

## Step-Up Synchronous PFM DC/DC Converter

☆ Green Operation Compatible

## ■ GENERAL DESCRIPTION

The XC9140 series are step-up synchronous DC/DC converters that support ceramic capacitors and have an internal  $0.6\Omega$  (TYP.) Nch driver transistor and an internal  $0.65\Omega$  (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 these products can be used in applications that start using a single alkaline or nickel-metal hydride battery. The output voltage can be set from 1.8V to 5.0V ( $\pm 2.0\%$ ) in steps of 0.1V.

A version with a UVLO (Under Voltage Lock-out) function is also available. This function enables the prevention of battery leakage by stopping IC's operation when the input voltage is low. The standard product has a UVLO release voltage of 1.65V, 2.15V and a custom version with a release voltage selectable from between 1.65V to 2.2V, in steps of 0.05V, is also available.

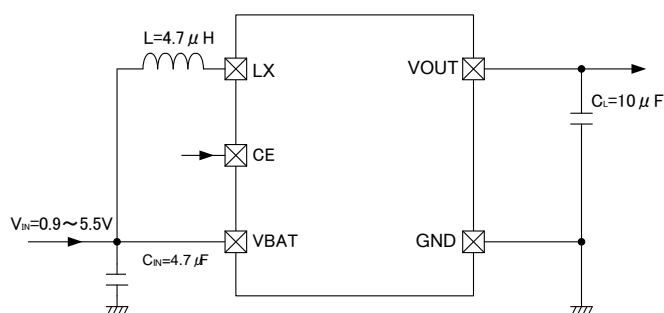
## ■ APPLICATIONS

- 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

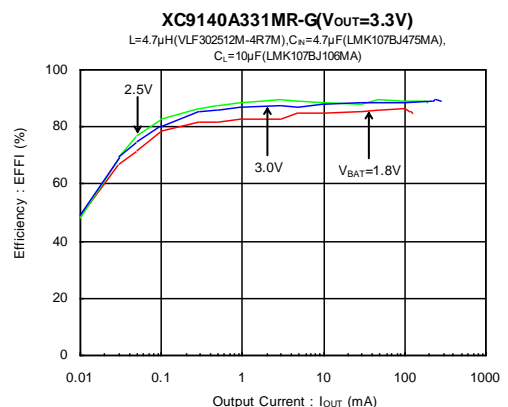
|                               |   |  |                 |
|-------------------------------|---|--|-----------------|
| Input Voltage Range           | : | operating hold voltage   | 0.7V ~ 5.5V     |
|                               |   | Start-up voltage   | 0.9V ~ 5.5V     |
| Output Voltage Setting        | : | 1.8V ~ 5.0V ( $\pm 2.0\%$ )  | 0.1V increments |
| Output Current                | : | 100mA@ $V_{OUT}=3.3V$ , $V_{BAT}=1.8V$                               | (TYP.)          |
| Driver Transistor             | : | 0.6 $\Omega$ Nch driver transistor                                   |                 |
|                               |   | 0.65 $\Omega$ Pch synchronous rectifier switch transistor            |                 |
| Supply Current                | : | 6.3 $\mu$ A ( $V_{BAT}=V_{OUT}+0.5V$ )                               |                 |
| Control Method                | : | PFM Control  |                 |
| High speed transient response | : | 50mV@ $V_{OUT}=3.3V$ , $V_{BAT}=1.8V$ , $I_{OUT}=1 \rightarrow 50mA$ |                 |
| PFM Switching Current         | : | 350mA  |                 |
| Functions                     | : | Load Disconnection (A,B Type)  |                 |
|                               |   | Bypass Mode (C Type)   |                 |
|                               |   | $C_L$ discharge (B Type), UVLO                                       |                 |
| Output Capacitor              | : | Ceramic Capacitor  |                 |
| Operating Ambient Temperature | : | -40°C ~ 85°C   |                 |
| Packages                      | : | SOT-25, USP-6EL  |                 |
| Environmentally Friendly      | : | EU RoHS Compliant, Pb Free   |                 |

## ■ TYPICAL APPLICATION CIRCUIT



## ■ TYPICAL PERFORMANCE CHARACTERISTICS

- Efficiency vs. Output Current



## ■ BLOCK DIAGRAM

XC9140Axx1/XC9140Cxx1 Type



\* Diodes inside the circuit are an ESD protection diodes and a parasitic diodes.

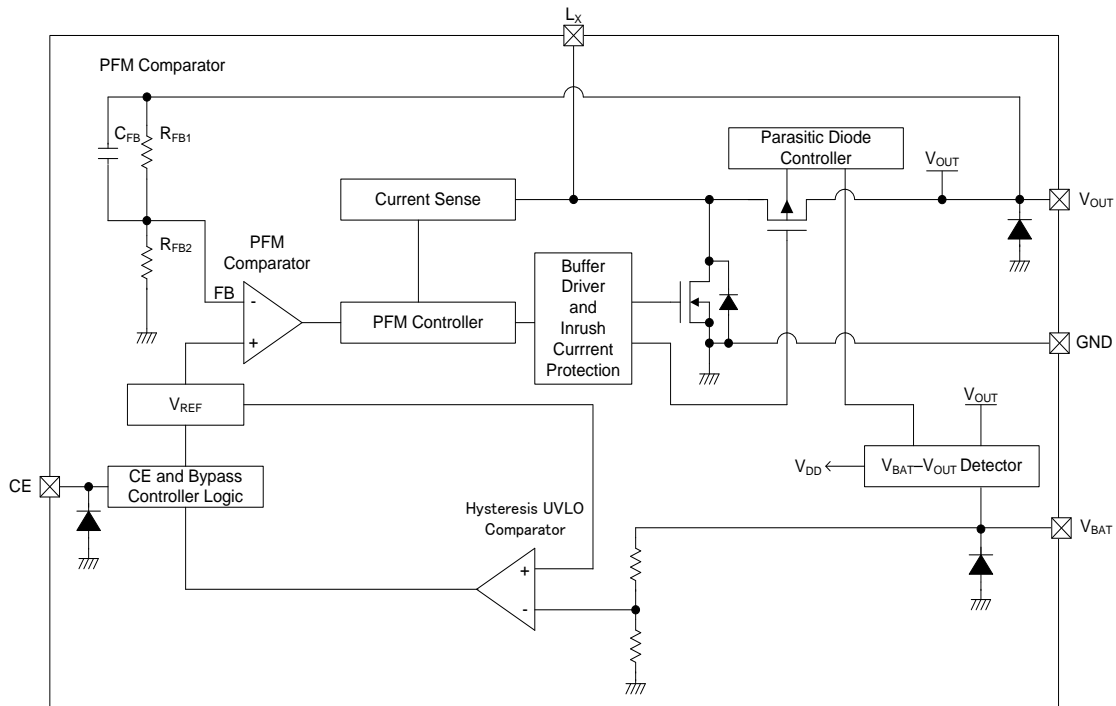
XC9140Bxx1 Type



\* Diodes inside the circuit are an ESD protection diodes and a parasitic diodes.

