XC9140 Series

Step-Up Synchronous PFM DC/DC Converter

GENERAL DESCRIPTION

GreenOperation Compatible

The XC9140 series are step-up synchronous DC/DC converters that support ceramic capacitors and have an internal 0.6Ω (TYP.) Nch driver transistor and an internal 0.65Ω (TYP.) Pch synchronous rectifier switch transistor. PFM control enables a low quiescent current, making these products ideal for portable devices that require high efficiency.

When the output voltage is 3.3V and the load current is 1mA, startup from an input voltage of V_{IN}=0.9V is possible which means that the XC9140 can be used in applications that start from a single alkaline or nickel-metal hydride battery. The output voltage can be set from 1.8V to 5.0V (±2.0%) in steps of 0.1V.

The XC9140 features a load disconnect function to break continuity between the input and output at shutdown (XC9140A), and also a bypass mode function to maintain continuity between the input and output (XC9140C).

A version with a UVLO (Under Voltage Lock-Out) function will also be available (currently under development) which enables the prevention of battery leakage by stopping the IC's operation when the input voltage is low. The standard product will have a UVLO release voltage of 2.15V (±3.0%) and a custom version with a UVLO release voltage selectable from between 1.65V to 2.2V, in steps of 0.1V, will also be made available.
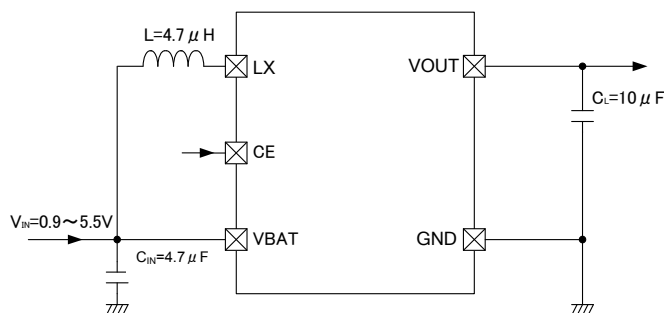
APPLICATIONS

Mouses, Keyboards
Bluetooths
Household use Medical equipments
Remote controls
Game consoles
Devices with 1~3 Alkaline, 1~3 Nickel Hydride,
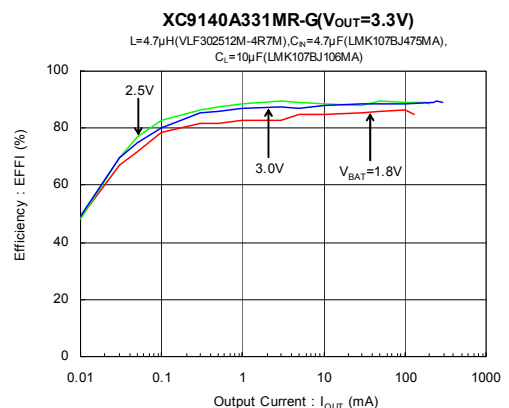1 Lithium and 1 Li-ion

FEATURES

Input Voltage Range	:	0.9V~5.5V
Output Voltage Setting	:	1.8V~5.0V (±2.0%) 0.1V increments
Output Current	:	100mA V_{OUT}=3.3V, V_{BAT}=1.8V (TYP.)
Driver Transistor	:	0.6Ω Nch driver transistor
		0.65Ω Pch synchronous rectifier switch transistor
Supply Current	:	6.3μ A (V_{BAT}=V_{OUT}+0.5V)
Control Method	:	PFM Control
High speed transient response	:	50mV@V_{OUT}=3.3V, V_{BAT}=1.8V, I_{OUT}=1→50mA
PFM Switching Current	:	350mA
Functions	:	Load Disconnection Function or
		Bypass Mode Function
		UVLO * Under development
		Ceramic Capacitor
Operating Ambient Temperature	:	-40 +85
Packages	:	SOT-25, USP-6EL
Environmentally Friendly	:	EU RoHS Compliant, Pb Free

TYPICAL APPLICATION CIRCUIT

■TYPICAL PERFORMANCE CHARACTERISTICS

Efficiency vs. Output Current

XC9140A331MR-G(V_{OUT}=3.3V)
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

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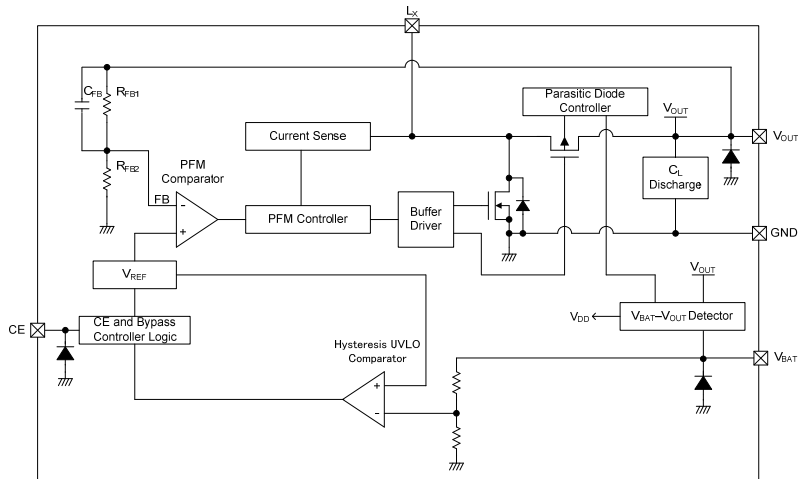
* Diodes inside the circuits are ESD protection diodes and parasitic diodes.

The XC9140A /XC9140C series do not have the C_L discharge function.

The XC9140Axx1/XC9140Cxx1 series do not have the UVLO function.

PRODUCT CLASSIFICATION

Ordering Information

XC9140　　　　　-

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
① (*1)	Product Type	A	Load Disconnection Without C_L Auto Discharge
		C	V_{BAT} Bypass Without C_L Auto Discharge
②③ (*2)	Output Voltage	18　50	Output Voltage e.g. V_{OUT}=3.3V　②=3, ③=3
④	UVLO Function	1	No UVLO
		2	V_{UVLO_R}=2.15V (TBD) * Under development
⑤⑥‐⑦ (*3)	Packages (Order Unit)	4R-G	USP-6EL (3,000/Reel)
		MR-G	SOT-25 (3,000/Reel)

(*1) The product with the C_L discharge function is a semi-custom product.

(*2) V_{OUT}=3.3V is standard.

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

■PIN CONFIGURATION

SOT-25
(TOP VIEW)
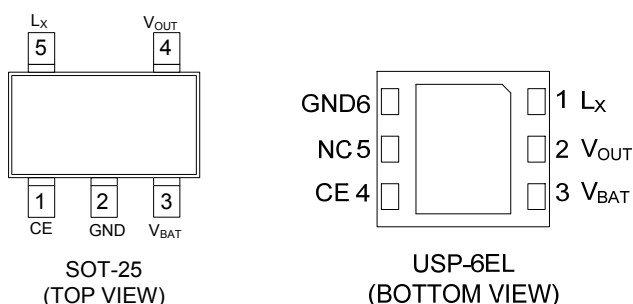
USP-6EL
(BOTTOM VIEW)

> * The dissipation pad for the USP-6EL package should be solder-plated in recommended mount pattern and metal masking so as to enhance mounting strength and heat release.
> The mount pattern should be connected to GND pin (No.6).

PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTIONS
USP-6EL	SOT-25		
1	5	L_X	Switching
2	4	V_{OUT}	Output Voltage
3	3	V_{BAT}	Power Input
4	1	CE	Chip Enable
5	-	NC	No Connection
6	2	GND	Ground

CE PIN FUNCTION

PIN NAME	SIGNAL	STATUS
CE	H	Active (All Series)
	L	Stand-by (XC9140A Series) or Bypass Mode (XC9140C Series)

* Please do not leave the CE pin open.

■ABSOLUTE MAXIMUM RATINGS

Ta=25°C

PARAMETER		SYMBOL	RATINGS	UNITS
BAT Pin Voltage		V_{BAT}	-0.3 ~ +7.0	V
L_X Pin Voltage		V_{LX}	-0.3 ~ V_{OUT}+0.3 or +7.0 [(*1)]	V
V_{OUT} Pin Voltage		V_{OUT}	-0.3 ~ +7.0	V
CE Pin Voltage		V_{CE}	-0.3 ~ +7.0	V
L_X Pin Current		I_{LX}	700	mA
Power Dissipation	SOT-25	Pd	250	mW
	USP-6EL		120	
Operating Ambient Temperature		Topr	-40 ~ +85	°C
Storage Temperature		Tstg	-55 ~ +125	°C

* All voltages are described based on the GND.

[(*1)] The maximum value should be either V_{OUT}+0.3 or +7.0 or in the lowest.

