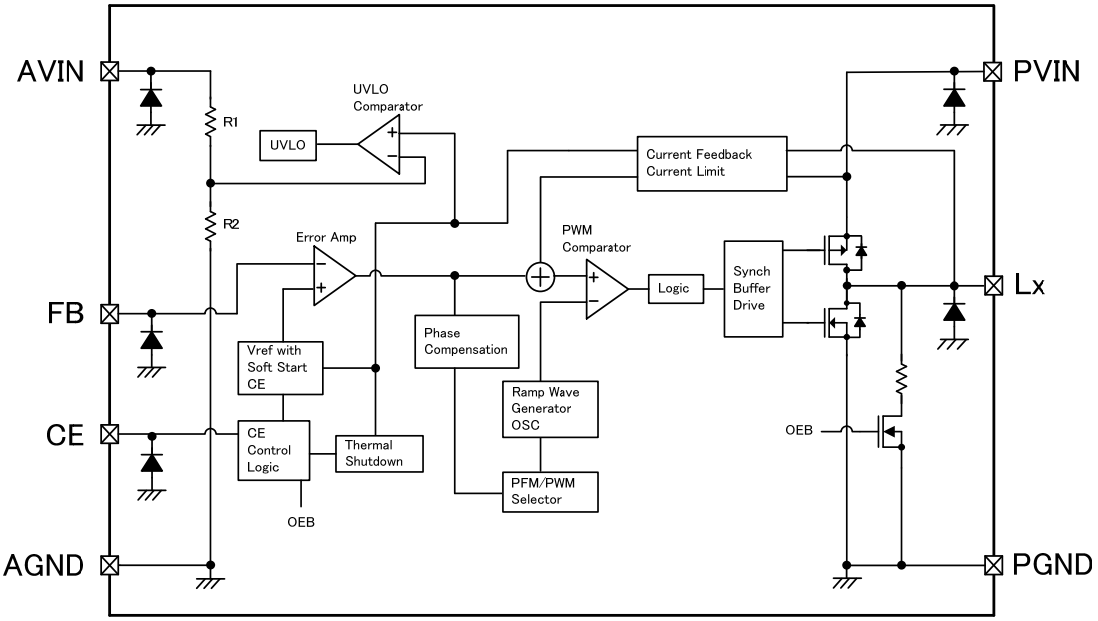
When C_{FB}=330pF, fzfb= 1/(2 × π×330pF ×47 kΩ) =10.26kHz

$V_{OUT}=0.8\times(R_{FB1}+R_{FB2})/R_{FB2}$

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	7.5	30	2000	2.5	51	24	300
1.2	15	30	1000	3	33	12	470
1.5	26	30	560	3.3	47	15	330
1.8	30	24	510	5	43	8.2	390

■ OPERATIONAL DESCRIPTION

The XD9242/XD9243 series consists of a reference voltage source, ramp wave circuit, error amplifier, PWM comparator, phase compensation circuit, output voltage adjustment resistors, P-channel MOS driver transistor, N-channel MOS switching transistor for the synchronous switch, current limiter circuit, UVLO circuit and others. (See the block diagram above.) The series ICs compare, using the error amplifier, the voltage of the internal voltage reference source with the feedback voltage from the FB pin. Phase compensation is performed on the resulting error amplifier output, to input a signal to the PWM comparator to determine the turn-on time during PWM operation. The PWM comparator compares, in terms of voltage level, the signal from the error amplifier with the ramp wave from the ramp wave circuit, and delivers the resulting output to the buffer driver circuit to cause the Lx pin to output a switching duty cycle. This process is continuously performed to ensure stable output voltage. The current feedback circuit monitors the P-channel 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 a low ESR capacitor such as a ceramic capacitor is used ensuring stable output voltage.



BLOCK DIAGRAM XD9242/XD9243 Series

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

<Reference Voltage Source>

The reference voltage source 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 internally and can be selected from 1.2MHz or 2.4MHz. 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 divided by the external split resistors, R1 and R2. 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.

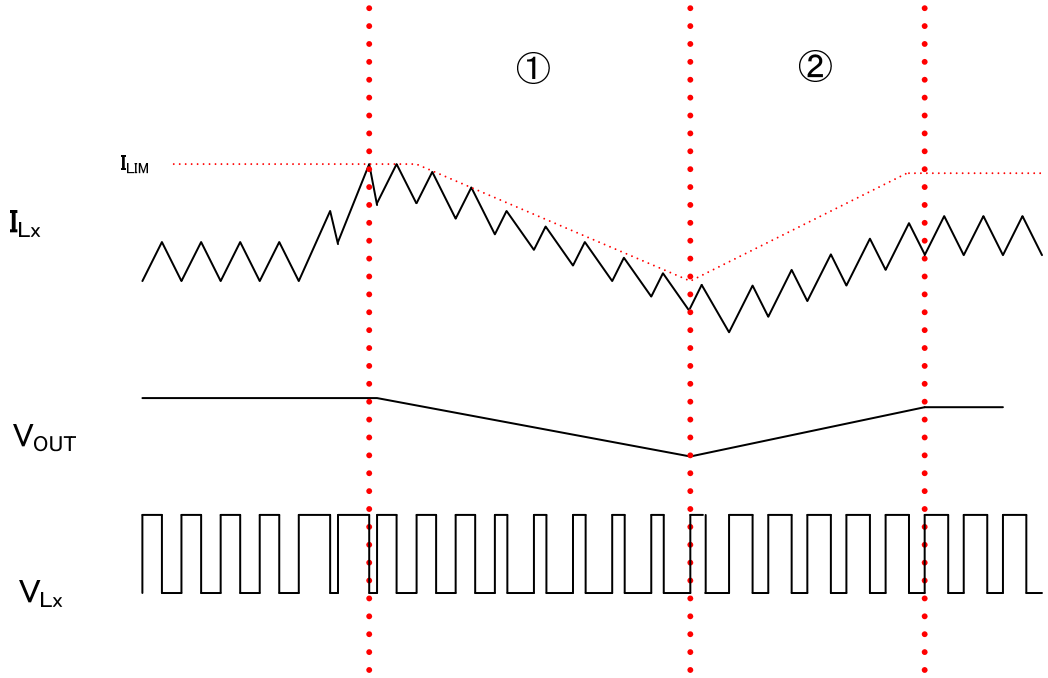
■ OPERATIONAL DESCRIPTION (Continued)

<Current Limit>

The XD9242/XD0243 series includes a fold-back circuit, which aids the operation of the current limiter and circuit protection. The XD9242/XD9243 series monitors the current flowing through the P-channel MOS driver transistor

①When current flowing through P-channel MOS driver transistor reaches current limit I_{LIM}, the current limiter circuit operates to limit the inductor current I_{LX}. If this state continues, the fold-back circuit operates and limit the output current in order to protect the IC from damage.

②The output voltage is automatically resumed if the load goes light. When it is resumed, the soft-start function operates.



<Thermal Shutdown>

For protection against heat damage, the thermal shutdown function monitors chip temperature. When the chip's temperature reaches 150°C (TYP.), the thermal shutdown circuit starts operating and the P-channel driver transistor will be turned off. At the same time, the output voltage decreases. When the temperature drops to 130°C (TYP.) after shutting off the current flow, the IC performs the soft start function to initiate output startup operation.

< Function of CE pin >

The XD9242/9243 series will enter into stand-by mode by inputting a low level signal to the CE pin. During a stand-by mode, the current consumption of the IC becomes 0μA (TYP.). The IC starts its operation by inputting a high level signal to the CE pin. The input of the CE pin is a CMOS input and the sink current is 0μA (TYP.).

<UVLO>

When the VIN pin voltage becomes 2.4V (TYP.) or lower, the P-channel MOS driver transistor output driver transistor is forced OFF to prevent false pulse output caused by unstable operation of the internal circuitry. When the V_{IN} pin voltage becomes 2.68V (MAX.) 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 VIN pin voltage falls momentarily below the UVLO operating 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.

<Soft Start>

The XD9242/XD9243 series provide 1.0ms (TYP). Soft start time is defined as the time interval to reach 90% of the output voltage from the time when the V_{CE} is turned on.