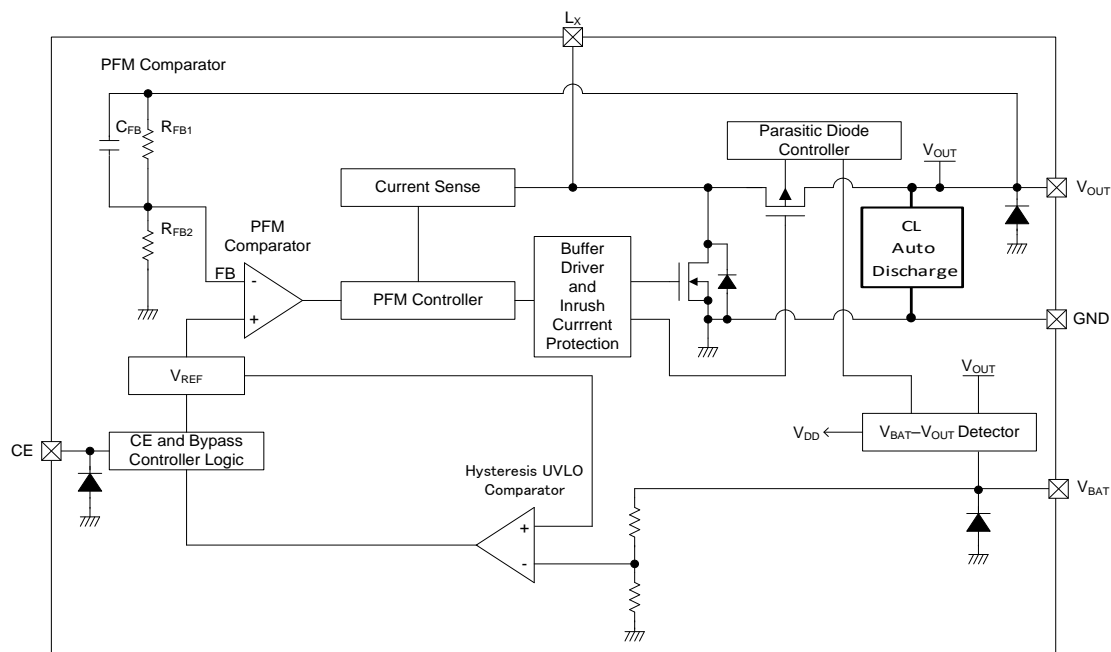
**■ BLOCK DIAGRAM**

XC9140Axxx/XC9140Cxxx Type (Types other than XC9140Axx1/XC9140Cxx1)



\* Diodes inside the circuit are an ESD protection diodes and a parasitic diodes.

XC9140Bxxx Type (Types other than XC9140Bxx1)



\* Diodes inside the circuit are an ESD protection diodes and a parasitic diodes.

## ■ PRODUCT CLASSIFICATION

### ● Ordering Information

XC9140①②③④⑤⑥-⑦

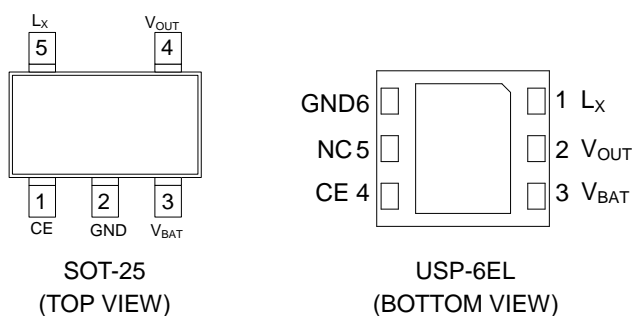
| DESIGNATOR | ITEM                     | SYMBOL  | DESCRIPTION  |
|------------|--------------------------|---------|--|
| ①          | Product Type             | A       | Load Disconnection Without C <sub>L</sub> Auto Discharge                   |
|            |                          | B       | Load Disconnection With C <sub>L</sub> Auto Discharge                      |
|            |                          | C       | V <sub>BAT</sub> Bypass Without C <sub>L</sub> Auto Discharge              |
| ②③         | Output Voltage           | 18 ~ 50 | Output Voltage (Increments : 0.1V)<br>e.g. V <sub>OUT</sub> =3.3V⇒②=3, ③=3 |
| ④ (*1)     | UVLO Function            | 1       | No UVLO  |
|            |                          | 2       | UVLO Function V <sub>UVLO,R</sub> =2.15V                                   |
|            |                          | 6       | UVLO Function V <sub>UVLO,R</sub> =1.65V                                   |
| ⑤⑥-⑦ (*2)  | Packages<br>(Order Unit) | 4R-G    | USP-6EL (3,000pcs/Reel)  |
|            |                          | MR-G    | SOT-25 (3,000pcs/Reel)   |

(\*1) Please contact our sales representatives for UVLO release voltage other than those listed above.

It can be set from 1.65V to 2.2V in 0.05V increments.

(\*2) The “-G” suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

## ■ PIN CONFIGURATION



\* 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 <sub>X</sub>   | Switching      |
| 2          | 4      | V <sub>OUT</sub> | Output Voltage |
| 3          | 3      | V <sub>BAT</sub> | Power Input    |
| 4          | 1      | CE               | Chip Enable    |
| 5          | -      | NC               | No Connection  |
| 6          | 2      | GND              | Ground         |

## ■ PIN FUNCTION ASSIGNMENT

| PIN NAME | SIGNAL | STATUS  |
|----------|--------|---|
| CE       | H      | Active (All Series)                                     |
|          | L      | Stand-by (XC9140A/B Type)<br>Bypass Mode (XC9140C Type) |

\* Please do not leave the CE pin open.