ELECTRICAL CHARACTERISTICS

XC9140Axx1 Type, without UVLO function, without C_L discharge function

Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
Input Voltage	V_{BAT}	-	-	-	5.5	V	-
Output Voltage	$V_{OUT(E)}$ [*2]	V_{PULL}=1.5V, Voltage to start oscillation while V_{OUT} is decreasing	E1			V	①
Operation Start Voltage	V_{ST1}	I_{OUT}=1mA	-	-	0.9	V	②
Operation Hold Voltage	V_{HLD}	R_L=1kΩ	-	0.7	-	V	②
Supply Current	Iq	Oscillation stops, V_{OUT}=$V_{OUT(T)}$+0.5V [*1]	E2			μA	③
Input Pin Current	I_{BAT}	V_{OUT}=$V_{OUT(T)}$+0.5V [*1]	-	0.25	1.0	μA	③
Stand-by Current	I_{STB}	V_{BAT}=V_{LX}=$V_{OUT(T)}$ [*1], V_{OUT}=V_{CE}=0V	-	0.1	1.0	μA	④
L_X Leak Current	I_{LXL}	V_{BAT}=V_{LX}=$V_{OUT(T)}$ [*1], V_{OUT}=V_{CE}=0V	-	0.1	1.0	μA	⑤
PFM Switching Current	I_{PFM}	I_{OUT}=3mA	295	350	405	mA	②
Maximum ON Time	t_{ONMAX}	V_{PULL}=1.5V, V_{OUT}=$V_{OUT(T)}$×0.98V [*1]	3.1	4.6	6.0	μs	①
Efficiency [*3]	EFFI	V_{BAT}=V_{CE}=1.8V, $V_{OUT(T)}$ [*1]=2.5V, I_{OUT}=30mA	-	81	-	%	②
Efficiency [*3]	EFFI	V_{BAT}=V_{CE}=1.8V, $V_{OUT(T)}$ [*1]=3.3V, I_{OUT}=30mA	-	85	-	%	②
Efficiency [*3]	EFFI	V_{BAT}=V_{CE}=1.8V, $V_{OUT(T)}$ [*1]=5.0V, I_{OUT}=30mA	-	86	-	%	②
LX SW "Pch" ON Resistance [*4]	R_{LXP}	V_{BAT}=V_{LX}=V_{CE}=$V_{OUT(T)}$+0.5V [*1], I_{OUT}=200mA	E3			Ω	⑦
LX SW "Nch" ON Resistance [*5]	R_{LXN}	V_{BAT}=V_{CE}=3.3V, V_{OUT}=1.7V	-	0.6	-	Ω	⑧
CE "High" Voltage	V_{CEH}	V_{BAT}=V_{PULL}=1.5V, V_{OUT}=$V_{OUT(T)}$×0.98V [*1] While V_{CE}=0.3→0.75V, Voltage to start oscillation	0.75	-	5.5	V	①
CE "Low" Voltage	V_{CEL}	V_{BAT}=V_{PULL}=1.5V, V_{OUT}=$V_{OUT(T)}$×0.98V [*1] While V_{CE}=0.75→0.3V, Voltage to stop oscillation	GND	-	0.3	V	①
CE "High" Current	I_{CEH}	V_{BAT}=V_{CE}=V_{LX}=V_{OUT}=5.5V	-0.1	-	0.1	μA	①
CE "Low" Current	I_{CEL}	V_{BAT}=V_{LX}=V_{OUT}=5.5V, V_{CE}=0V	-0.1	-	0.1	μA	①

Unless otherwise stated, V_{BAT}=V_{CE}=1.5V

[*1] $V_{OUT(T)}$=Nominal Output Voltage

[*2] $V_{OUT(E)}$=Effective Output Voltage

    The actual output voltage value $V_{OUT(E)}$ is the PFM comparator threshold voltage in the IC.

    Therefore, the DC/DC circuit output voltage, including the peripheral components, is boosted by the ripple voltage average value.

    Please refer to the characteristic example.

[*3] EFFI=[{ (Output Voltage)×(Output Current)] / [(Input Voltage)×(Input Current)}]×100

[*4] LX SW "Pch" ON resistance=(V_{LX}-V_{OUT} pin measurement voltage) / 200mA

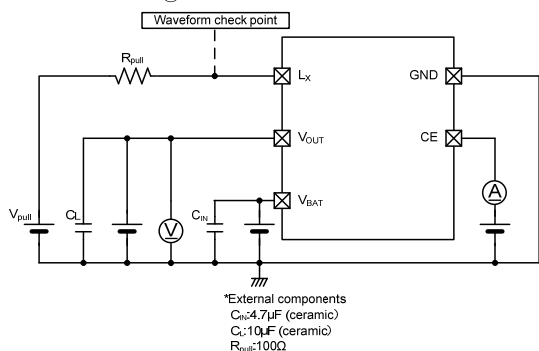[*5] The LX SW "Nch" ON resistance measurement method is shown in the measurement circuit diagram.
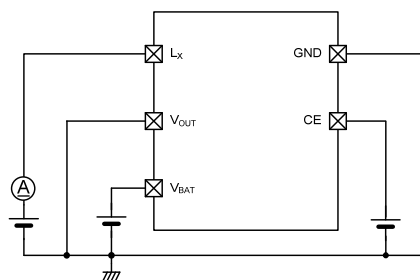
■ELECTRICAL CHARACTERISTICS (Continued)

XC9140Cxx1 Type, without UVLO function, without C_L discharge function

Ta=25˚C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
Input Voltage	V_{BAT}		-	-	5.5	V	-
Output Voltage	$V_{OUT(E)}$ [*2]	V_{PULL}=1.5V, Voltage to start oscillation while V_{OUT} is decreasing		E1		V	①
Operation Start Voltage	V_{ST1}	I_{OUT}=1mA	-	-	0.9	V	②
Operation Hold Voltage	V_{HLD}	R_L=1kΩ	-	0.7	-	V	②
Supply Current	Iq	Oscillation stops, V_{OUT}=$V_{OUT(T)}$+0.5V [*1]		E2		μA	③
Input Pin Current	I_{BAT}	V_{OUT}=$V_{OUT(T)}$+0.5V [*1]	-	0.25	1.0	μA	③
Bypass Mode Current	I_{BYP}	V_{BAT}=V_{LX}=5.5V, V_{CE}=0V	-	3.5	6.1	μA	⑥
PFM Switching Current	I_{PFM}	I_{OUT}=3mA	295	350	405	mA	②
Maximum ON Time	t_{ONMAX}	V_{PULL}=1.5V, V_{OUT}=$V_{OUT(T)}$×0.98V [*1]	3.1	4.6	6.0	μs	①
Efficiency [*3]	EFFI	V_{BAT}=V_{CE}=1.8V, $V_{OUT(T)}$ [*1]=2.5V, I_{OUT}=30mA	-	81	-	%	②
Efficiency [*3]	EFFI	V_{BAT}=V_{CE}=1.8V, $V_{OUT(T)}$ [*1]=3.3V, I_{OUT}=30mA	-	85	-	%	②
Efficiency [*3]	EFFI	V_{BAT}=V_{CE}=1.8V, $V_{OUT(T)}$ [*1]=5.0V, I_{OUT}=30mA	-	86	-	%	②
LX SW "Pch" ON Resistance [*4]	R_{LXP}	V_{BAT}=V_{LX}=V_{CE}=$V_{OUT(T)}$+0.5V [*1], I_{OUT}=200mA		E3		Ω	⑦
LX SW "Nch" ON Resistance [*5]	R_{LXN}	V_{BAT}=V_{CE}=3.3V, V_{OUT}=1.7V	-	0.6	-	Ω	⑧
CE "High" Voltage	V_{CEH}	V_{BAT}=V_{PULL}=1.5V, V_{OUT}=$V_{OUT(T)}$×0.98V [*1] While V_{CE}=0.3→0.75V, Voltage to start oscillation	0.75	-	5.5	V	①
CE "Low" Voltage	V_{CEL}	V_{BAT}=V_{PULL}=1.5V, V_{OUT}=$V_{OUT(T)}$×0.98V [*1] While V_{CE}=0.75→0.3V, Voltage to stop oscillation	GND	-	0.3	V	①
CE "High" Current	I_{CEH}	V_{BAT}=V_{CE}=V_{LX}=V_{OUT}=5.5V	-0.1	-	0.1	μA	①
CE "Low" Current	I_{CEL}	V_{BAT}=V_{LX}=V_{OUT}=5.5V, V_{CE}=0V	-0.1	-	0.1	μA	①

Unless otherwise stated, V_{BAT}=V_{CE}=1.5V

[*1] $V_{OUT(T)}$=Nominal Output Voltage

[*2] $V_{OUT(E)}$=Effective Output Voltage

The actual output voltage value $V_{OUT(E)}$ is the PFM comparator threshold voltage in the IC.

Therefore, the DC/DC circuit output voltage, including the peripheral components, is boosted by the ripple voltage average value.

Please refer to the characteristic example.

[*3] EFFI={[(Output Voltage)×(Output Current)] / [(Input Voltage)×(Input Current)]}×100

[*4] LX SW "Pch" ON resistance=(V_{LX}-V_{OUT} pin measurement voltage) / 200mA

[*5] The LX SW "Nch" ON resistance measurement method is shown in the measurement circuit diagram.

■ELECTRICAL CHARACTERISTICS (Continued)

XC9140 Voltage Chart 1

SYMBOL	E1		E2		E3	
PARAMETER	OUTPUT VOLTAGE		SUPPLY CURRENT		LX SW "Pch" ON RESISTANCE	
UNITS: V	UNITS: V		UNITS: μA		UNITS: Ω	
OUTPUT VOLTAGE	MIN.	MAX.	TYP.	MAX.	TYP.	MAX.
1.8	1.764	1.836				
1.9	1.862	1.938				
2.0	1.960	2.040	6.1	9.4	0.84	1.08
2.1	2.058	2.142				
2.2	2.156	2.244				
2.3	2.254	2.346				
2.4	2.352	2.448				
2.5	2.450	2.550				
2.6	2.548	2.652	6.2	9.7	0.75	0.97
2.7	2.646	2.754				
2.8	2.744	2.856				
2.9	2.842	2.958				
3.0	2.940	3.060				
3.1	3.038	3.162				
3.2	3.136	3.264	6.3	10.0	0.65	0.85
3.3	3.234	3.366				
3.4	3.332	3.468				
3.5	3.430	3.570				
3.6	3.528	3.672				
3.7	3.626	3.774	6.4	10.2	0.61	0.78
3.8	3.724	3.876				
3.9	3.822	3.978				
4.0	3.920	4.080				
4.1	4.018	4.182				
4.2	4.116	4.284	6.5	10.4	0.57	0.74
4.3	4.214	4.386				
4.4	4.312	4.488				
4.5	4.410	4.590				
4.6	4.508	4.692				
4.7	4.606	4.794	6.7	10.7	0.53	0.72
4.8	4.704	4.896				
4.9	4.802	4.998				
5.0	4.900	5.100				