■ OPERATIONAL DESCRIPTION (Continued)

<C_L High Speed Discharge>

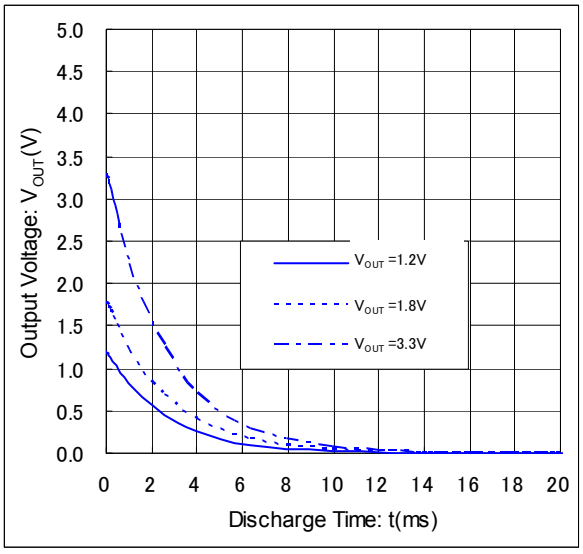
The XD9242/XD9243 series can quickly discharge the electric charge at the output capacitor (C_L) when a low signal to the CE pin which enables a whole IC circuit put into OFF state, is inputted via the N-channel MOS switch transistor located between the L_X pin and the V_{GND} pin. When the IC is disabled, electric charge at the output capacitor (C_L) is quickly discharged so that it may avoid application malfunction. Discharge time of the output capacitor (C_L) is set by the C_L auto-discharge resistance (R) and the output capacitor (C_L). By setting time constant of a C_L auto-discharge resistance value [R] and an output capacitor value (C_L) as τ (τ =C x R), discharge time of the output voltage after discharge via the N-channel transistor is calculated by the following formulas.

$$V = V_{OUT(E)} \times e^{-t/\tau} \quad or \quad t = -\tau \ln (V_{OUT(E)} / V)$$

V : Output voltage after discharge
$V_{OUT(E)}$: Output voltage
t: Discharge time
τ $C_L \times R_{DCHG}$
C_L : Capacitance of Output capacitor
R_{DCHG} : C_L auto-discharge resistance

Output Voltage Dischage characteristics

R_{DCHG} = 130Ω(TYP.) C_L=20μF



■ OPERATIONAL DESCRIPTION (Continued)

<PFM Switch Current> (*1)

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

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

< PFM Duty Limit > (*1)

In 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 P-channel MOS driver transistor to be turned off even when coil current doesn't reach to IPFM. Please refer to I_{PFM}②

(*1) XD9242 Series is excluded.

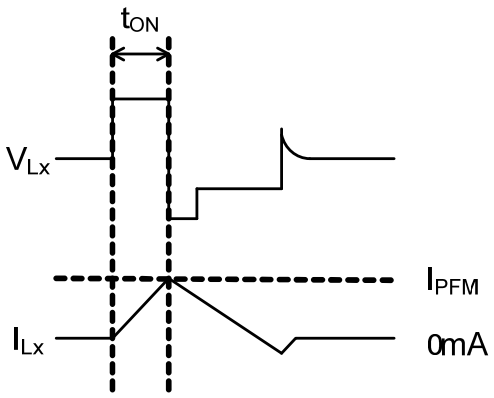


Fig. I_{PFM}①

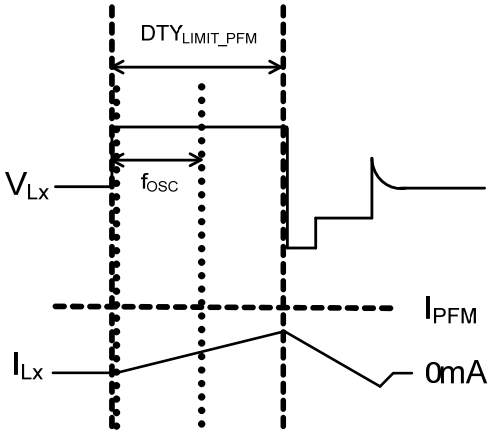


Fig. I_{PFM}②

■ 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. 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.

3. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current.
Please wire the input capacitor (CIN) and the output capacitor (CL) as close to the IC as possible.

4. When the difference between VIN and VOUT is large in PWM control, very narrow pulses will be outputted, and there is the possibility that some cycles may be skipped completely.

5. When the difference between V_{IN} and V_{OUT} is small, and the load current is heavy, very wide pulses will be outputted and there is the possibility that some cycles may be skipped completely.

6. With the IC, the peak current of the coil is controlled by the current limit circuit. Since the peak current increases when dropout voltage or load current is high, current limit starts operation, and this can lead to instability. When peak current becomes high, please adjust the coil inductance value and fully check the circuit operation. In addition, please calculate the peak current according to the following formula:

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

L : Coil Inductance Value
f_{OSC}: Oscillation Frequency

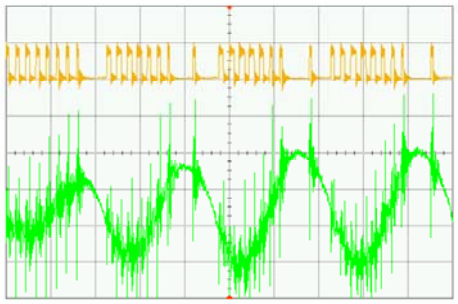
7. Use of the IC at voltages below the recommended voltage range may lead to instability.

8. This IC should be used within the stated absolute maximum ratings in order to prevent damage to the device.

9. When the IC is used in high temperature, output voltage may increase up to input voltage level at no load because of the leak current of the P-channel driver transistor.

10. The XD9242/XD9243 uses fold-back circuit limiter. However, fold-back may become “droop” affected by the wiring conditions. Care must be taken especially for C_{IN} distance and position.

11. If CL capacitance reduction happens such as in the case of low temperature, the IC may enter unstable operation. Care must be taken for CL capacitor selection and its capacitance value.



Ta = - 50℃
V_{IN} = 3.6V, V_{OUT} = 0.9V, f_{OSC} = 2.4MHz
C_{IN} = 20 μF(Ceramic)
C_L = 14.7 μF(Ceramic)
I_{OUT} = 300mA

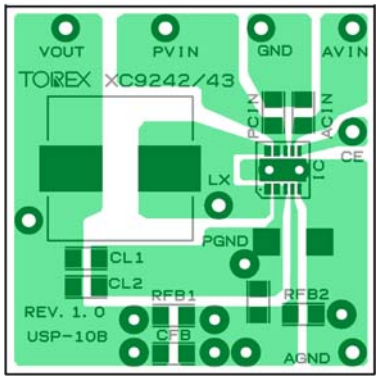
12. Torex places an importance on improving our products and its reliability.
However, by any possibility, we would request user fail-safe design and post-aging treatment on system or equipment.

■ NOTE ON USE (Continued)

Instructions of pattern layouts

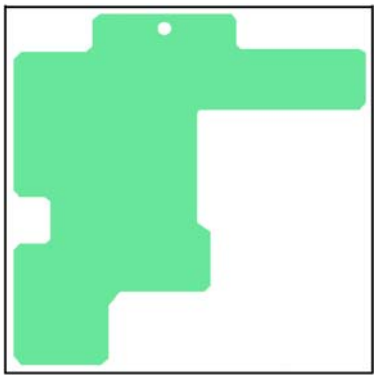
1. In order to stabilize V_{IN} voltage level, we recommend that a by-pass capacitor (C_{IN}) be connected as close as possible to the PVIN & PGND pins and the AVIN & AGND pins.
2. Make sure to avoid noise from the PVIN pin to the AVIN pin. Please connect the AGND pin and PGND pin in the shortest length for wiring.
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. This series' internal driver transistors bring on heat because of the output current and ON resistance of P-channel and N-channel MOS driver transistors.
6. Make sure that the PCB 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.

1st Layer(USP-10B)

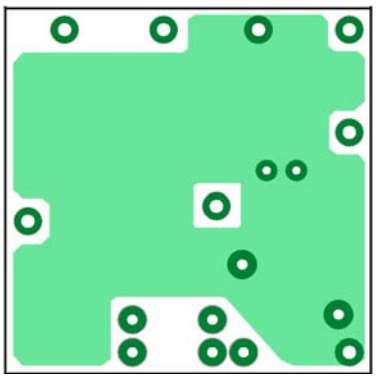


2nd Layer(USP-10B)

3rd Layer(USP-10B)

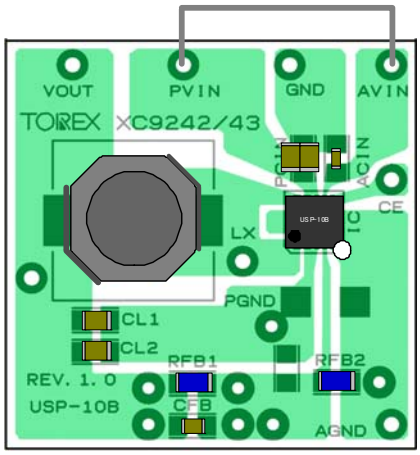


4th Layer(USP-10B)



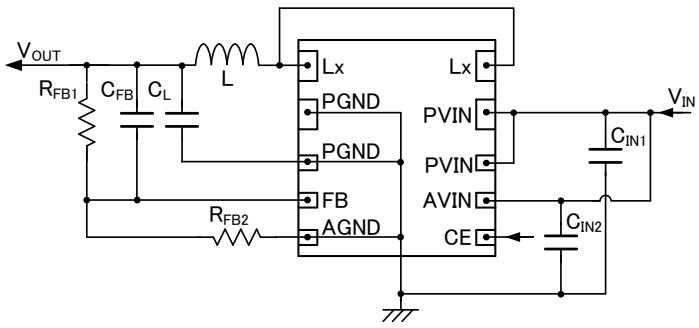
●PCB (USP-10B)

1) XD9242/XD9243 Series



●Typical Application Circuit (USP-10B)

1) XD9242/XD9243 Series



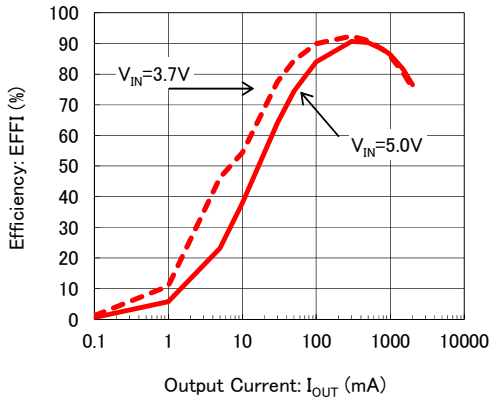
※XD9242/43 series PCB is the common substrate with the XC9242/43 series(non-AEC qualified products).