## ■ ABSOLUTE MAXIMUM RATINGS

| PARAMETER                                   | SYMBOL           | RATINGS   | UNITS |
|---|------------------|---|-------|
| BAT Pin Voltage                             | V <sub>BAT</sub> | -0.3 ~ 7.0  | V     |
| L <sub>X</sub> Pin Voltage                  | V <sub>LX</sub>  | -0.3 ~ V <sub>OUT</sub> + 0.3 or 7.0 <sup>(1)</sup> | V     |
| V <sub>OUT</sub> Pin Voltage                | V <sub>OUT</sub> | -0.3 ~ 7.0  | V     |
| CE Pin Voltage                              | V <sub>CE</sub>  | -0.3 ~ 7.0  | V     |
| L <sub>X</sub> Pin Current                  | I <sub>LX</sub>  | 700   | mA    |
| Power Dissipation<br>(T <sub>a</sub> =25°C) | SOT-25           | 250   | mW    |
|   |                  | 600 (40mm x 40mm Standard board) <sup>(2)</sup>     |       |
|   | USP-6EL          | 120   |       |
|   |                  | 1000 (40mm x 40mm Standard board) <sup>(2)</sup>    |       |
| Operating Ambient Temperature               | T <sub>opr</sub> | -40 ~ 85  | °C    |
| Storage Temperature                         | T <sub>stg</sub> | -55 ~ 125   | °C    |

\* All voltages are described based on the GND.

<sup>(1)</sup> The maximum value should be either V<sub>OUT</sub>+0.3V or 7.0V or in the lowest.

<sup>(2)</sup> This power dissipation figure shown is PCB mounted and is for reference only.

The mounting condition is please refer to PACKAGING INFORMATION

## ELECTRICAL CHARACTERISTICS (Continued)

XC9140Axx1, XC9140Bxx1 Type

Ta=25°C

| PARAMETER                                | SYMBOL                             | CONDITIONS   | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|--|------------------------------------|--|------|------|------|-------|---------|
| Input Voltage                            | V <sub>BAT</sub>                   | -  | -    | -    | 5.5  | V     |         |
| Output Voltage                           | V <sub>OUT(E)</sub> <sup>(2)</sup> | V <sub>PULL</sub> =1.5V, Voltage to start oscillation while V <sub>OUT</sub> is decreasing   | E1   |      |      | V     | ①       |
| Operation Start Voltage                  | V <sub>ST1</sub>                   | I <sub>OUT</sub> =1mA  | -    | -    | 0.9  | V     | ②       |
| Operation Hold Voltage                   | V <sub>HLD</sub>                   | R <sub>L</sub> =1kΩ  | -    | 0.7  | -    | V     | ②       |
| Supply Current                           | I <sub>q</sub>                     | Oscillation stops, V <sub>OUT</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup>  | E2   |      |      | μA    | ③       |
| Input Pin Current                        | I <sub>BAT</sub>                   | V <sub>OUT</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup>   | -    | 0.25 | 1.0  | μA    | ③       |
| Stand-by Current                         | I <sub>STB</sub>                   | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT(T)</sub> <sup>(1)</sup> , V <sub>OUT</sub> =V <sub>CE</sub> =0V  | -    | 0.1  | 1.0  | μA    | ④       |
| L <sub>X</sub> Leak Current              | I <sub>LXL</sub>                   | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT(T)</sub> <sup>(1)</sup> , V <sub>OUT</sub> =V <sub>CE</sub> =0V  | -    | 0.1  | 1.0  | μA    | ⑤       |
| PFM Switching Current                    | I <sub>PFM</sub>                   | I <sub>OUT</sub> =3mA  | 295  | 350  | 405  | mA    | ②       |
| Maximum ON Time                          | t <sub>ONMAX</sub>                 | V <sub>PULL</sub> =1.5V, V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup>  | 3.1  | 4.6  | 6.0  | μs    | ①       |
| Efficiency <sup>(3)</sup>                | EFFI                               | V <sub>BAT</sub> =V <sub>CE</sub> =1.8V, V <sub>OUT(T)</sub> <sup>(1)</sup> =2.5V, I <sub>OUT</sub> =30mA  | -    | 81   | -    | %     | ②       |
| Efficiency <sup>(3)</sup>                | EFFI                               | V <sub>BAT</sub> =V <sub>CE</sub> =1.8V, V <sub>OUT(T)</sub> <sup>(1)</sup> =3.3V, I <sub>OUT</sub> =30mA  | -    | 85   | -    | %     | ②       |
| Efficiency <sup>(3)</sup>                | EFFI                               | V <sub>BAT</sub> =V <sub>CE</sub> =1.8V, V <sub>OUT(T)</sub> <sup>(1)</sup> =5.0V, I <sub>OUT</sub> =30mA  | -    | 86   | -    | %     | ②       |
| LX SW "Pch" ON Resistance <sup>(4)</sup> | R <sub>LXP</sub>                   | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>CE</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup> , I <sub>OUT</sub> =200mA   | E3   |      |      | Ω     | ⑦       |
| LX SW "Nch" ON Resistance <sup>(5)</sup> | R <sub>LXN</sub>                   | V <sub>BAT</sub> =V <sub>CE</sub> =3.3V, V <sub>OUT</sub> =1.7V  | -    | 0.6  | -    | Ω     | ⑧       |
| CE "H" Voltage                           | V <sub>CEH</sub>                   | V <sub>BAT</sub> =V <sub>PULL</sub> =1.5V, V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup> While V <sub>CE</sub> =0.3→0.75V, Voltage to start oscillation | 0.75 | -    | 5.5  | V     | ①       |
| CE "L" Voltage                           | V <sub>CEL</sub>                   | V <sub>BAT</sub> =V <sub>PULL</sub> =1.5V, V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup> While V <sub>CE</sub> =0.75→0.3V, Voltage to stop oscillation  | GND  | -    | 0.3  | V     | ①       |
| CE "H" Current                           | I <sub>CEH</sub>                   | V <sub>BAT</sub> =V <sub>CE</sub> =V <sub>LX</sub> =V <sub>OUT</sub> =5.5V   | -0.1 | -    | 0.1  | μA    | ①       |
| CE "L" Current                           | I <sub>CEL</sub>                   | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT</sub> =5.5V, V <sub>CE</sub> =0V   | -0.1 | -    | 0.1  | μA    | ①       |
| CL Discharge Resistance (B Type)         | R <sub>DCHG</sub>                  | V <sub>BAT</sub> =V <sub>OUT</sub> =2.0V, V <sub>CE</sub> =0V  | 165  | 210  | 254  | Ω     | ③       |

Unless otherwise stated, V<sub>BAT</sub>=V<sub>CE</sub>=1.5V

<sup>(1)</sup> V<sub>OUT(T)</sub>=Nominal Output Voltage

<sup>(2)</sup> V<sub>OUT(E)</sub>=Effective Output Voltage

The actual output voltage value V<sub>OUT(E)</sub> 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.