■TEST CIRCUITS

< Test Circuit No.① >

*External components
C$_{IN}$:4.7μF (ceramic)
C$_L$:10μF (ceramic)
R$_{pull}$:100Ω

< Test Circuit No.⑤ >

< Test Circuit No.② >

*External components
L: 4.7μH
C$_{IN}$:4.7μF (ceramic)
C$_L$:10μF (ceramic)
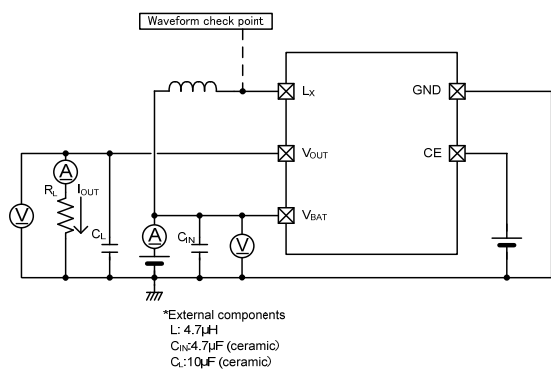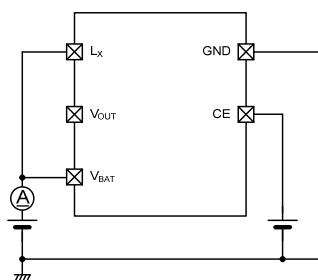
< Test Circuit No.⑥ >

< Test Circuit No.③ >

< Test Circuit No.⑦ >

*External components
C$_{IN}$:4.7μF (ceramic)
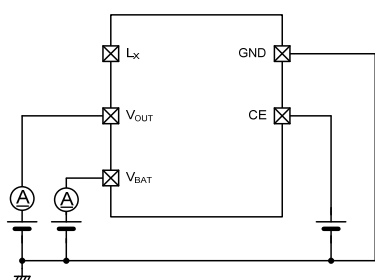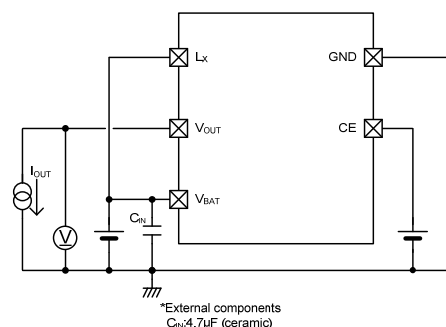
< Test Circuit No.④ >

< Test Circuit No.⑧ >

*External components
C$_{IN}$:4.7μF (ceramic)
C$_L$:10μF (ceramic)
R$_{pull}$:4.7Ω

<L$_X$ SW "Nch" ON Resistance Measurement Method>
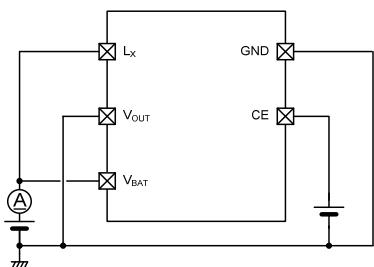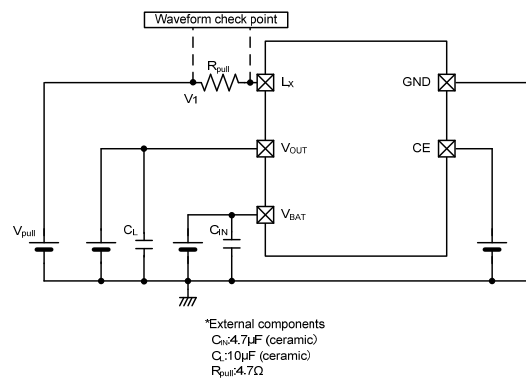
Use Test Circuit No.8 to adjust V$_{pull}$ so that the L$_X$ pin voltage becomes 100mV when the Nch drive Tr is ON and then the voltage at both ends of R$_{pull}$ is measured to find the Lx SW "Nch" ON resistance.

$$R_{LXN}=0.1 / \{(V1 - 0.1) / 4.7)\}$$

Note that V1 is the R$_{pull}$ previous voltage when the Nch driver Tr is ON. Use an oscilloscope or other instrument to measure the L$_X$ pin voltage and V1.

■TYPICAL APPLICATION CIRCUIT
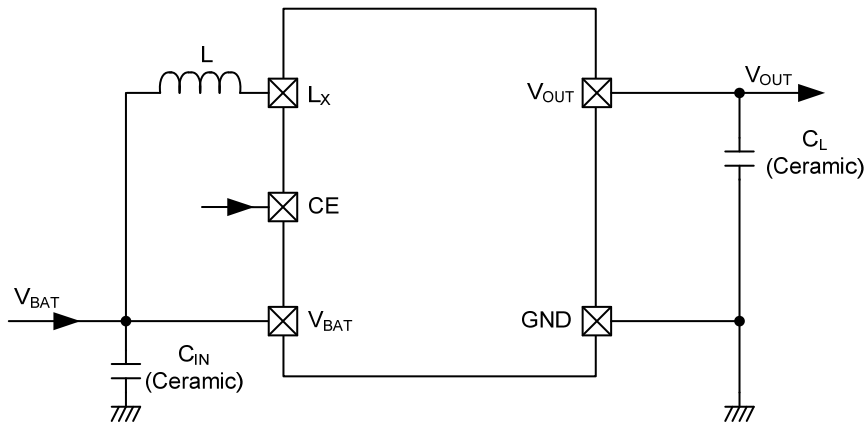
【Reference External Components】

	MANUFACTURE	PRODUCT NUMBER	VALUE
L	TDK	VLF302512M-4R7	4.7μH
C_{IN}	TAIYO YUDEN	LMK107BJ475MA	4.7μF/10V
C_L	TAIYO YUDEN	LMK107BJ106MA	10μF/10V

* When selecting components, take into consideration capacitance reduction, voltage, etc.

* The characteristics are dependent on the variation in the coil inductance value, so check these carefully in the actual product.

* A coil inductance value of 4.7 to 10.0μH can be used, but using 4.7μH is recommended.

* The ripple voltage will increase if tantalum or electrolytic capacitors are used for the load capacitor C_L. The operation could also become unstable, so carefully check this in the actual product.

■OPERATIONAL EXPLANATION

The XC9140 Series consists of a standard voltage source, a PFM comparator, a Nch driver Tr, a Pch synchronous rectifier switch Tr, a current sense circuit, a PFM control circuit and a CE control circuit, etc. (refer to the block diagram below.)
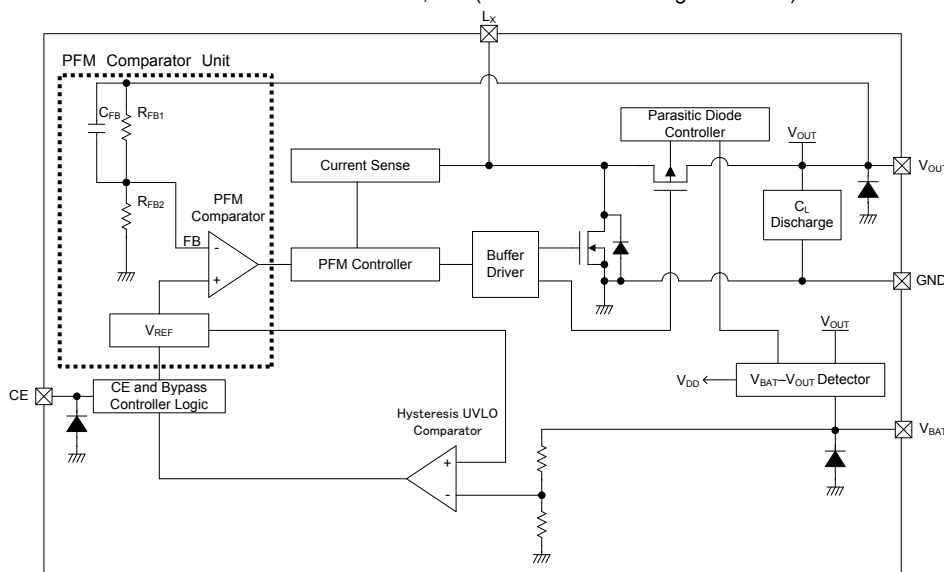
Current limit PFM control is used for the control method to make it difficult for the output voltage ripple to increase even when the switching current is superimposed, so the product can be used within a wide voltage and current range. Further, because PFM control is used, it has excellent transient response to support low capacity ceramic capacitors to realize a compact, high-performance boost DC/DC converter.
The synchronous driver and rectifier switch Tr efficiently sends the coil energy to the capacitor connected to the V_{OUT} pin to achieve highly efficient operation from low to high loads.