■ TYPICAL PERFORMANCE CHARACTERISTICS

(1) Efficiency vs. Output Current

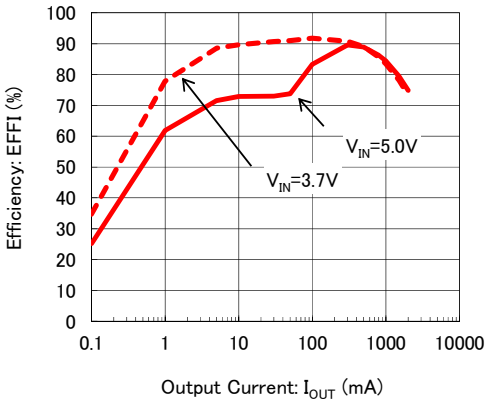
XD9242B08C (V_{OUT}=1.2V)

L=4.7μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



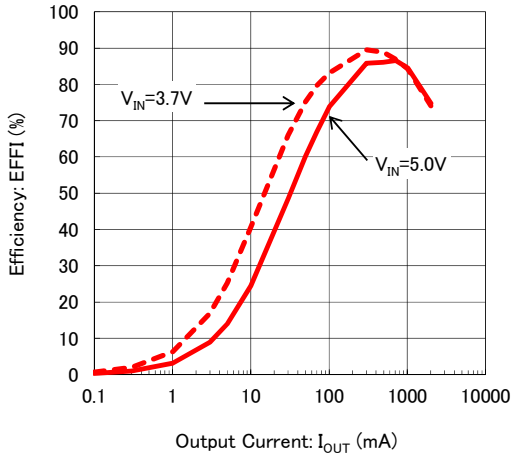
XD9243B08C (V_{OUT}=1.2V)

L=4.7μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



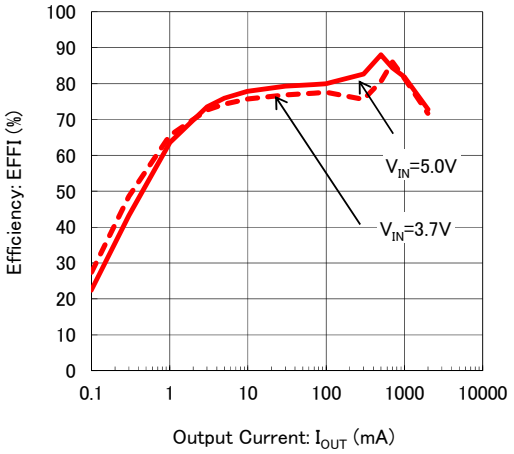
XD9242B08D (V_{OUT}=1.2V)

L=2.2μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



XD9243B08D (V_{OUT}=1.2V)

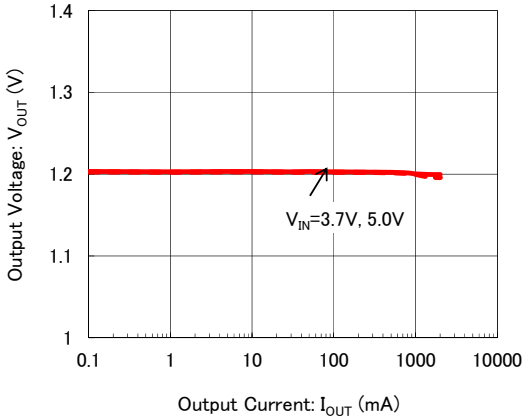
L=2.2μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



(2) Output Voltage vs. Output Current

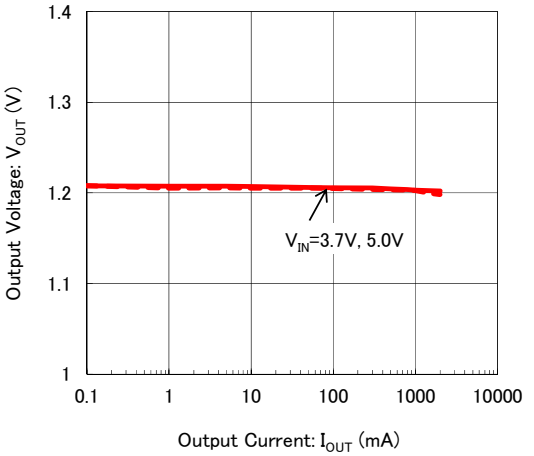
XD9242B08C (V_{OUT}=1.2V)

L=4.7μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



XD9243B08C (V_{OUT}=1.2V)

L=4.7μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF

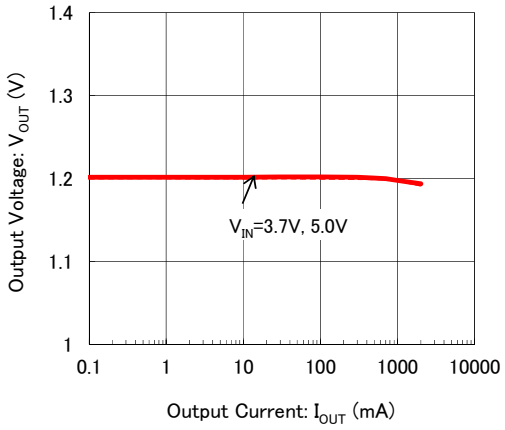


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Output Current

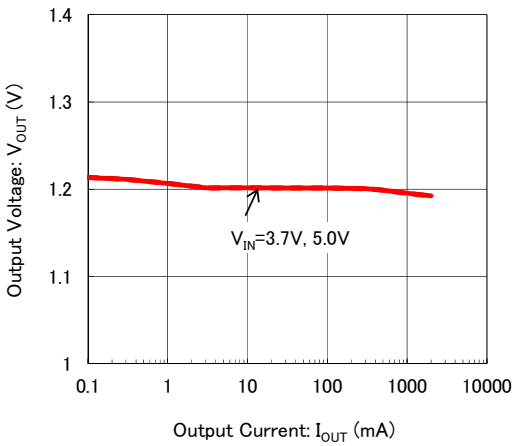
XD9242B08D (V_{OUT}=1.2V)

L=2.2μH(SLF7055),CIN=20μF(LMK212ABJ106KGx2)
CIN=1μF(LMK107BJ105KAx1),CL=20μF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF



XD9243B08D (V_{OUT}=1.2V)

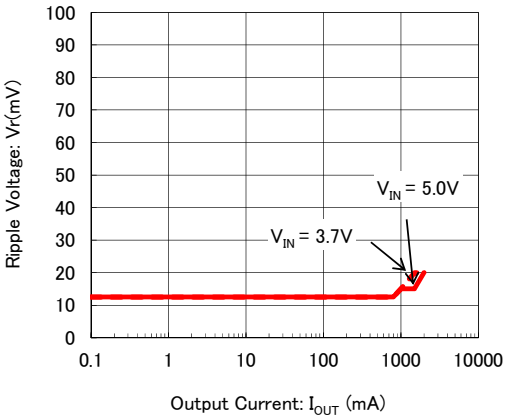
L=2.2μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



(3) Ripple Voltage vs. Output Current

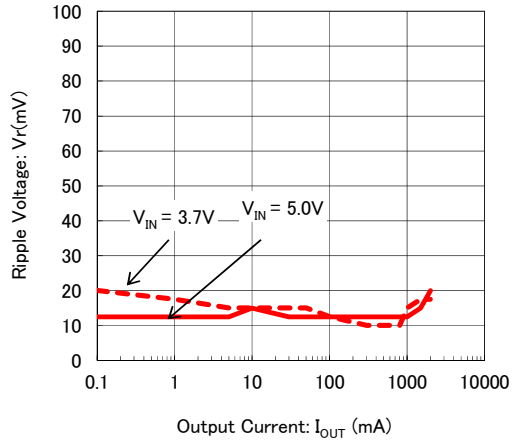
XD9242B08C (V_{OUT}=1.2V)

L=4.7μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



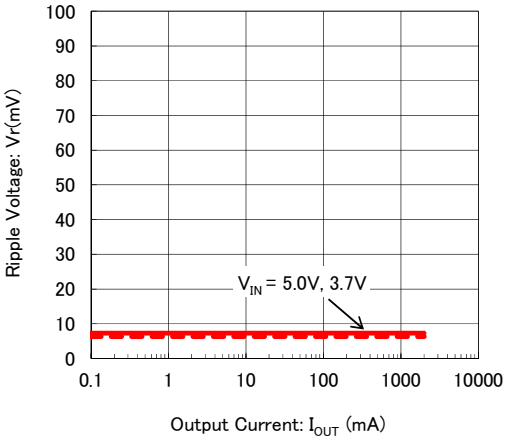
XD9243B08C (V_{OUT}=1.2V)

L=4.7μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



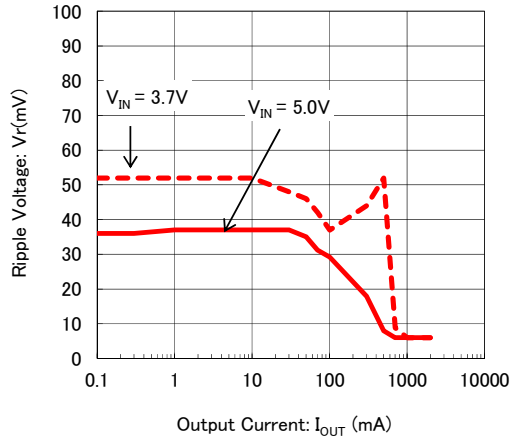
XD9242B08D (V_{OUT}=1.2V)