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

<sup>(4)</sup> LX SW "Pch" ON resistance=(V<sub>LX</sub>-V<sub>OUT</sub> pin measurement voltage) / 200mA

<sup>(5)</sup> The LX SW "Nch" ON resistance measurement method is shown in the measurement circuit diagram.

## ■ ELECTRICAL CHARACTERISTICS (Continued)

XC9140Cxx1 Type

Ta=25°C

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

Unless otherwise stated, V<sub>BAT</sub>=V<sub>CE</sub>=1.5V

<sup>(1)</sup> V<sub>OUT(T)</sub>=Nominal Output Voltage

<sup>(2)</sup> V<sub>OUT(E)</sub>=Effective Output Voltage

The actual output voltage value V<sub>OUT(E)</sub> 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.

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

<sup>(4)</sup> LX SW "Pch" ON resistance=(V<sub>LX</sub>-V<sub>OUT</sub> pin measurement voltage) / 200mA

<sup>(5)</sup> The LX SW "Nch" ON resistance measurement method is shown in the measurement circuit diagram.

## ELECTRICAL CHARACTERISTICS (Continued)

XC9140Axxx types (types other than XC9140Axx1), XC9140Bxxx types (types other than XC9140Bxx1)

Ta=25°C

| PARAMETER                                | SYMBOL                                 | CONDITIONS  | MIN.                                  | TYP. | MAX.                                   | UNITS | CIRCUIT |
|--|--|---|---------------------------------------|------|--|-------|---------|
| Input Voltage                            | V <sub>BAT</sub>                       | -   | -                                     | -    | 5.5                                    | V     |         |
| Output Voltage                           | V <sub>OUT(E)</sub> <sup>(2)</sup>     | V <sub>PULL</sub> =1.5V, Voltage to start oscillation while V <sub>OUT</sub> is decreasing  | E1                                    |      |  | V     | ①       |
| Operation Start Voltage                  | V <sub>ST1</sub>                       | I <sub>OUT</sub> =1mA   | -                                     | -    | V <sub>RELEASE(E)</sub> <sup>(7)</sup> | V     | ②       |
| Operation Hold Voltage                   | V <sub>HLD</sub>                       | R <sub>L</sub> =1kΩ   | V <sub>DETECT(E)</sub> <sup>(8)</sup> | -    | -                                      | V     | ②       |
| Supply Current2                          | I <sub>q</sub>                         | Oscillation stops, V <sub>OUT</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup>   | E4                                    |      |  | μA    | ③       |
| Input Pin Current2                       | I <sub>BAT</sub>                       | V <sub>OUT</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup>  | E5                                    |      |  | μA    | ③       |
| Stand-by Current                         | I <sub>STB</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT(T)</sub> <sup>(1)</sup> , V <sub>OUT</sub> =V <sub>CE</sub> =0V   | -                                     | 0.1  | 1.0                                    | μA    | ④       |
| L <sub>x</sub> Leak Current              | I <sub>LXL</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT(T)</sub> <sup>(1)</sup> , V <sub>OUT</sub> =V <sub>CE</sub> =0V   | -                                     | 0.1  | 1.0                                    | μA    | ⑤       |
| PFM Switching Current                    | I <sub>PFM</sub>                       | I <sub>OUT</sub> =3mA   | 295                                   | 350  | 405                                    | mA    | ②       |
| Maximum ON Time                          | t <sub>ONMAX</sub>                     | V <sub>PULL</sub> = V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup>   | 3.1                                   | 4.6  | 6.0                                    | μs    | ①       |
| Efficiency <sup>(3)</sup>                | EFFI                                   | V <sub>OUT(T)</sub> <sup>(1)</sup> =2.5V, I <sub>OUT</sub> =30mA  | -                                     | 81   | -                                      | %     | ②       |
| Efficiency <sup>(3)</sup>                | EFFI                                   | V <sub>OUT(T)</sub> <sup>(1)</sup> =3.3V, I <sub>OUT</sub> =30mA  | -                                     | 85   | -                                      | %     | ②       |
| Efficiency <sup>(3)</sup>                | EFFI                                   | V <sub>OUT(T)</sub> <sup>(1)</sup> =5.0V, I <sub>OUT</sub> =30mA  | -                                     | 86   | -                                      | %     | ②       |
| LX SW "Pch" ON Resistance <sup>(4)</sup> | R <sub>LXP</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>CE</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup> , I <sub>OUT</sub> =200mA  | E3                                    |      |  | Ω     | ⑦       |
| LX SW "Nch" ON Resistance <sup>(5)</sup> | R <sub>LXN</sub>                       | V <sub>BAT</sub> =V <sub>CE</sub> =3.3V, V <sub>OUT</sub> =1.7V   | -                                     | 0.6  | -                                      | Ω     | ⑧       |
| CE "H" Voltage                           | V <sub>CEH</sub>                       | V <sub>BAT</sub> =V <sub>PULL</sub> = V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup><br>While V <sub>CE</sub> =0.3→0.75V,<br>Voltage to start oscillation              | 0.75                                  | -    | 5.5                                    | V     | ①       |
| CE "L" Voltage                           | V <sub>CEL</sub>                       | V <sub>BAT</sub> =V <sub>PULL</sub> = V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup><br>While V <sub>CE</sub> =0.75→0.3V,<br>Voltage to stop oscillation               | GND                                   | -    | 0.3                                    | V     | ①       |
| CE "H" Current                           | I <sub>CEH</sub>                       | V <sub>BAT</sub> =V <sub>CE</sub> =V <sub>LX</sub> =V <sub>OUT</sub> =5.5V  | -0.1                                  | -    | 0.1                                    | μA    | ①       |
| CE "L" Current                           | I <sub>CEL</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT</sub> =5.5V, V <sub>CE</sub> =0V  | -0.1                                  | -    | 0.1                                    | μA    | ①       |
| UVLO Current                             | I <sub>DQ</sub>                        | V <sub>BAT</sub> = V <sub>CE</sub> = V <sub>DETECT(E)</sub> - 0.1V <sup>(8)</sup> , I <sub>OUT</sub> =0mA   | E6                                    |      |  | μA    | ②       |
| UVLO Release Voltage                     | V <sub>RELEASE(E)</sub> <sup>(7)</sup> | V <sub>PULL</sub> = V <sub>OUT</sub> = V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup> , V <sub>BAT</sub> = V <sub>CE</sub><br>Voltage to start oscillation while V <sub>BAT</sub> is increasing   | E7                                    |      |  | V     | ①       |
| UVLO Hysteresis Voltage                  | V <sub>HYS(E)</sub> <sup>(9)</sup>     | V <sub>PULL</sub> = V <sub>OUT</sub> = V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup> , V <sub>BAT</sub> = V <sub>CE</sub><br>V <sub>RELEASE(E)</sub> - Voltage to stop oscillation while V <sub>BAT</sub> is decreasing <sup>(7)</sup> | 0.1                                   | 0.15 | 0.2                                    | V     | ①       |