The electrical characteristics actual output voltage $V_{OUT(E)}$ is the PFM comparator threshold voltage shown in the block diagram. Therefore, the booster circuit output voltage average value, including the peripheral components, depends on the ripple voltage, so this must be carefully evaluated before being used in the actual product.
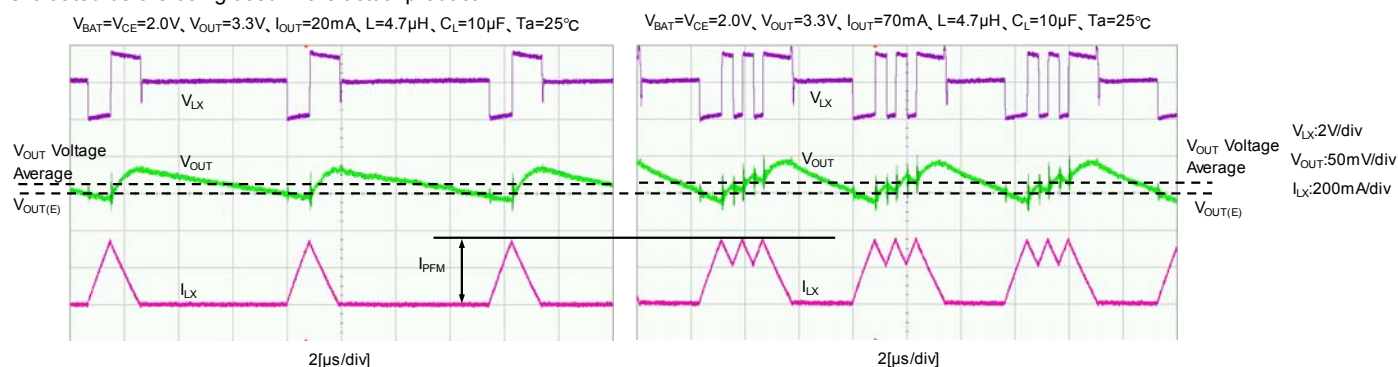
< Reference Voltage Source (V_{REF})>
The reference voltage source (V_{REF} voltage) provides the reference voltage to ensure stable output voltage of the DC/DC converter.

< PFM Control >
①The voltage from the output voltage divided by the division resistors R_{FB1} and R_{FB2} in the IC is used as feedback voltage (FB voltage), and the PFM comparator is compared with the FB voltage and V_{REF}. If the FB voltage is lower than V_{REF}, the signal is sent to the buffer driver via the PFM control circuit and the Nch driver Tr is turned ON. If the FB voltage is higher than V_{REF}, the PFM comparator sends a signal that does not turn ON the Nch driver Tr.
②The current sense circuit monitors the current flowing in the Nch driver Tr connected to the Lx pin when the Nch driver Tr is ON. When the prescribed PFM switching current (I_{PFM}) is reached, the signal is sent to the buffer driver via the PFM control circuit to turn OFF the Nch driver Tr and turn ON the Pch synchronous rectifier switch Tr.
③The Pch synchronous rectifier switch Tr ON time (off time) is dynamically optimized internally. After the off time has passed, when the PFM comparator confirms the V_{OUT} voltage has exceeded the set voltage, a signal that does not allow the Nch driver Tr to be turned on is sent from the PFM comparator to the PFM control circuit, but if the V_{OUT} voltage remains lower than the set voltage, then Nch driver Tr ON is started.
The intervals of the above ①②③ linked operations are continuously adjusted in response to the load current to ensure the output voltage is kept stable from low to high loads and that it is done with good efficiency.

■ OPERATIONAL EXPLANATION (Continued)

<PFM Switching Current>

The PFM switching current unit monitors the current flowing in the Nch driver Tr and functions to limit the current flowing in the Nch driver Tr, but if the load current becomes much larger than the PFM switching energy, the V_{OUT} voltage becomes lower and prevents the coil current in the Nch driver Tr OFF period from lowering, which affects the internal circuit delay time and results in an excessive current that is larger than the PFM switching current flowing in the Nch driver Tr and Pch synchronous rectifier switch Tr.

<Load Disconnection Function, Bypass Mode>

When a "L" voltage is input to the CE pin, the XC9140A type enters into standby mode and the XC9140C type enters into bypass mode to stop the circuit required for the boost operation.

In the standby mode the load cut-off function operates and both the Nch driver Tr and Pch synchronous rectifier switch Tr are turned OFF, which cuts off the current to the L_X pin and V_{OUT} pin and the parasitic diode control circuit connects the parasitic diode cathode of the Pch synchronous rectifier switch Tr to the L_X pin ①. In the bypass mode the Nch driver Tr is OFF, the Pch synchronous rectifier switch Tr is ON when $V_{LX} > V_{OUT}$, and the parasitic diode control circuit connects the parasitic diode cathode of the Pch synchronous rectifier switch Tr to the V_{OUT} pin ②. Also, when $V_{LX} <$ V_{OUT}, the Pch synchronous rectifier switch Tr is turned OFF and the parasitic diode cathode is connected to the V_{OUT} pin ②.

Note: Except for the moment when the V_{BAT} voltage is input.
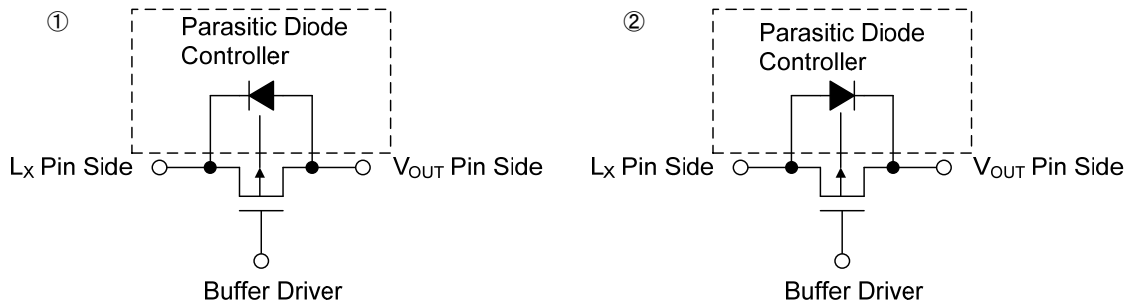
< V_{BAT}-V_{OUT} Voltage Detection Circuit>

The V_{BAT}-V_{OUT} voltage detection circuit compares the V_{BAT} pin voltage with the V_{OUT} pin voltage, and whichever is the highest is operated to become the IC power supply (V_{DD}).

In addition, if, during normal operation, the input voltage becomes higher than the output voltage, the Nch driver Tr is turned OFF and the Pch synchronous rectifier switch Tr is kept ON so that the input voltage pass through to the output voltage (through mode). When the input voltage becomes lower than the output voltage, the circuit automatically returns to the normal boost operation. This detection circuit does not operate when in the standby mode.

<UVLO>

With the XC9140 Series an optional UVLO function (under development) can be selected. When the V_{BAT} pin voltage drops below the UVLO detection voltage, the IC stops switching operation. In addition, when the V_{BAT} pin voltage recovers to above the UVLO release voltage, the IC begins operating again.

<C_L Discharge Function>

With the XC9140 Series an optional C_L discharge function (under development) can be selected. This function uses the Nch Tr connected between V_{OUT} and GND to discharge, at high speed, the load capacity C_L charge when the "L" voltage is input to the CE pin (when in the IC standby mode). This is done to prevent malfunction of the application caused by a residual charge in C_L when the IC is stopped. The discharge time is determined by the C_L discharge resistance R_{DCHG}, including the Nch Tr, and C_L. The constant $\tau = C_L \times R_{DCHG}$ is determined at this time, and the following formula is used to find the output voltage discharge time. However, the C_L discharge resistance R_{DCHG} varies depending on the V_{BAT} or V_{OUT} voltage, so the discharge time cannot be determined easily. Therefore, carefully check this in the actual product.

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

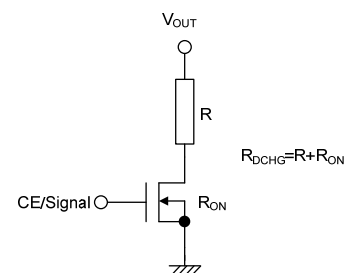V: Output voltage after discharge

V_{OUT}: Output voltage

t: Discharge time

τ : $C_L \times R_{DCHG}$

C_L: Capacity value of the load capacitor (C_L)

R_{DCHG}: Low resistance value of the C_L discharge resistance.

However, this changes depending on the voltage.

$$R_{DCHG} = R + R_{ON}$$

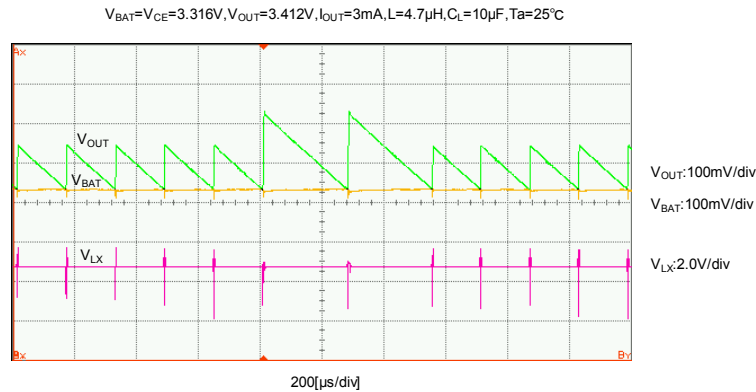The XC9140A/ XC9140C series do not have a C_L discharge function as standard.

■NOTE ON USE

1. Be careful not to exceed the absolute maximum ratings for externally connected components and this IC.

2. The DC/DC converter characteristics greatly depend not only on the characteristics of this IC but also on those of externally connected components, so refer to the specifications of each component and be careful when selecting the components. Be especially careful of the characteristics of the capacitor used for the load capacity C_L and use a capacitor with B characteristics (JIS Standard) or an X7R/X5R (EIA Standard) ceramic capacitor.

3. Use a ground wire of sufficient strength. Ground potential fluctuation caused by the ground current during switching could cause the IC operation to become unstable, so reinforce the area around the GND pin of the IC in particular.

4. Mount the externally connected components in the vicinity of the IC. Also use short, thick wires to reduce the wire impedance.

5. An excessive current that is larger than the PFM switching current flowing in the Nch driver Tr and Pch synchronous rectifier switch Tr, which could destroy the IC.

6. When in the bypass mode, the internal Pch synchronous rectifier switch Tr turns ON to allow current to flow to the Lx pin and V_{OUT} pin. When an excessive current comes from the V_{OUT} pin when this bypass operates, it could destroy the Pch synchronous rectifier switch Tr.