L=2.2μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



XD9243B08D (V_{OUT}=1.2V)

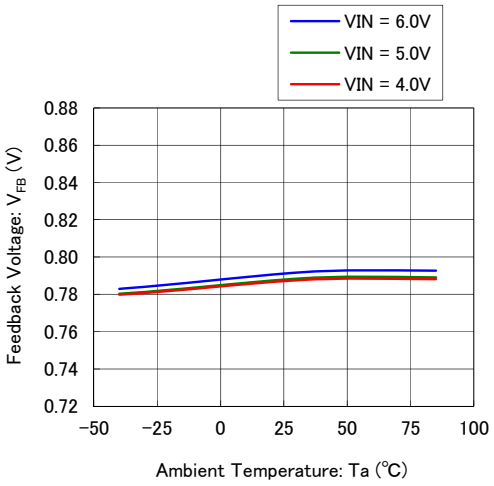
L=2.2μH(SLF7055),C_{IN}=20μF(LMK212ABJ106KGx2)
C_{IN}=1μF(LMK107BJ105KAx1),C_L=20μF(LMK212ABJ106KGx2)
R_{FB1}=15kΩ, R_{FB2}=30kΩ, C_{FB}=1000pF



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

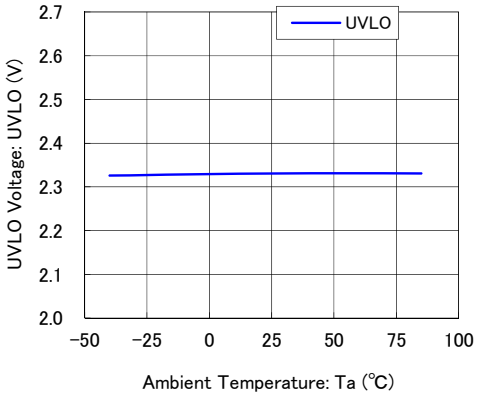
(4) FB Voltage vs. Ambient Temperature

XD9242B08C



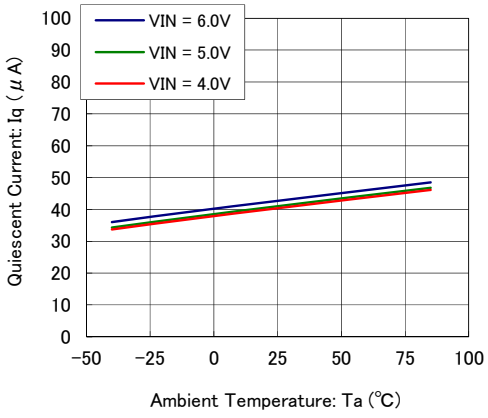
(5) UVLO Voltage vs. Ambient Temperature

XD9242B08C

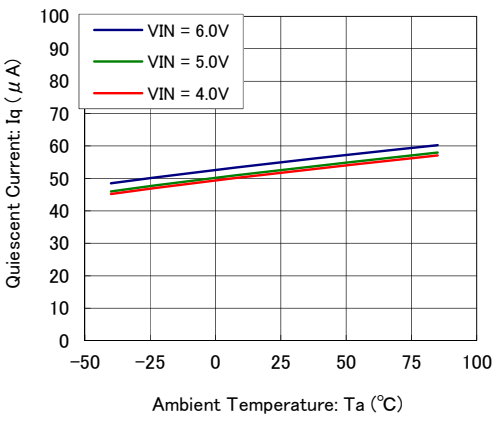


(6) Quiescent Current vs. Ambient Temperature

XD9242B08C

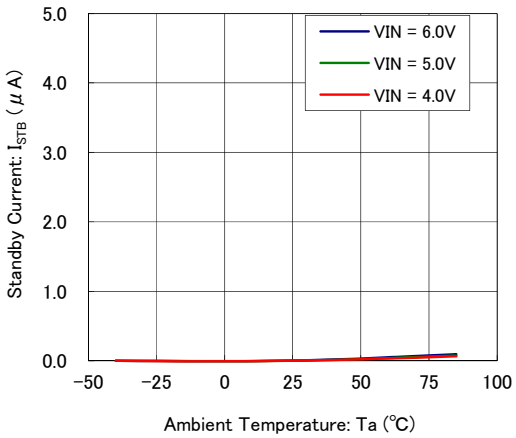


XD9242B08D

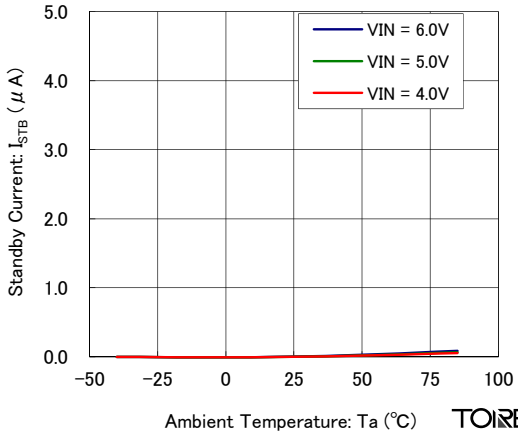


(7) Stand-by Current vs. Ambient Temperature

XD9242B08C



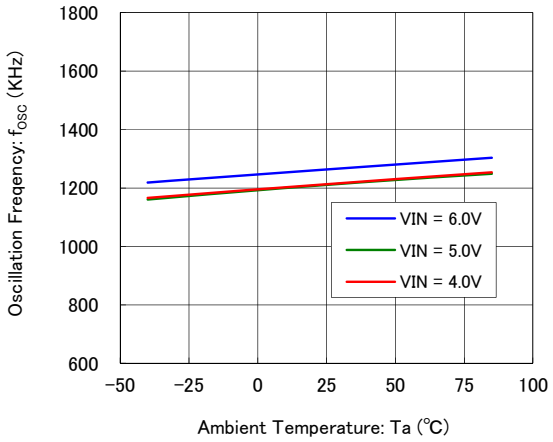
XD9242B08D



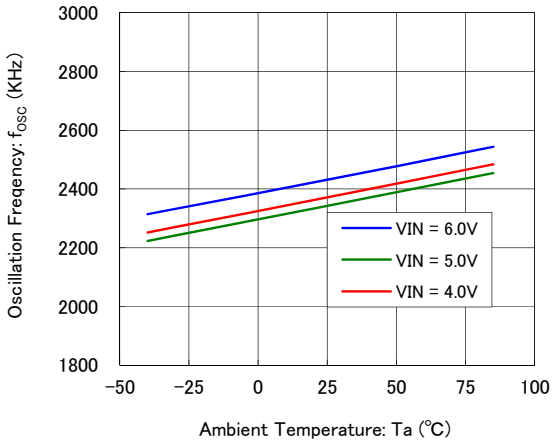
■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Oscillation Frequency vs. Ambient Temperature