Unless otherwise stated, V<sub>BAT</sub>=V<sub>CE</sub>=V<sub>RELEASE(T)</sub>+0.1V<sup>(6)</sup>

<sup>(1)</sup> V<sub>OUT(T)</sub>= Nominal Output Voltage

<sup>(2)</sup> V<sub>OUT(E)</sub>= Effective Output Voltage

The actual output voltage value V<sub>OUT(E)</sub> 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.

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

<sup>(4)</sup> LX SW "Pch" ON resistance=(V<sub>LX</sub>-V<sub>OUT</sub> pin measurement voltage) / 200mA

<sup>(5)</sup> The LX SW "Nch" ON resistance measurement method is shown in the measurement circuit diagram.

<sup>(6)</sup> V<sub>RELEASE(T)</sub>= Nominal UVLO release voltage

<sup>(7)</sup> V<sub>RELEASE(E)</sub>= Actual UVLO release voltage

<sup>(8)</sup> V<sub>DETECT(E)</sub>=V<sub>RELEASE(E)</sub> -V<sub>HYS(E)</sub>= Actual UVLO detect voltage

<sup>(9)</sup> V<sub>HYS(E)</sub>= Actual UVLO hysteresis voltage



## ■ ELECTRICAL CHARACTERISTICS (Continued)

XC9140Cxxx type (types other than XC9140Cxx1)

Ta=25°C

| PARAMETER                                | SYMBOL                                 | CONDITIONS   | MIN.                                  | TYP. | MAX.                                   | UNITS | CIRCUIT |
|--|--|--|---------------------------------------|------|--|-------|---------|
| Input Voltage                            | V <sub>BAT</sub>                       |  | -                                     | -    | 5.5                                    | V     |         |
| Output Voltage                           | V <sub>OUT(E)</sub> <sup>(2)</sup>     | V <sub>PULL</sub> =1.5V, Voltage to start oscillation while V <sub>OUT</sub> is decreasing   | E1                                    |      |  | V     | ①       |
| Operation Start Voltage                  | V <sub>ST1</sub>                       | I <sub>OUT</sub> =1mA  | -                                     | -    | V <sub>RELEASE(E)</sub> <sup>(7)</sup> | V     | ②       |
| Operation Hold Voltage                   | V <sub>HLD</sub>                       | R <sub>L</sub> =1kΩ  | V <sub>DETECT(E)</sub> <sup>(8)</sup> | -    | -                                      | V     | ②       |
| Supply Current2                          | I <sub>q</sub>                         | Oscillation stops, V <sub>OUT</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup>  | E4                                    |      |  | μA    | ③       |
| Input Pin Current2                       | I <sub>BAT</sub>                       | V <sub>OUT</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup>   | E5                                    |      |  | μA    | ③       |
| Bypass Mode Current                      | I <sub>BYP</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>CE</sub> =0V  | -                                     | 5.5  | 8.1                                    | μA    | ⑥       |
| PFM Switching Current                    | I <sub>PFM</sub>                       | I <sub>OUT</sub> =3mA  | 295                                   | 350  | 405                                    | mA    | ②       |
| Maximum ON Time                          | t <sub>ONMAX</sub>                     | V <sub>PULL</sub> =V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup>   | 3.1                                   | 4.6  | 6.0                                    | μs    | ①       |
| Efficiency <sup>(3)</sup>                | EFFI                                   | V <sub>OUT(T)</sub> <sup>(1)</sup> =2.5V, I <sub>OUT</sub> =30mA   | -                                     | 81   | -                                      | %     | ②       |
| Efficiency <sup>(3)</sup>                | EFFI                                   | V <sub>OUT(T)</sub> <sup>(1)</sup> =3.3V, I <sub>OUT</sub> =30mA   | -                                     | 85   | -                                      | %     | ②       |
| Efficiency <sup>(3)</sup>                | EFFI                                   | V <sub>OUT(T)</sub> <sup>(1)</sup> =5.0V, I <sub>OUT</sub> =30mA   | -                                     | 86   | -                                      | %     | ②       |
| LX SW "Pch" ON Resistance <sup>(4)</sup> | R <sub>LXP</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>CE</sub> =V <sub>OUT(T)</sub> +0.5V <sup>(1)</sup> , I <sub>OUT</sub> =200mA   | E3                                    |      |  | Ω     | ⑦       |
| LX SW "Nch" ON Resistance <sup>(5)</sup> | R <sub>LXN</sub>                       | V <sub>BAT</sub> =V <sub>CE</sub> =3.3V, V <sub>OUT</sub> =1.7V  | -                                     | 0.6  | -                                      | Ω     | ⑧       |
| CE "H" Voltage                           | V <sub>CEH</sub>                       | V <sub>BAT</sub> =V <sub>PULL</sub> =V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup><br>While V <sub>CE</sub> =0.3→0.75V,<br>Voltage to start oscillation            | 0.75                                  | -    | 5.5                                    | V     | ①       |
| CE "L" Voltage                           | V <sub>CEL</sub>                       | V <sub>BAT</sub> =V <sub>PULL</sub> =V <sub>RELEASE(T)</sub> +0.1V <sup>(6)</sup> , V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup><br>While V <sub>CE</sub> =0.75→0.3V,<br>Voltage to stop oscillation             | GND                                   | -    | 0.3                                    | V     | ①       |
| CE "H" Current                           | I <sub>CEH</sub>                       | V <sub>BAT</sub> =V <sub>CE</sub> =V <sub>LX</sub> =V <sub>OUT</sub> =5.5V   | -0.1                                  | -    | 0.1                                    | μA    | ①       |
| CE "L" Current                           | I <sub>CEL</sub>                       | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>OUT</sub> =5.5V, V <sub>CE</sub> =0V   | -0.1                                  | -    | 0.1                                    | μA    | ①       |
| UVLO Current                             | I <sub>DQ</sub>                        | V <sub>BAT</sub> =V <sub>CE</sub> =V <sub>DETECT(E)</sub> -0.1V <sup>(8)</sup> , I <sub>OUT</sub> =0mA   | E6                                    |      |  | μA    | ②       |
| UVLO Bypass Current                      | I <sub>DBYP</sub>                      | V <sub>BAT</sub> =V <sub>LX</sub> =V <sub>DETECT(E)</sub> -0.1V <sup>(8)</sup> , V <sub>CE</sub> =0V   | E8                                    |      |  | μA    | ⑥       |
| UVLO Release Voltage                     | V <sub>RELEASE(E)</sub> <sup>(7)</sup> | V <sub>PULL</sub> =V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup> , V <sub>BAT</sub> =V <sub>CE</sub><br>Voltage to start oscillation while V <sub>BAT</sub> is increasing   | E7                                    |      |  | V     | ①       |
| UVLO Hysteresis Voltage                  | V <sub>HYS(E)</sub> <sup>(9)</sup>     | V <sub>PULL</sub> =V <sub>OUT</sub> =V <sub>OUT(T)</sub> ×0.98 <sup>(1)</sup> , V <sub>BAT</sub> =V <sub>CE</sub><br>V <sub>RELEASE(E)</sub> - Voltage to stop oscillation while V <sub>BAT</sub> is decreasing <sup>(7)</sup> | 0.1                                   | 0.15 | 0.2                                    | V     | ①       |