7. The CE pin does not have an internal pull-up or pull-down, etc. Apply the prescribed voltage to the CE pin.

8. The coil inductance value applicable range is 4.7μH to 10μH, but 4.7μH is recommended because at this value the coil size and DC/DC performance are optimized. If you want to use another inductance value other than 4.7μH but which is in the above applicable range, be sure to carefully evaluate it first before use.

9. At high temperatures, the product performance could vary causing the efficiency to decline. Evaluate this carefully before use if the product will be used at high temperatures.

10. Please note that the leak current of the Pch synchronous rectifier switch Tr during high-temperature standby operation could cause the output voltage to increase.

11. The output voltage ripple effect from the load current causes the output voltage average value to fluctuate, so carefully evaluate this in the actual product before use.

12. When the booster circuit is activated by a low input voltage, during the time until the output voltage reaches about 1.7V, the PFM switching current function might not operate causing the coil current to be superimposed. (See the figure below.)
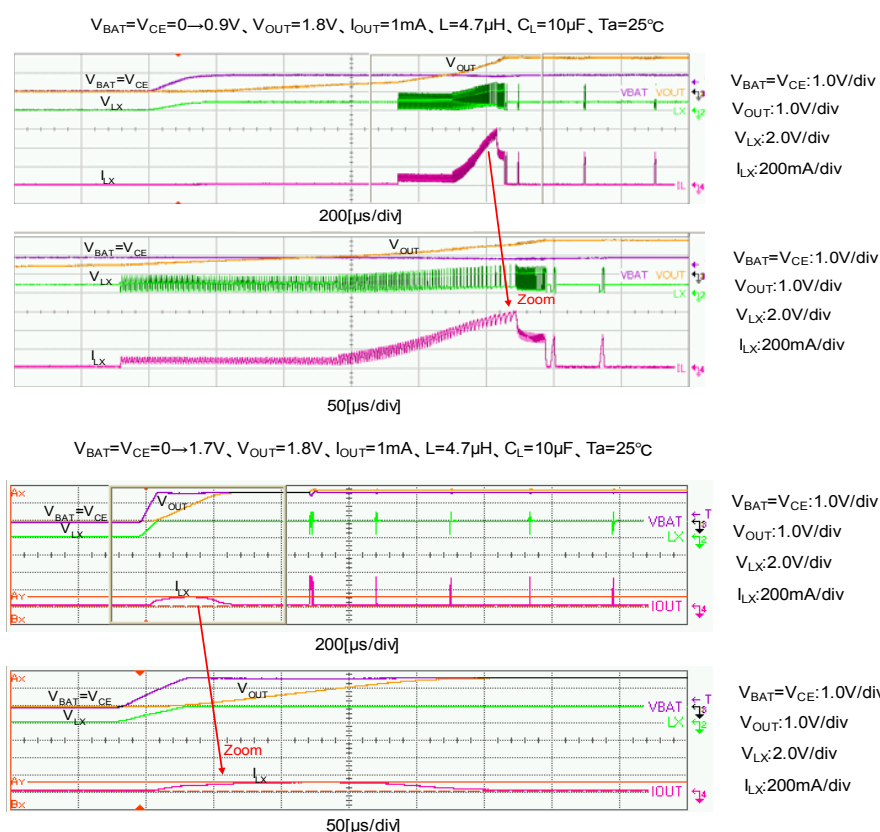
■NOTE ON USE (Continued)

13. If the C_L capacity or load current becomes excessively large, the output voltage start-up time, when the power is turned on, will increase, so the coil current might be superimposed during the time it takes for the output voltage to become sufficiently higher than the V_{BAT} voltage.

14. If the input voltage is higher than the output voltage, then the circuit automatically enters the through mode. When the input voltage becomes close to the output voltage, there could be repeated switching between the boost mode and through mode causing the ripple voltage to fluctuate. (Refer to the graphic below)

$V_{BAT}=V_{CE}=3.316V, V_{OUT}=3.412V, I_{OUT}=3mA, L=4.7\mu H, C_L=10\mu F, Ta=25°C$

V_{OUT}:100mV/div
V_{BAT}:100mV/div
V_{LX}:2.0V/div

200[μs/div]

15. If a different power supply is connected from an external source to the XC9140A/XC9140C, the IC could be destroyed.

16. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.

17. 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)

●Instructions of pattern layouts

1. In order to stabilize V_{BAT} voltage level, we recommend that a by-pass capacitor (C_{IN}) be connected as close as possible to the V_{BAT} and ground 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 ground 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. Internal driver transistors bring on heat because of the transistor current and ON resistance of the driver transistors.

●Recommended Pattern Layout (SOT-25)
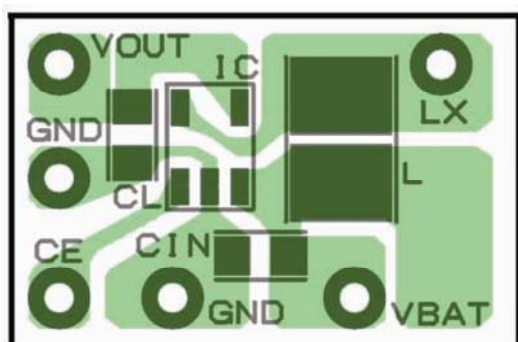
FRONT
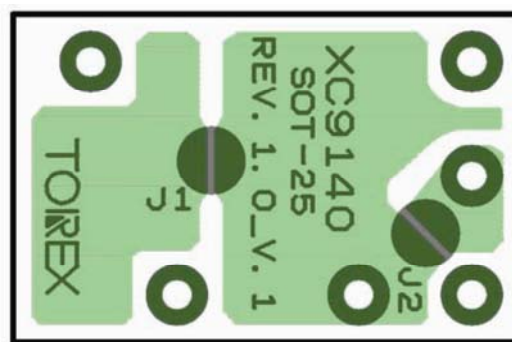
BACK

●Recommended Pattern Layout (USP-6EL)
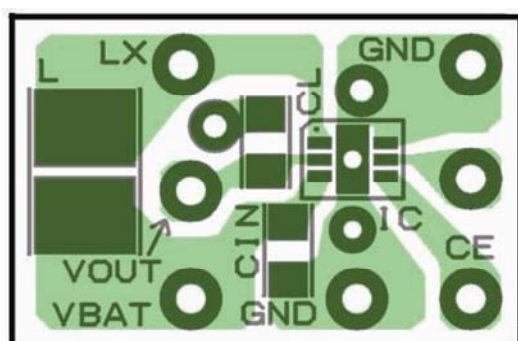
FRONT
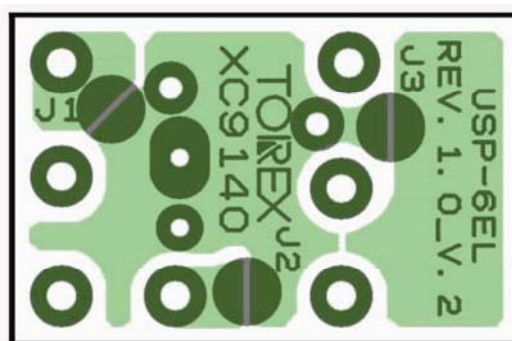
BACK

■TYPICAL PERFORMANCE CHARACTERISTICS

(1) Efficiency vs. Output Current

XC9140A331MR-G(V$_{OUT}$=3.3V)
L=4.7μH(VLF302512M-4R7M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)

XC9140A331MR-G(V$_{OUT}$=3.3V)
L=10μH(VLF302512M-100M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)

XC9140A501MR-G(V$_{OUT}$=5.0V)
L=4.7μH(VLF302512M-4R7M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)

XC9140A501MR-G(V$_{OUT}$=5.0V)
L=10μH(VLF302512M-100M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)

(2) Output Voltage vs. Output Current

XC9140A331MR-G(V$_{OUT}$=3.3V)
L=4.7μH(VLF302512M-4R7M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)

XC9140A331MR-G(V$_{OUT}$=3.3V)
L=10μH(VLF302512M-100M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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

XC9140A501MR-G(V_{OUT}=5.0V)
L=4.7µH(VLF302512M-4R7M),C_{IN}=4.7µF(LMK107BJ475MA),
C_L=10µF(LMK107BJ106MA)

XC9140A501MR-G(V_{OUT}=5.0V)
L=10µH(VLF302512M-100M),C_{IN}=4.7µF(LMK107BJ475MA),
C_L=10µF(LMK107BJ106MA)
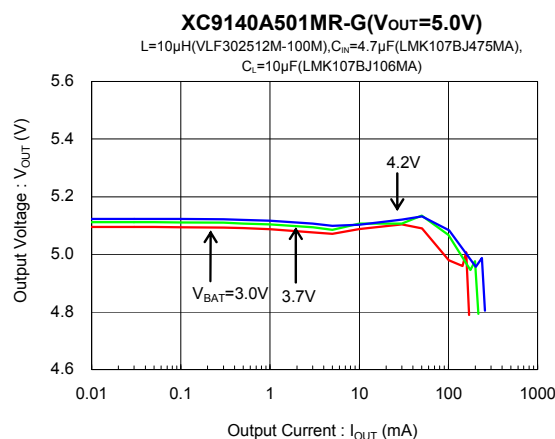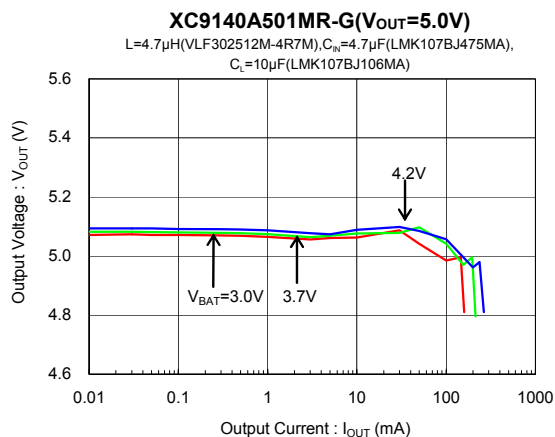
(3) Ripple Voltage vs. Output Current