XD9242B08C

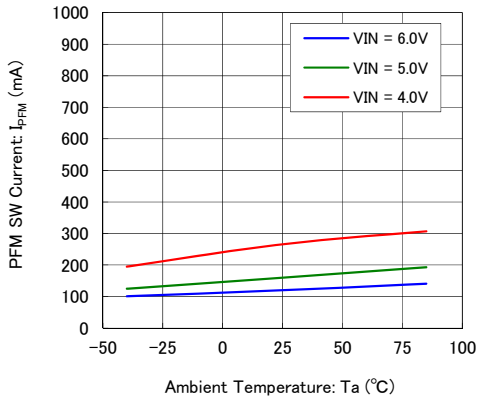


XD9242B08D

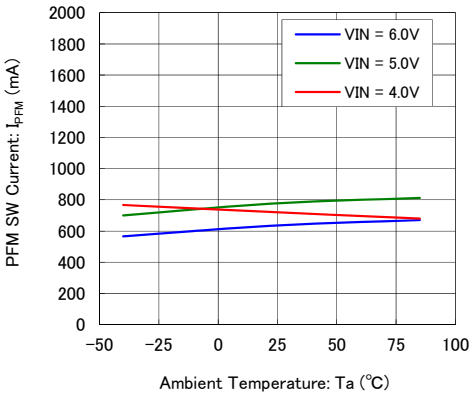


(9) PFM Switching Current vs. Ambient Temperature

XD9243B08C

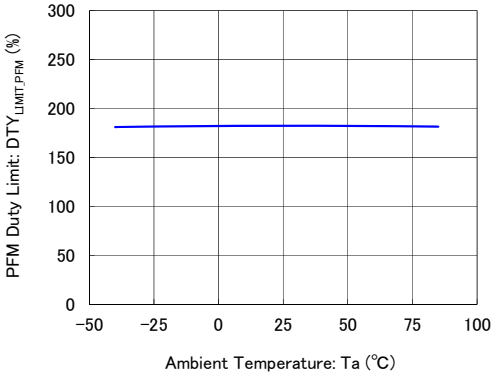


XD9243B08D

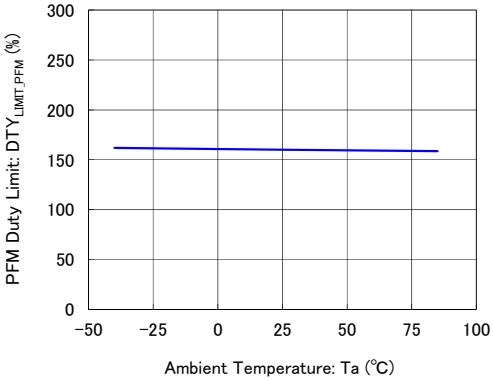


(10) PFM Duty Limit vs. Ambient Temperature

XD9243B08C



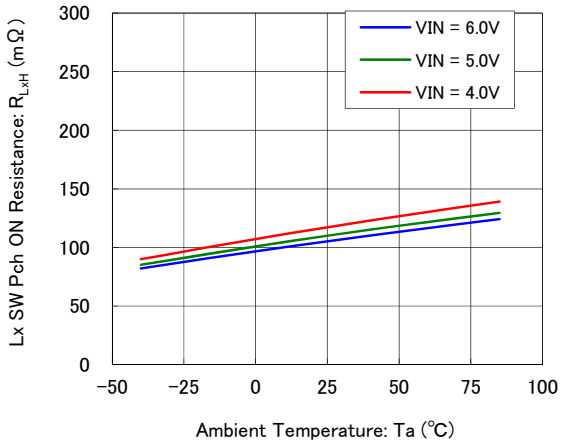
XD9243B08D



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

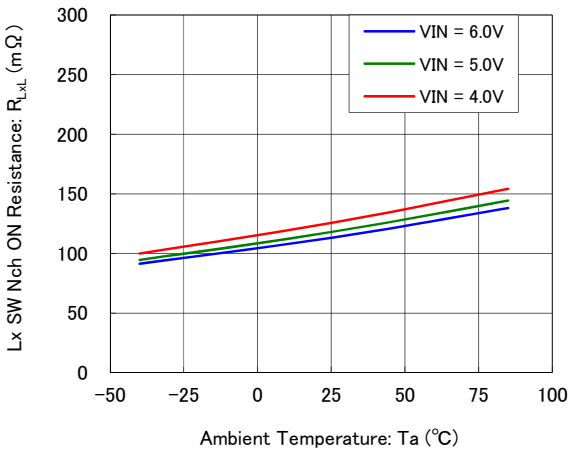
(11) Pch Driver ON Resistance vs. Ambient Temperature

XD9242B08C



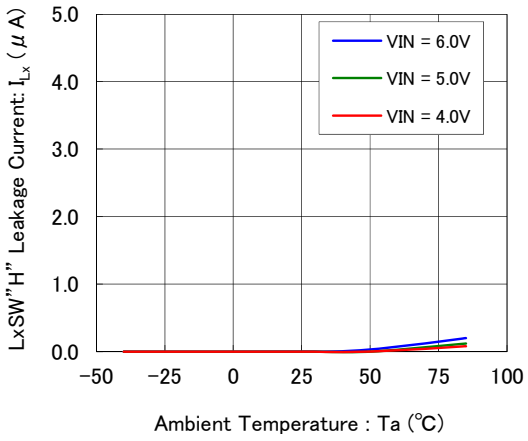
(12) Nch Driver ON Resistance vs. Ambient Temperature

XD9242B08C



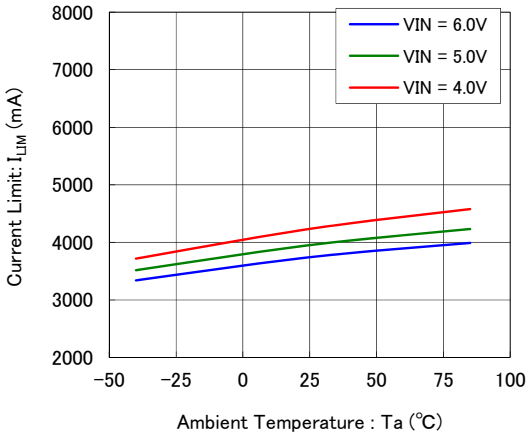
(13) LxSW"H" Leakage Current vs. Ambient Temperature

XD9242B08C



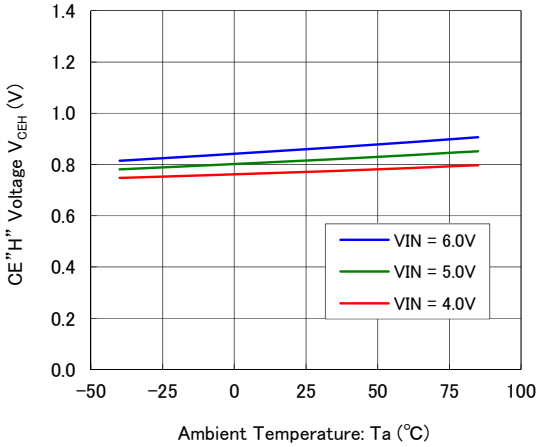
(14) Current Limit vs. Ambient Temperature

XD9242B08C



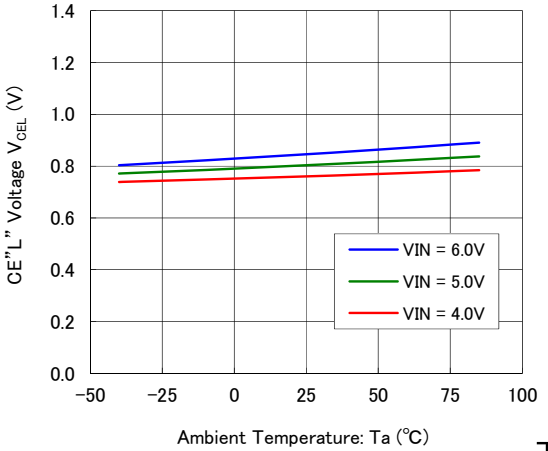
(15) CE"H" Voltage vs. Ambient Temperature

XD9242B08C



(16) CE"L" Voltage vs. Ambient Temperature

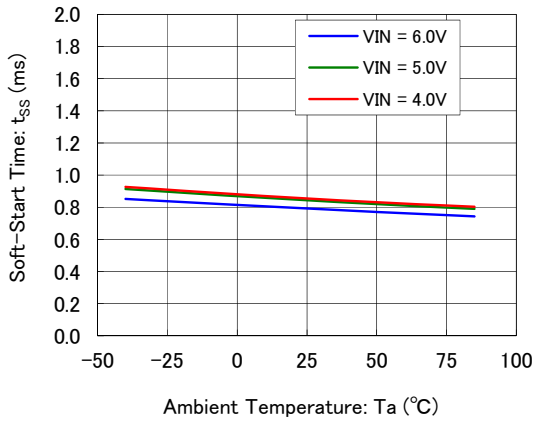
XD9242B08C



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

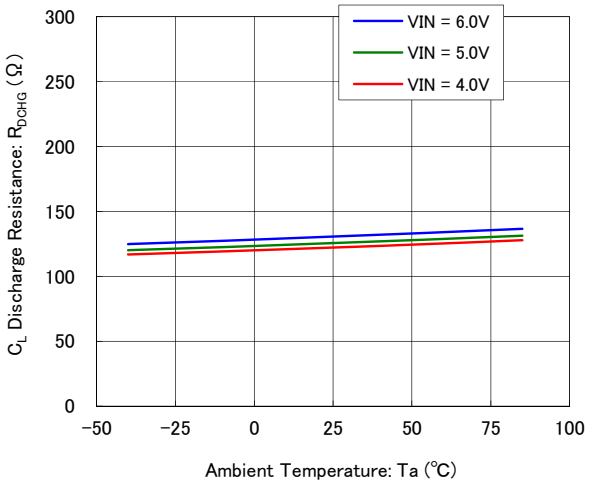
(17) Soft-Start Time vs. Ambient Temperature