Unless otherwise stated, V<sub>BAT</sub>=V<sub>CE</sub>=V<sub>RELEASE(T)</sub>+0.1V<sup>(6)</sup>

<sup>(1)</sup> V<sub>OUT(T)</sub>=Nominal Output Voltage

<sup>(2)</sup> V<sub>OUT(E)</sub>=Effective Output Voltage

The actual output voltage value V<sub>OUT(E)</sub> 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.

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

<sup>(4)</sup> LX SW "Pch" ON resistance=(V<sub>LX</sub>-V<sub>OUT</sub> pin measurement voltage) / 200mA

<sup>(5)</sup> The LX SW "Nch" ON resistance measurement method is shown in the measurement circuit diagram.

<sup>(6)</sup> V<sub>RELEASE(T)</sub>= Nominal UVLO release voltage

<sup>(7)</sup> V<sub>RELEASE(E)</sub>= Actual UVLO release voltage

<sup>(8)</sup> V<sub>DETECT(E)</sub>= V<sub>RELEASE(E)</sub> -V<sub>HYS(E)</sub>= Actual UVLO detect voltage

<sup>(9)</sup> V<sub>HYS(E)</sub>= Actual UVLO hysteresis voltage

## ELECTRICAL CHARACTERISTICS (Continued)

XC9140 Voltage Chart 1

| SYMBOL         | E1             |       | E2             |      | E3                        |      | E4              |      |
|----------------|----------------|-------|----------------|------|---------------------------|------|-----------------|------|
| PARAMETER      | Output Voltage |       | Supply Current |      | LX SW "Pch" ON RESISTANCE |      | Supply Current2 |      |
| UNITS: V       | UNITS: V       |       | UNITS: $\mu$ A |      | UNITS: $\Omega$           |      | UNITS: $\mu$ A  |      |
| OUTPUT VOLTAGE | MIN.           | MAX.  | TYP.           | MAX. | TYP.                      | MAX. | TYP.            | MAX. |
| 1.8            | 1.764          | 1.836 | 6.1            | 9.4  | 0.84                      | 1.08 | 6.8             | 9.7  |
| 1.9            | 1.862          | 1.938 |                |      |                           |      |                 |      |
| 2.0            | 1.960          | 2.040 |                |      |                           |      |                 |      |
| 2.1            | 2.058          | 2.142 |                |      |                           |      |                 |      |
| 2.2            | 2.156          | 2.244 |                |      |                           |      |                 |      |
| 2.3            | 2.254          | 2.346 | 6.2            | 9.7  | 0.75                      | 0.97 | 6.9             | 9.8  |
| 2.4            | 2.352          | 2.448 |                |      |                           |      |                 |      |
| 2.5            | 2.450          | 2.550 |                |      |                           |      |                 |      |
| 2.6            | 2.548          | 2.652 |                |      |                           |      |                 |      |
| 2.7            | 2.646          | 2.754 |                |      |                           |      |                 |      |
| 2.8            | 2.744          | 2.856 | 6.3            | 10.0 | 0.65                      | 0.85 | 7.0             | 10.0 |
| 2.9            | 2.842          | 2.958 |                |      |                           |      |                 |      |
| 3.0            | 2.940          | 3.060 |                |      |                           |      |                 |      |
| 3.1            | 3.038          | 3.162 |                |      |                           |      |                 |      |
| 3.2            | 3.136          | 3.264 |                |      |                           |      |                 |      |
| 3.3            | 3.234          | 3.366 | 6.4            | 10.2 | 0.61                      | 0.78 | 7.1             | 10.1 |
| 3.4            | 3.332          | 3.468 |                |      |                           |      |                 |      |
| 3.5            | 3.430          | 3.570 |                |      |                           |      |                 |      |
| 3.6            | 3.528          | 3.672 |                |      |                           |      |                 |      |
| 3.7            | 3.626          | 3.774 |                |      |                           |      |                 |      |
| 3.8            | 3.724          | 3.876 | 6.5            | 10.4 | 0.57                      | 0.74 | 7.2             | 10.2 |
| 3.9            | 3.822          | 3.978 |                |      |                           |      |                 |      |
| 4.0            | 3.920          | 4.080 |                |      |                           |      |                 |      |
| 4.1            | 4.018          | 4.182 |                |      |                           |      |                 |      |
| 4.2            | 4.116          | 4.284 |                |      |                           |      |                 |      |
| 4.3            | 4.214          | 4.386 | 6.7            | 10.7 | 0.53                      | 0.72 | 7.3             | 10.3 |
| 4.4            | 4.312          | 4.488 |                |      |                           |      |                 |      |
| 4.5            | 4.410          | 4.590 |                |      |                           |      |                 |      |
| 4.6            | 4.508          | 4.692 |                |      |                           |      |                 |      |
| 4.7            | 4.606          | 4.794 |                |      |                           |      |                 |      |
| 4.8            | 4.704          | 4.896 | 6.7            | 10.7 | 0.53                      | 0.72 | 7.3             | 10.3 |
| 4.9            | 4.802          | 4.998 |                |      |                           |      |                 |      |
| 5.0            | 4.900          | 5.100 |                |      |                           |      |                 |      |