XC9140A331MR-G(V_{OUT}=3.3V)
L=4.7µH(VLF302512M-4R7M),C_{IN}=4.7µF(LMK107BJ475MA),
C_L=10µF(LMK107BJ106MA)

XC9140A331MR-G(V_{OUT}=3.3V)
L=10µH(VLF302512M-100M),C_{IN}=4.7µF(LMK107BJ475MA),
C_L=10µF(LMK107BJ106MA)

XC9140A501MR-G(V_{OUT}=5.0V)
L=4.7µH(VLF302512M-4R7M),C_{IN}=4.7µF(LMK107BJ475MA),
C_L=10µF(LMK107BJ106MA)

XC9140A501MR-G(V_{OUT}=5.0V)
L=10µH(VLF302512M-100M),C_{IN}=4.7µF(LMK107BJ475MA),
C_L=10µF(LMK107BJ106MA)
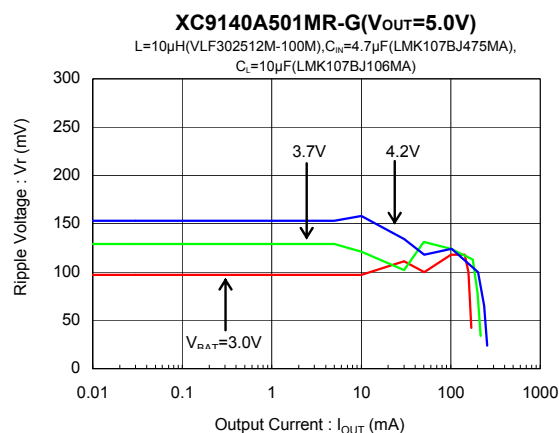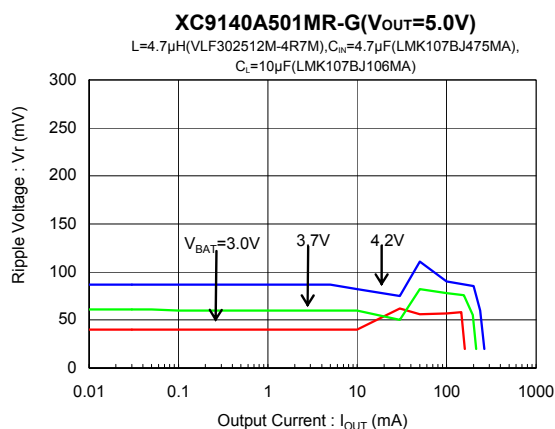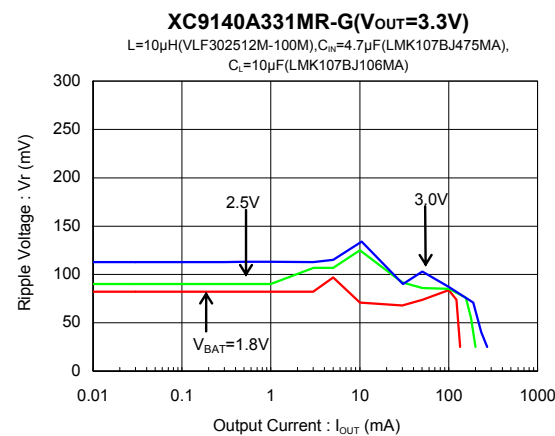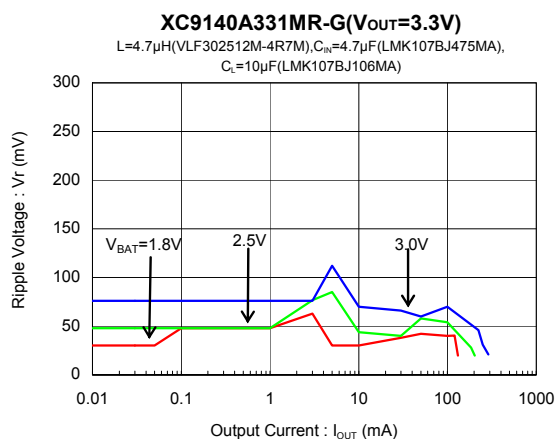
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(4) Output Voltage vs. Ambient Temperature

XC9140x33x(V$_{OUT}$=3.3V)

XC9140x50x(V$_{OUT}$=5.0V)
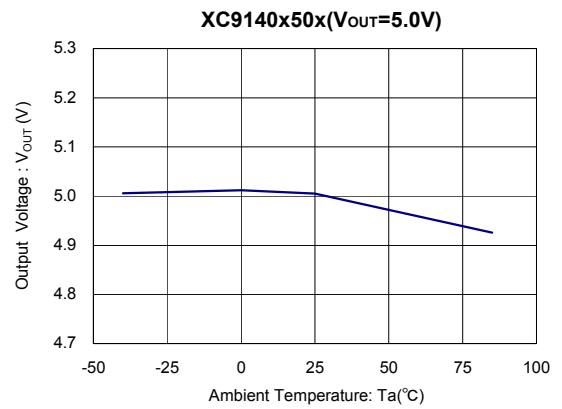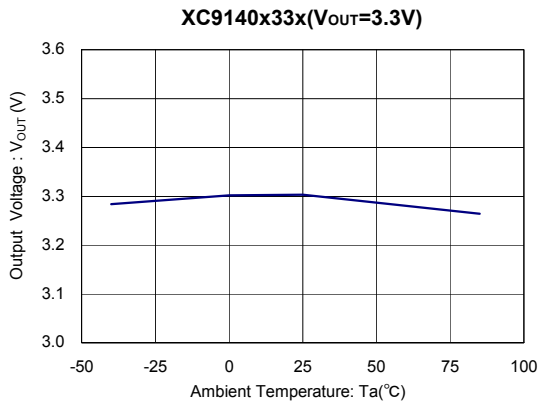
(5) Supply Current vs. Ambient Temperature

XC9140xxx1

V$_{OUT}$=5.0V
3.0V
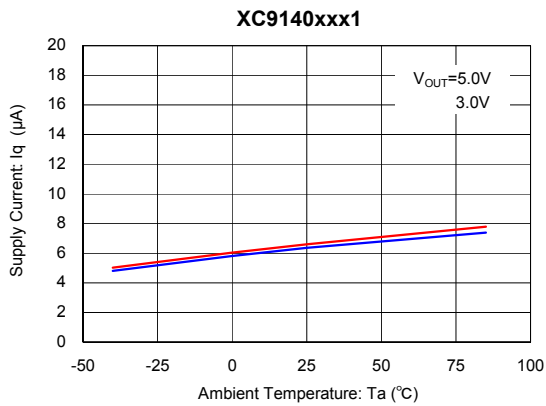
(6) Input Pin Current vs. Ambient Temperature

XC9140xxx1

V$_{OUT}$=5.0V
3.0V
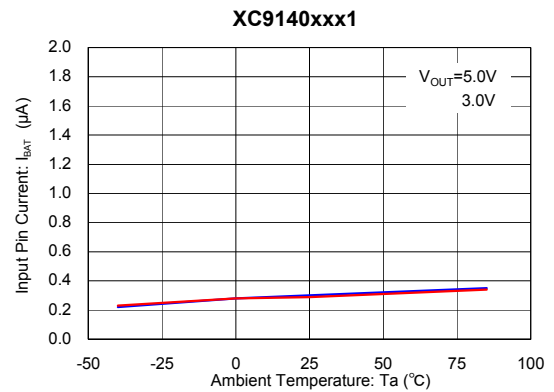
(7) Stand-by Current vs. Ambient Temperature

XC9140A

V$_{OUT}$=5.0V
3.0V
1.8V
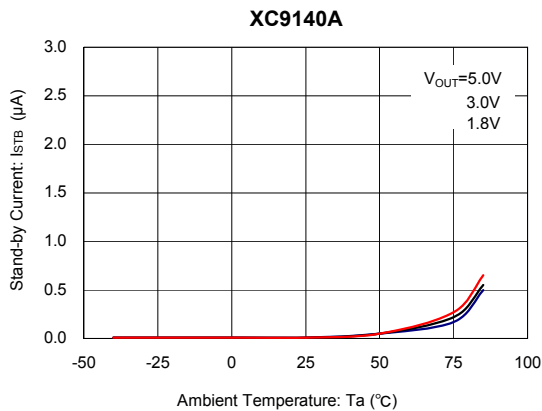
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) PFM Switching Current vs. Ambient Temperature

XC9140

L=4.7μH(VLF302512M-4R7M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)
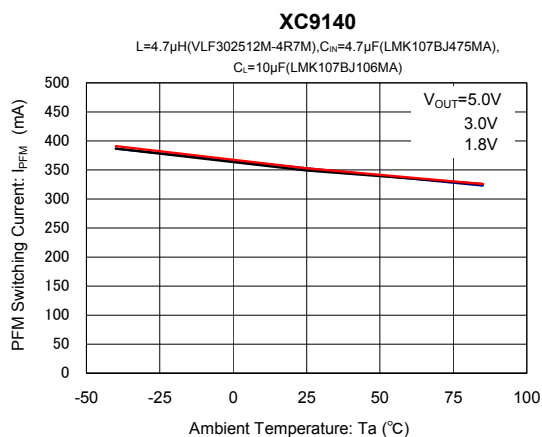
(9) PFM Switching Current vs. Input Voltage