XD9242B08C



(18) CL Discharge Resistance vs. Ambient Temperature

XD9242B08C

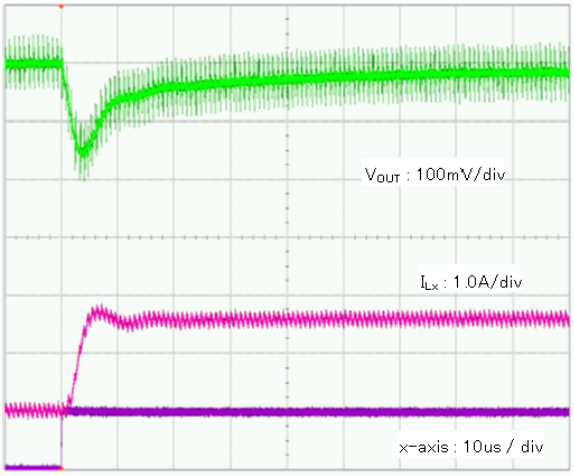


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

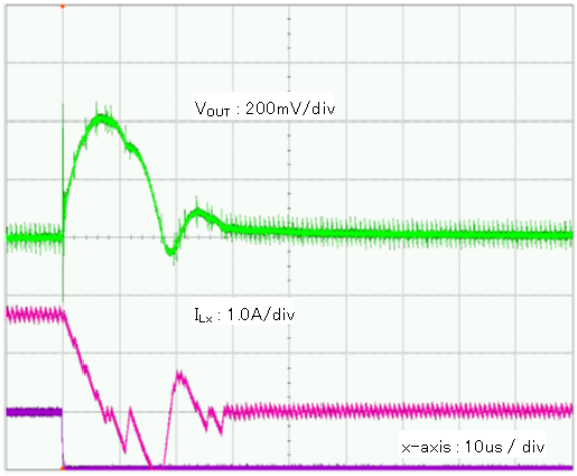
(19) Load Transient Response

XD9242B08C

VIN = 5.0V, VOUT = 1.2V, IOUT = 1mA ⇒1.5A



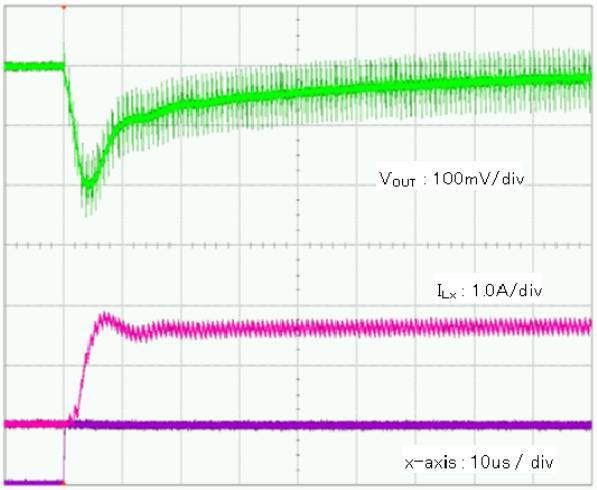
VIN = 5.0V, VOUT = 1.2V, IOUT = 1.5A ⇒ 1mA



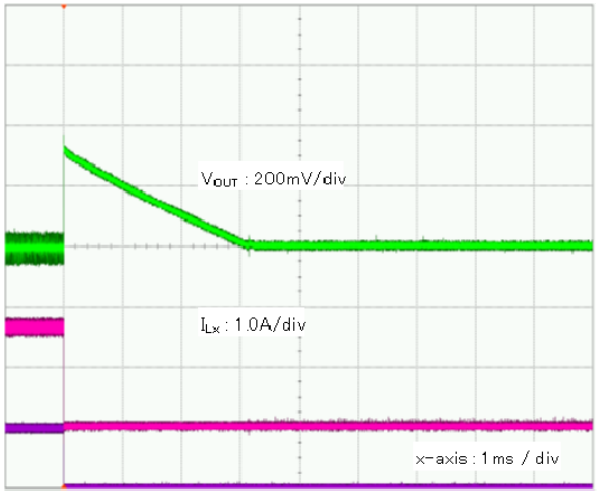
L=4.7μH(SLF7055),CIN=20μF(LMK212ABJ106KGx2)
CIN=1μF(LMK107BJ105KAx1),CL=20μF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF

XD9243B08C

VIN = 5.0V, VOUT = 1.2V, IOUT = 1mA ⇒1.5A



VIN = 5.0V, VOUT = 1.2V, IOUT = 1.5A ⇒ 1mA



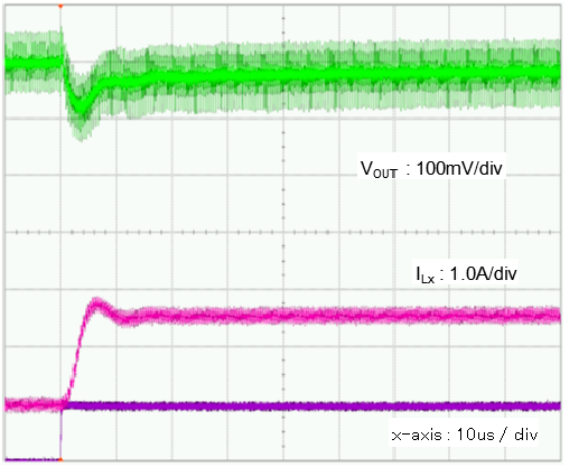
L=4.7μH(SLF7055),CIN=20μF(LMK212ABJ106KGx2)
CIN=1μF(LMK107BJ105KAx1),CL=20μF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

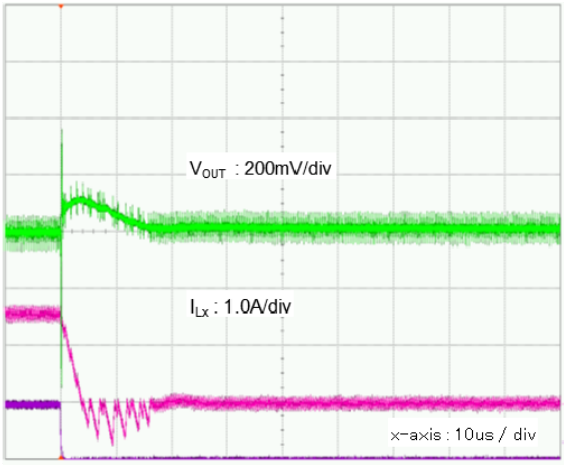
(19) Load Transient Response

XD9242B08D

VIN = 5.0V, VOUT = 1.2V, IOUT = 1mA ⇒1.5 A



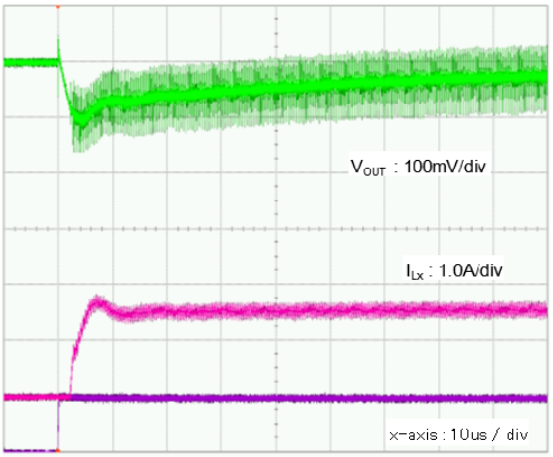
VIN = 5.0V, VOUT = 1.2V, IOUT = 1.5A ⇒ 1m A



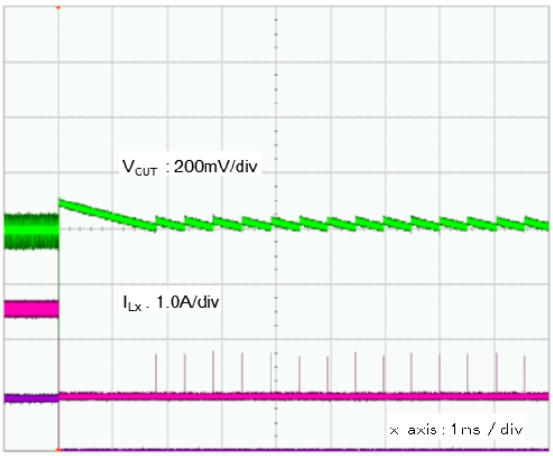
L=2.2µH(SLF7055),CIN=20µF(LMK212ABJ106KGx2)
CIN=1µF(LMK107BJ105KAx1),CL=20µF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF

XD9243B08D

VIN = 5.0V, VOUT = 1.2V, IOUT = 1mA ⇒1.5 A



VIN = 5.0V, VOUT = 1.2V, IOUT = 1.5A ⇒ 1m A



L=2.2µH(SLF7055),CIN=20µF(LMK212ABJ106KGx2)
CIN=1µF(LMK107BJ105KAx1),CL=20µF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF

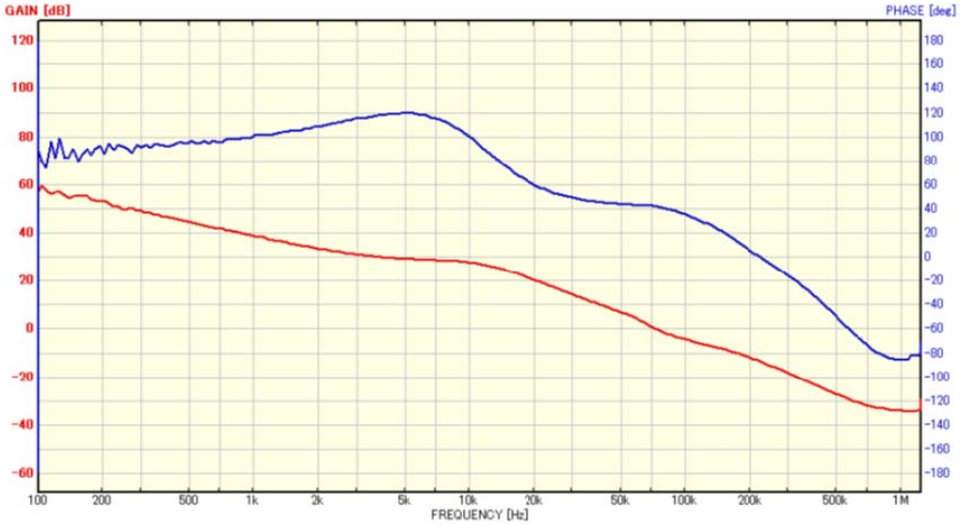
■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(20) Frequency Response