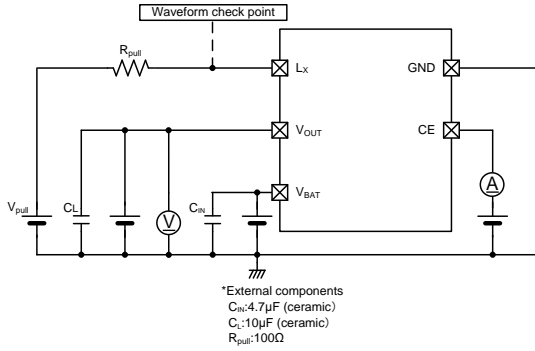
**■ ELECTRICAL CHARACTERISTICS (Continued)**

XC9140 Voltage Chart 2

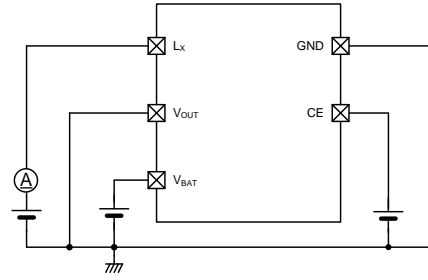
| SYMBOL               | E5                             |      | E6             |      | E7                   |       | E8                  |      |
|----------------------|--------------------------------|------|----------------|------|----------------------|-------|---------------------|------|
| PARAMETER            | Input Pin Current <sup>2</sup> |      | UVLO Current   |      | UVLO RELEASE VOLTAGE |       | UVLO Bypass Current |      |
| UNITS: V             | UNITS: $\mu$ A                 |      | UNITS: $\mu$ A |      | UNITS: V             |       | UNITS: $\mu$ A      |      |
| UVLO Release Voltage | TYP.                           | MAX. | TYP.           | MAX. | MIN.                 | MAX.  | TYP.                | MAX. |
| 1.65                 | 0.71                           | 1.50 | 3.25           | 6.00 | 1.601                | 1.699 | 2.15                | 4.10 |
| 1.70                 |                                |      |                |      | 1.649                | 1.751 |                     |      |
| 1.75                 | 0.73                           | 1.60 | 3.27           | 6.10 | 1.698                | 1.802 | 2.20                | 4.20 |
| 1.80                 |                                |      |                |      | 1.746                | 1.854 |                     |      |
| 1.85                 | 0.75                           | 1.60 | 3.29           | 6.20 | 1.795                | 1.905 | 2.30                | 4.20 |
| 1.90                 |                                |      |                |      | 1.843                | 1.957 |                     |      |
| 1.95                 | 0.77                           | 1.60 | 3.31           | 6.20 | 1.892                | 2.008 | 2.35                | 4.30 |
| 2.00                 |                                |      |                |      | 1.940                | 2.060 |                     |      |
| 2.05                 | 0.79                           | 1.70 | 3.33           | 6.30 | 1.989                | 2.111 | 2.40                | 4.30 |
| 2.10                 |                                |      |                |      | 2.037                | 2.163 |                     |      |
| 2.15                 | 0.82                           | 1.70 | 3.35           | 6.30 | 2.086                | 2.214 | 2.45                | 4.40 |
| 2.20                 |                                |      |                |      | 2.134                | 2.266 |                     |      |

## TEST CIRCUITS

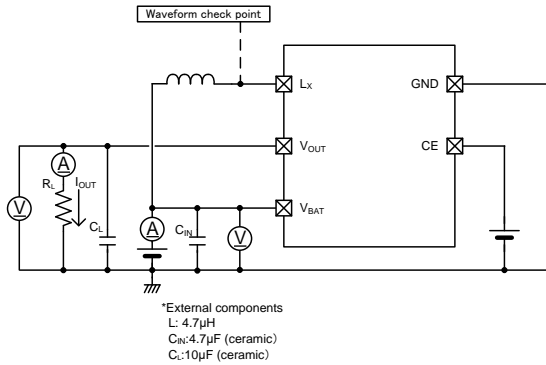
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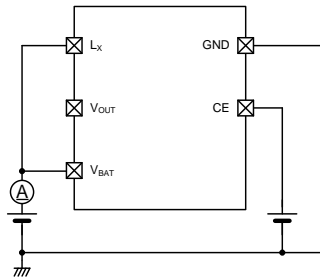
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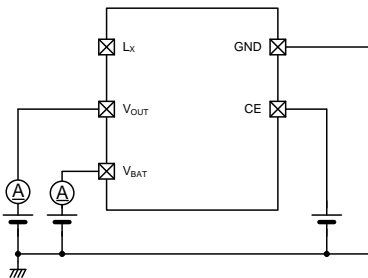
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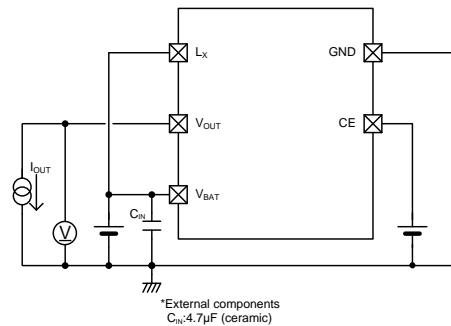
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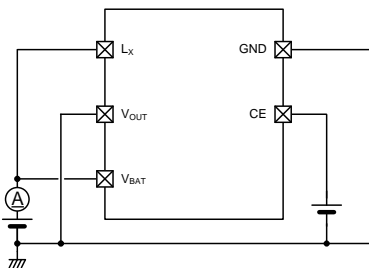
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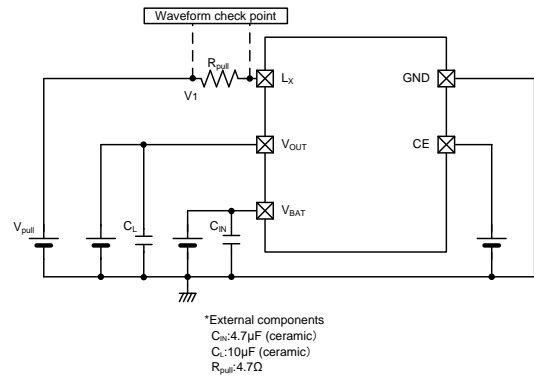
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< Test Circuit No.④ >