XC9140x50x

L=4.7μH(VLF302512M-4R7M),C$_{IN}$=4.7μF(LMK107BJ475MA),
C$_L$=10μF(LMK107BJ106MA)
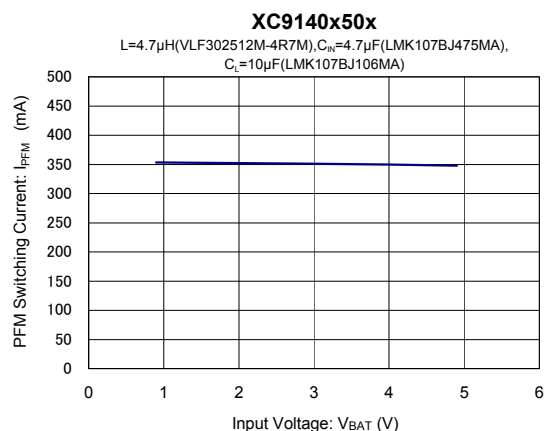
(10) MAX. ON Time vs. Ambient Temperature
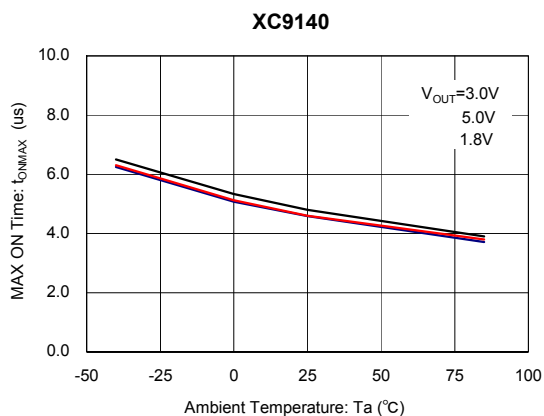
XC9140

(11) Lx SW "Nch" ON Resistance vs. Output Voltage

XC9140

(12) Lx SW "Pch" ON Resistance vs. Output Voltage

XC9140xxx1

V$_{BAT}$=V$_{LX}$=V$_{CE}$=V$_{OUT(E)}$+0.5V,I$_{OUT}$=200mA
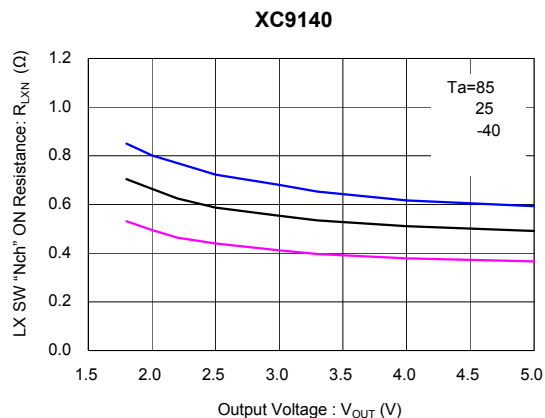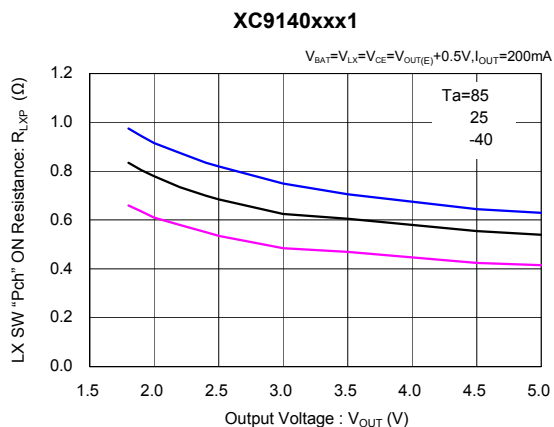
(13) Lx Leak Current vs. Ambient Temperature

XC9140Axx1

V$_{BAT}$=V$_{LX}$=V$_{OUT(E)}$, V$_{OUT}$=V$_{CE}$=0V
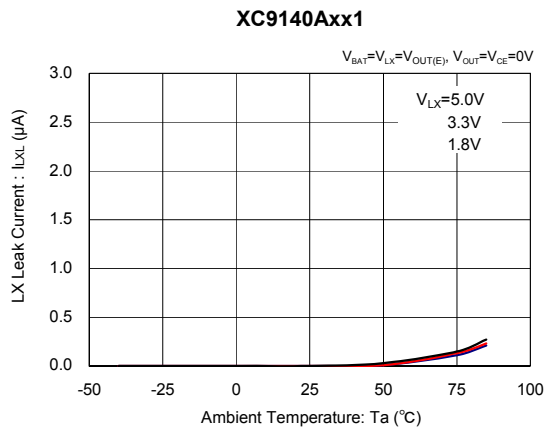
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(14) CE "High" Voltage vs. Output Voltage

XC9140
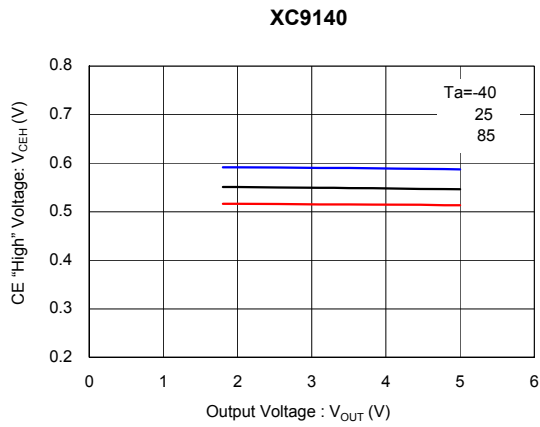
(15) CE "Low" Voltage vs. Output Voltage
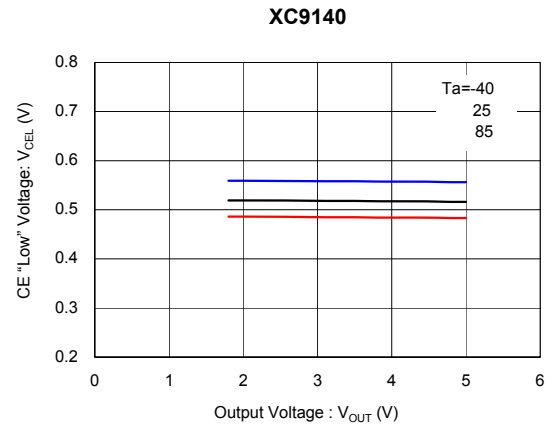
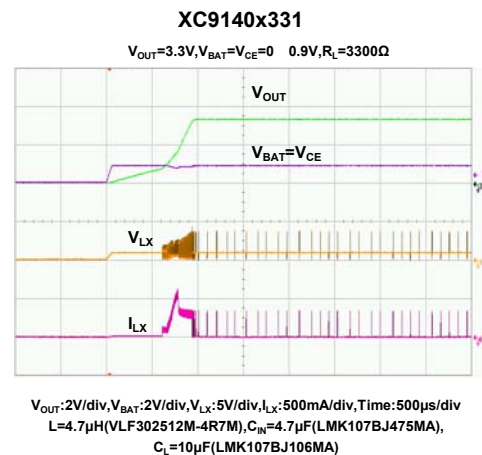**XC9140**

(16) Operation Start Voltage vs. Ambient Temperature

XC9140xxx1

L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA),R_L=$V_{OUT(E)}$/1mA
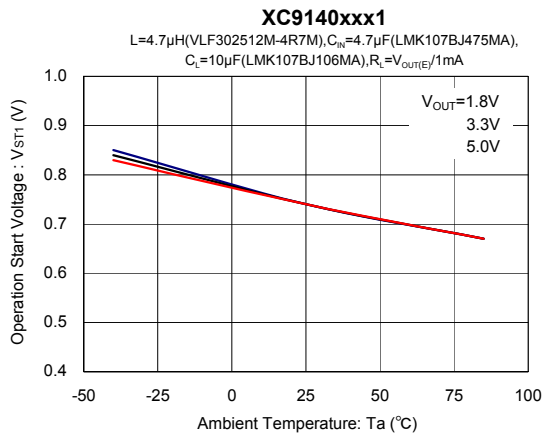
(17) Operation Hold Voltage vs. Ambient Temperature

XC9140xxx1

L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA),R_L=1kΩ

(18) Rising Output Voltage

XC9140x331

V_{OUT}=3.3V,V_{BAT}=V_{CE}=0 1.8V,R_L=330Ω

V_{OUT}:2V/div,V_{BAT}:2V/div,V_{LX}:5V/div,I_{LX}:500mA/div,Time:500μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

XC9140x331

V_{OUT}=3.3V,V_{BAT}=V_{CE}=0 0.9V,R_L=3300Ω

V_{OUT}:2V/div,V_{BAT}:2V/div,V_{LX}:5V/div,I_{LX}:500mA/div,Time:500μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)
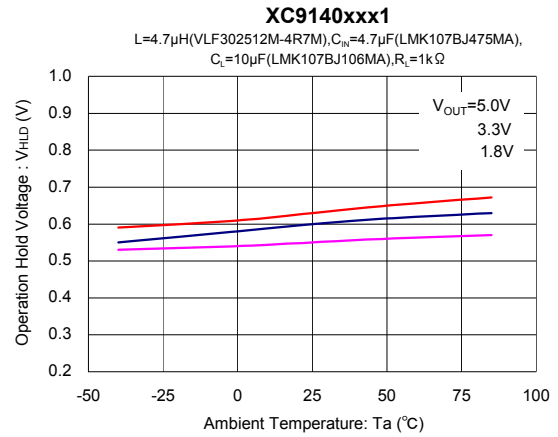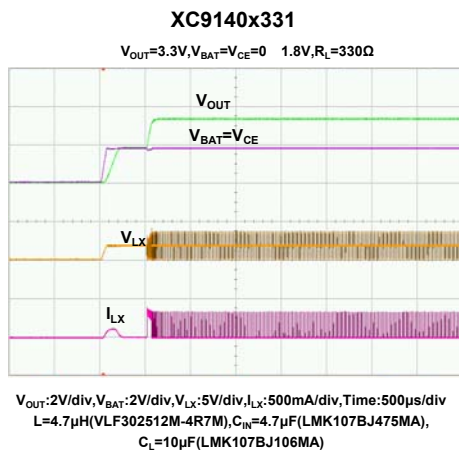
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) Rising Output Voltage (Continued)