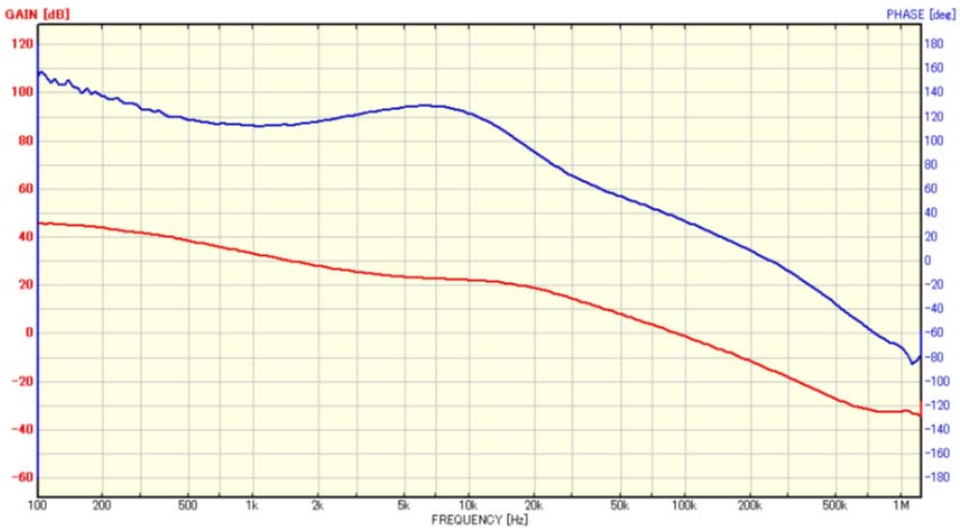
Test Condition:
Measurement equipment:NF FRA5097 Version:3.00
OSC amplitude=20.0mVpeak OSC.Dcbias=0.00V
OSC waveform:SIN, Sweep minimum frequency=1Hz
Sweep maximum frequency=15MHz
Sweep resolution=300steps/sweep
Integration period=100cycle, Delay time=0cycle
Order of harmonic analysis=1, Measure mode:CH1&CH2
Auto integration:OFF, Amplitude compression:OFF
Slow sweep:OFF

XD9242B08C

L=4.7µH(SLF7055),CIN=20µF(LMK212ABJ106KGx2)
CIN=1µF(LMK107BJ105KAx1),CL=20µF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF
VIN = 5.0V, CE=VIN, VOUT = 1.2V, IOUT = 1mA



L=4.7µH(SLF7055),CIN=20µF(LMK212ABJ106KGx2)
CIN=1µF(LMK107BJ105KAx1),CL=20µF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF
VIN = 5.0V, CE=VIN, VOUT = 1.2V, IOUT = 1mA



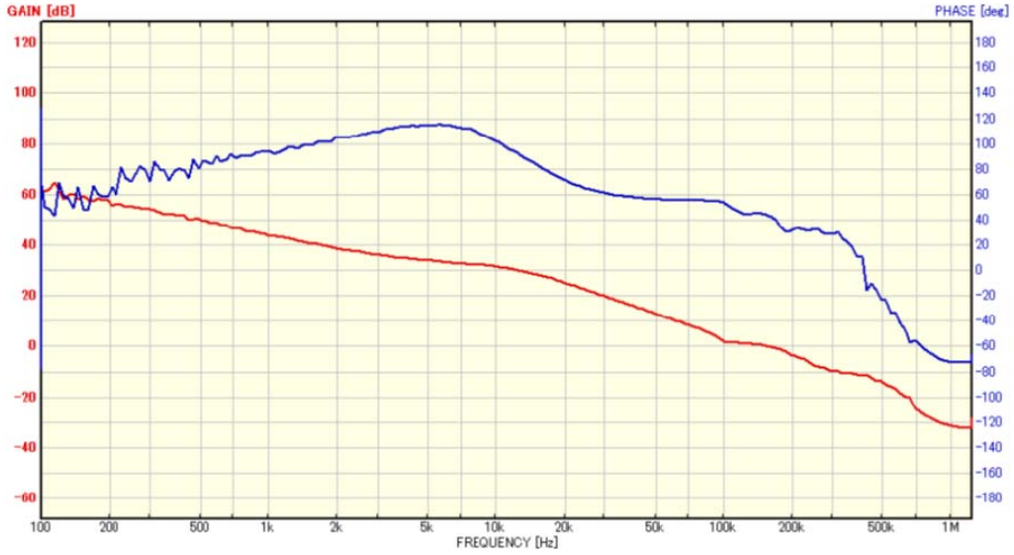
■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(20) Frequency Response

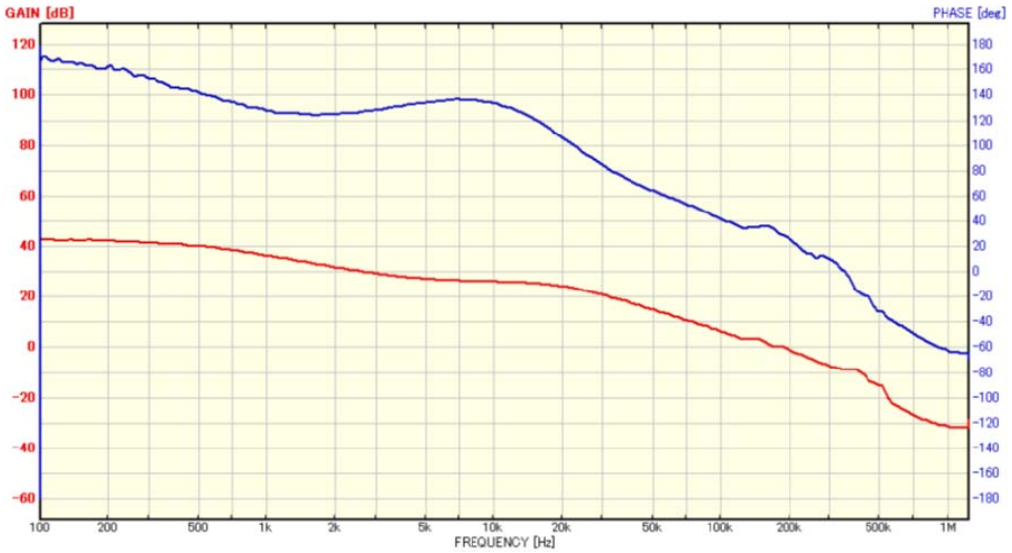
Test Condition:
Measurement equipment:NF FRA5097 Version:3.00
OSC amplitude=20.0mVpeak OSC.Dcbias=0.00V
OSC waveform:SIN, Sweep minimum frequency=1Hz
Sweep maximum frequency=15MHz
Sweep resolution=300steps/sweep
Integration period=100cycle, Delay time=0cycle
Order of harmonic analysis=1, Measure mode:CH1&CH2
Auto integration:OFF, Amplitude compression:OFF
Slow sweep:OFF

XD9242B08D

L=2.2μH(SLF7055),CIN=20μF(LMK212ABJ106KGx2)
CIN=1μF(LMK107BJ105KAx1),CL=20μF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF
VIN = 5.0V, CE=VIN, VOUT = 1.2V, IOUT = 1mA



L=2.2μH(SLF7055),CIN=20μF(LMK212ABJ106KGx2)
CIN=1μF(LMK107BJ105KAx1),CL=20μF(LMK212ABJ106KGx2)
RFB1=15kΩ, RFB2=30kΩ, CFB=1000pF
VIN = 5.0V, CE=VIN, VOUT = 1.2V, IOUT = 1mA

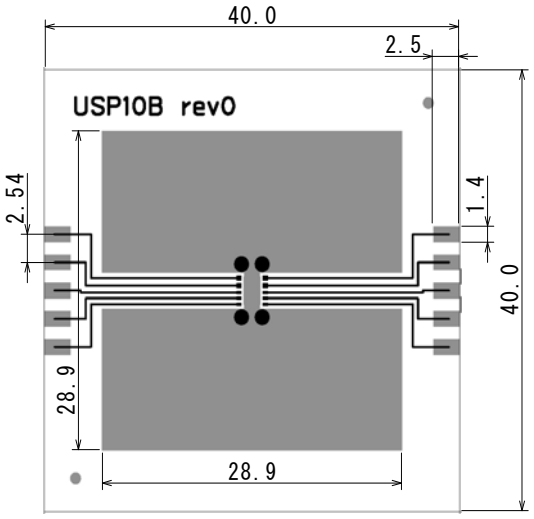


●USP-10B Power Dissipation

Power dissipation data for the USP-10B is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)

Condition: Mount on a board
Ambient: Natural convection
Soldering: Lead (Pb) free
Board: Dimensions40mm×40mm (1600mm^2 in one side)
1st Inner Metal Layer about 50%
2nd Inner Metal Layer does not exist
3rd Inner Metal Layer does not exist
4th Inner Metal Layer about 50%
Each heat sink back metal is connected to the Inner layers respectively.
Material: Glass Epoxy (FR-4)
Thickness: 1.6mm
Through-hole: 4 × 0.8mm Diameter

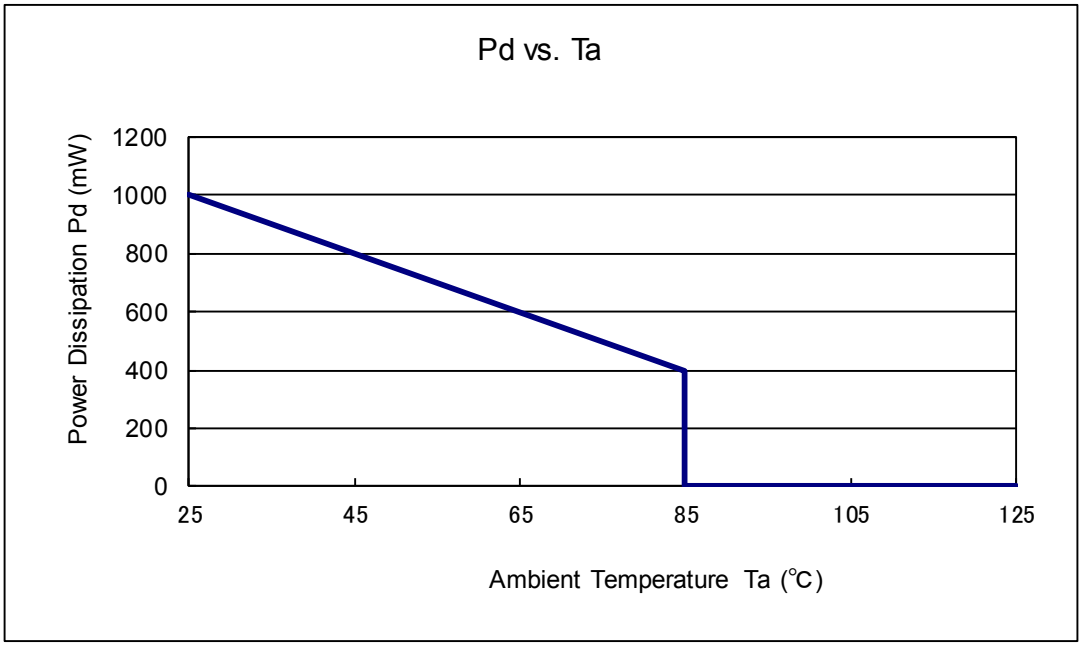


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature

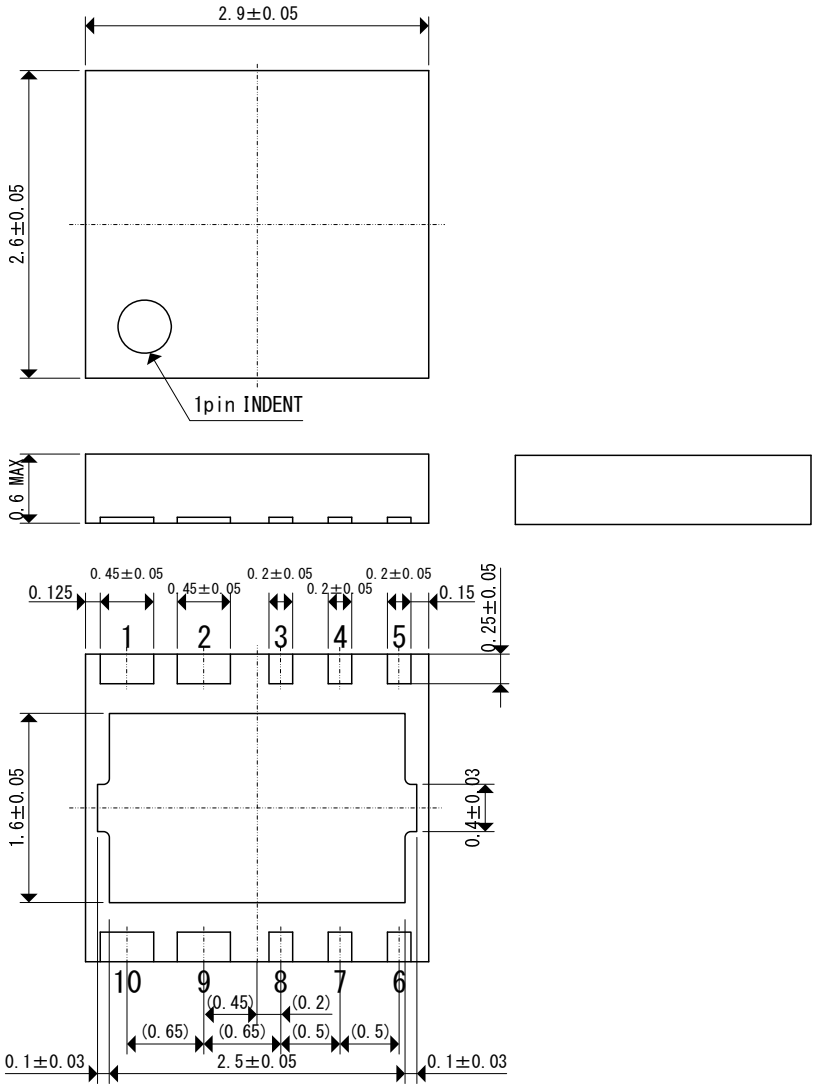
Board Mount (Tjmax = 125℃)

Ambient Temperature (℃)	Power Dissipation Pd (mW)	Thermal Resistance (℃/W)
25	1000	100.00
85	400	

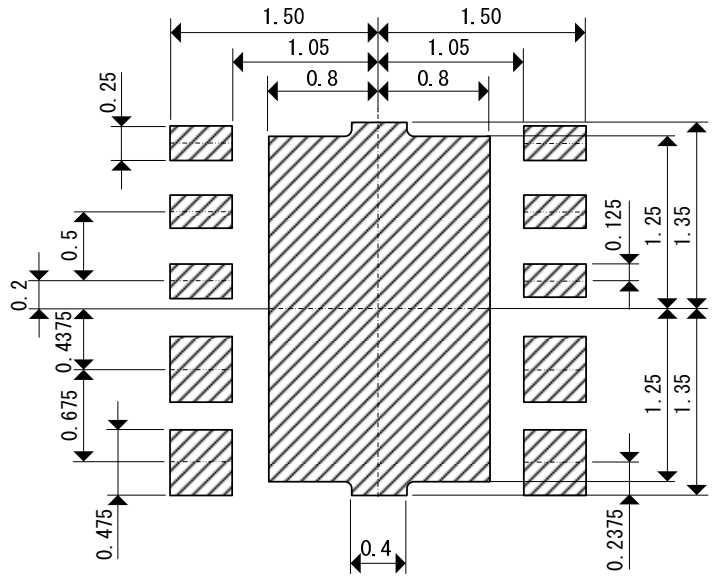


■PACKAGING INFORMATION

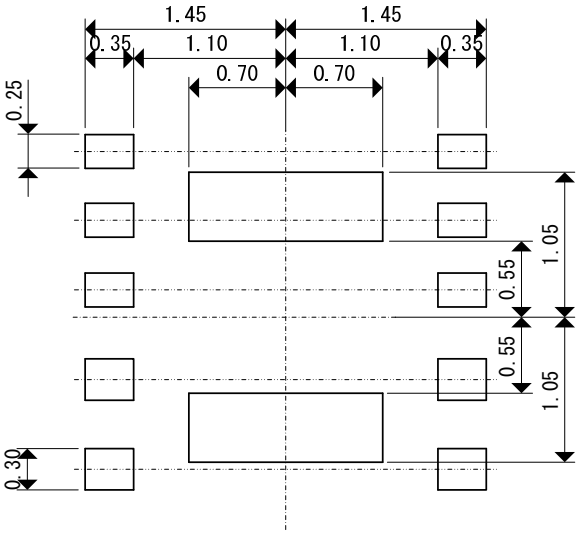
●USP-10B (unit: mm)



●USP-10B Reference Pattern Layout (unit: mm)

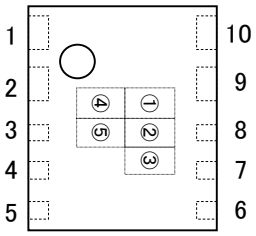


●USP-10B Reference Metal Mask Design (unit: mm)



■MARKING RULE

●USP-10B



① represents product series

MARK	PRODUCT SERIES
2	XD9242******-Q
D	XD9243******-Q

② represents product function

MARK	FUNCTION	PRODUCT SERIES
B	C_L High Speed Discharge	XD924*B*****-Q

③ represents oscillation frequency

MARK	OSCILLATION FREQUENCY (MHz)	PRODUCT SERIES
C	1.2	XD924*B**C**-Q
D	2.4	XD924*B**D**-Q

④,⑤ represents production lot number
01 to 09, 0A to 0Z, A1 to A9, AA to AZ, B1 to ZZ repeated
(G, I, J, O, Q, W excluded)
*No character inversion used.

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3. Applicable export control laws and regulations should be complied and the procedures required by such laws and regulations should also be followed, when the product or any information contained in this datasheet is exported.
4. The product is neither intended nor warranted for use in equipment of systems which require extremely high levels of quality and/or reliability and/or a malfunction or failure which may cause loss of human life, bodily injury, serious property damage including but not limited to devices or equipment used in 1) nuclear facilities, 2) aerospace industry, 3) medical facilities, 4) automobile industry and other transportation industry and 5) safety devices and safety equipment to control combustions and explosions, excluding when specified for in-vehicle use or other uses.
   Do not use the product for in-vehicle use or other uses unless agreed by us in writing in advance.
5. Although we make continuous efforts to improve the quality and reliability of our products; nevertheless Semiconductors are likely to fail with a certain probability. So in order to prevent personal injury and/or property damage resulting from such failure, customers are required to incorporate adequate safety measures in their designs, such as system fail safes, redundancy and fire prevention features.
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7. Please use the product listed in this datasheet within the specified ranges.
8. We assume no responsibility for damage or loss due to abnormal use.
9.

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