XC9140x501

V_{OUT}=5.0V,V_{BAT}=V_{CE}=0   3.3V,R_L=500Ω

V_{OUT}:2V/div,V_{BAT}:2V/div,V_{LX}:5V/div,I_{LX}:500mA/div,Time:500μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

XC9140x501

V_{OUT}=5.0V,V_{BAT}=V_{CE}=0   5.5V,R_L=500Ω

V_{OUT}:2V/div,V_{BAT}:2V/div,V_{LX}:5V/div,I_{LX}:500mA/div,Time:500μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)
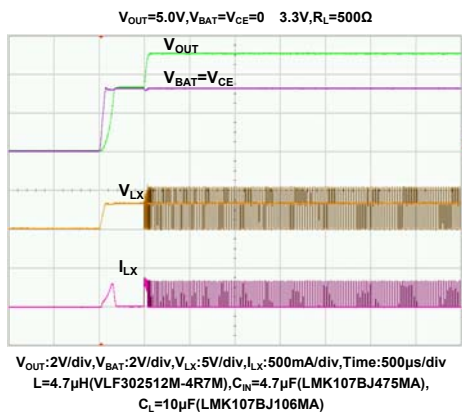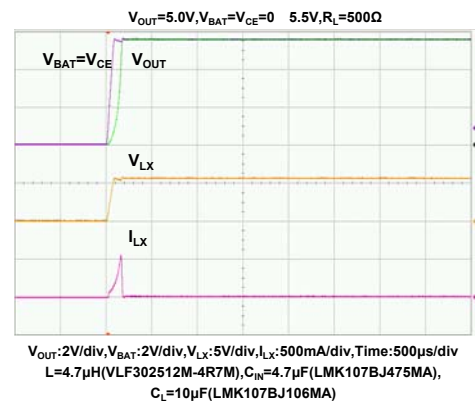
(19) Load Transient Response

XC9140x181

V_{OUT}=1.8V,V_{BAT}=V_{CE}=0.9V,I_{OUT}=1mA→25mA

V_{OUT}:100mV/div,V_{LX}:5V/div,I_{LX}:500mA/div,I_{OUT}:25mA/div,Time:50s/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

XC9140x181

V_{OUT}=1.8V,V_{BAT}=V_{CE}=0.9V,I_{OUT}=25mA→1mA

V_{OUT}:100mV/div,V_{LX}:5V/div,I_{LX}:500mA/div,I_{OUT}:25mA/div,Time:50μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

XC9140x331

V_{OUT}=3.3V,V_{BAT}=V_{CE}=1.8V,I_{OUT}=1mA→50mA

V_{OUT}:100mV/div,V_{LX}:5V/div,I_{LX}:500mA/div,I_{OUT}:50mA/div,Time:50μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

XC9140x331

V_{OUT}=3.3V,V_{BAT}=V_{CE}=1.8V,I_{OUT}=50mA→1mA

V_{OUT}:100mV/div,V_{LX}:5V/div,I_{LX}:500mA/div,I_{OUT}:50mA/div,Time:50μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(19) Load Transient Response (Continued)

XC9140x501

V_{OUT}=5.0V,V_{BAT}=V_{CE}=3.7V,I_{OUT}=1mA→100mA
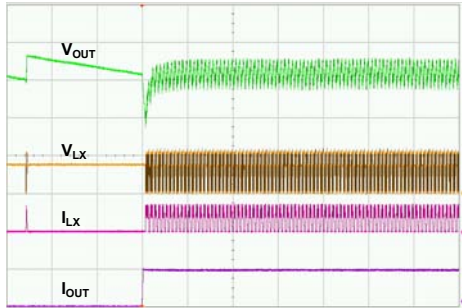
V_{OUT}:100mV/div,V_{LX}:5V/div,I_{LX}:500mA/div,I_{OUT}:100mA/div,Time:50μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

XC9140x501

V_{OUT}=5.0V,V_{BAT}=V_{CE}=3.7V,I_{OUT}=100mA→1mA
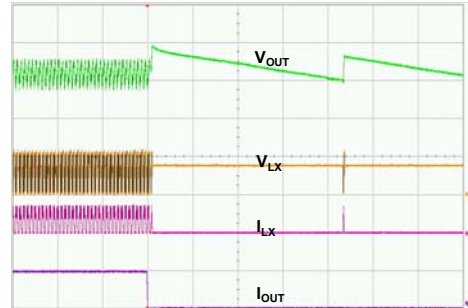
V_{OUT}:100mV/div,V_{LX}:5V/div,I_{LX}:500mA/div,I_{OUT}:100mA/div,Time:50μs/div
L=4.7μH(VLF302512M-4R7M),C_{IN}=4.7μF(LMK107BJ475MA),
C_L=10μF(LMK107BJ106MA)

■PACKAGING INFORMATION

●SOT-25 (unit: mm)
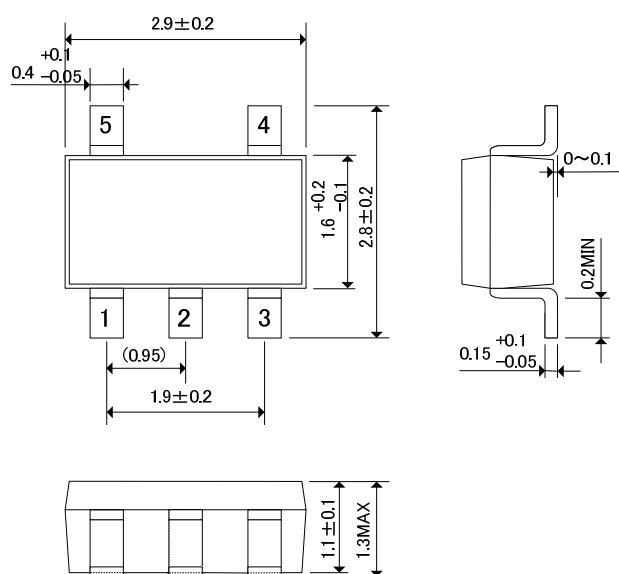
●USP-6EL (unit: mm)
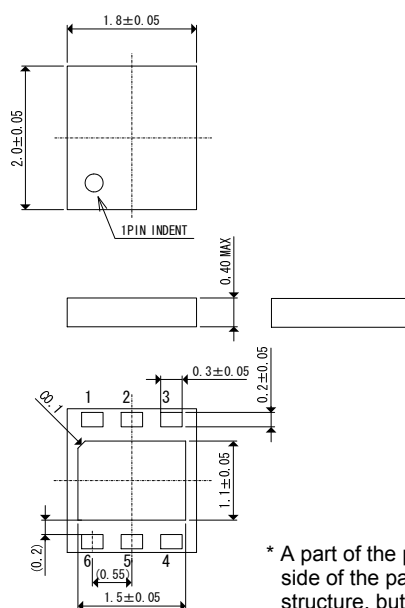
* A part of the pin may appear from the side of the package because of it's structure, but reliability of the package and strength will not be changed below the standard.

●USP-6EL Reference Pattern Layout (unit: mm)
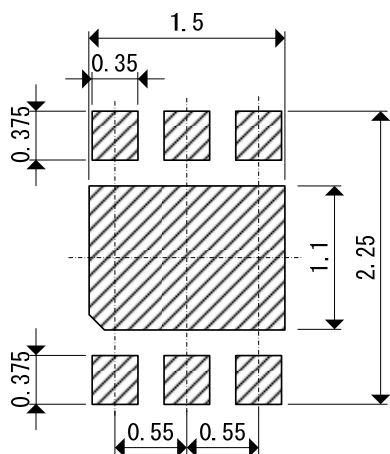
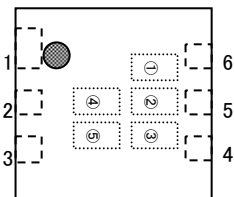●USP-6EL Reference Metal Mask Design (unit: mm)
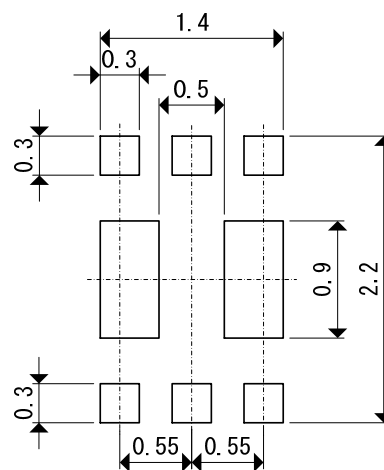
■MARKING RULE

SOT-25
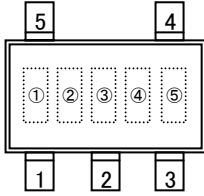
USP-6EL

① represents product series

MARK	PRODUCT SERIES
4	XC9140A**1**-G
	XC9140C**1**-G

② represents output voltage

MARK	OUTPUT VOLTAGE		MARK	OUTPUT VOLTAGE	
0	1.8	3.5	9	2.7	4.4
1	1.9	3.6	A	2.8	4.5
2	2.0	3.7	B	2.9	4.6
3	2.1	3.8	C	3.0	4.7
4	2.2	3.9	D	3.1	4.8
5	2.3	4.0	E	3.2	4.9
6	2.4	4.1	F	3.3	5.0
7	2.5	4.2	H	3.4	-
8	2.6	4.3			

③ represents product function

MARK	OUTPUT VOLTAGE	PRODUCT SERIES
N	1.8 3.4V	XC9140A**1**-G
P	3.5 5.0V	
T	1.8 3.4V	XC9140C**1**-G
U	3.5 5.0V	

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.