< Test Circuit No.⑧ >



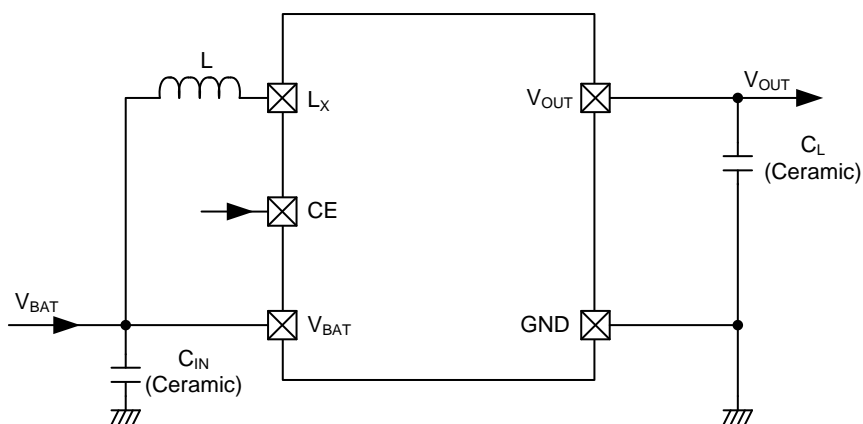
### <Lx SW "Nch" ON Resistance Measurement Method>

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  $L_x$  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



### 【Typical External Components】

|                 | MANUFACTURE | PRODUCT NUMBER | VALUE           |
|-----------------|-------------|----------------|-----------------|
| L               | TDK         | VLF302512M-4R7 | 4.7 $\mu$ H     |
|                 | Murata      | 1239AS-H-4R7M  | 4.7 $\mu$ H     |
| C <sub>IN</sub> | TAIYO YUDEN | LMK107BJ475MA  | 4.7 $\mu$ F/10V |
| C <sub>L</sub>  | TAIYO YUDEN | LMK107BJ106MA  | 10 $\mu$ F/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  $\mu$ H to 10  $\mu$ H can be used, but using 4.7  $\mu$ H is recommended.
- \* The ripple voltage will increase if tantalum or electrolytic capacitors are used for the load capacitor C<sub>L</sub>.  
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  $T_r$ , a Pch synchronous rectifier switch  $T_r$ , 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  $T_r$  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 >

① The 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  $T_r$  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  $T_r$ .

② The current sense circuit monitors the current flowing in the Nch driver  $T_r$  connected to the  $L_x$  pin when the Nch driver  $T_r$  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  $T_r$  and turn ON the Pch synchronous rectifier switch  $T_r$ .

③ The Pch synchronous rectifier switch  $T_r$  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  $T_r$  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  $T_r$  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/XC9140B 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 >

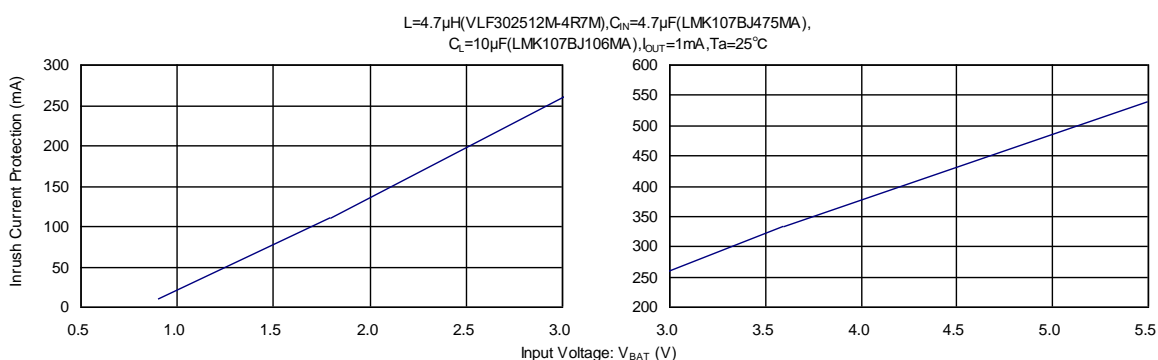
The  $V_{BAT}$ - $V_{OUT}$  voltage detection circuit compares the  $V_{BAT}$  pin voltage with the  $V_{OUT}$  pin voltage, and whichever is the highest is operated to become the IC power supply ( $V_{DD}$ ).

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.

### <Inrush Current Protection Function>

When the  $V_{BAT}$  or  $V_{CE}$  power supply is input,  $C_L$  is charged via the stable current that results from the inrush current protection function (refer to graphs below). Therefore, this function minimizes potential over current from the  $V_{BAT}$  pin to the  $V_{OUT}$  pin. Also, this current value depends on the  $V_{BAT}$  voltage. After  $C_L$  is charged by the aforementioned stable current and  $V_{OUT}$  reaches around the  $V_{BAT}$  voltage level, the inrush current protection function will be released after several hundred  $\mu s$  ~ several ms and the IC will then move to step-up mode, by pass mode or through mode.

### Inrush Current Protection Characteristics



## OPERATIONAL EXPLANATION (Continued)

### <UVLO Function >

The UVLO function is selectable on the XC9140 series as an option. When the V<sub>BAT</sub> pin voltage falls below the UVLO detect voltage, the IC stops switching or BYPASS operation and cuts off the current to the L<sub>X</sub> pin and V<sub>OUT</sub> pin (UVLO mode). In addition, when the V<sub>BAT</sub> pin voltage recovers to above the UVLO release voltage, the IC begins operating again.

### <C<sub>L</sub> Discharge Function>

With the XC9140B Series an optional C<sub>L</sub> discharge function can be selected. This function uses the Nch Tr connected between V<sub>OUT</sub> and GND to discharge, at high speed, the load capacity C<sub>L</sub> 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<sub>L</sub> when the IC is stopped.

The discharge time is determined by the C<sub>L</sub> discharge resistance R<sub>DCHG</sub>, including the Nch Tr, and C<sub>L</sub>. 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<sub>L</sub> discharge resistance R<sub>DCHG</sub> varies depending on the V<sub>BAT</sub> or V<sub>OUT</sub> 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<sub>OUT</sub>: Output voltage

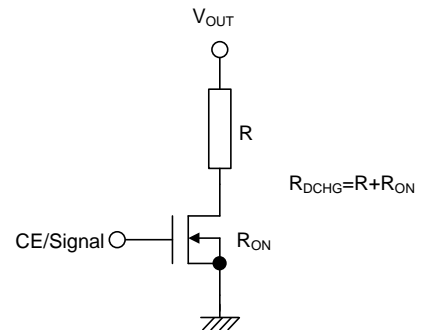
t: Discharge time

$\tau = C_L \times R_{DCHG}$

C<sub>L</sub>: Capacity value of the load capacitor (C<sub>L</sub>)

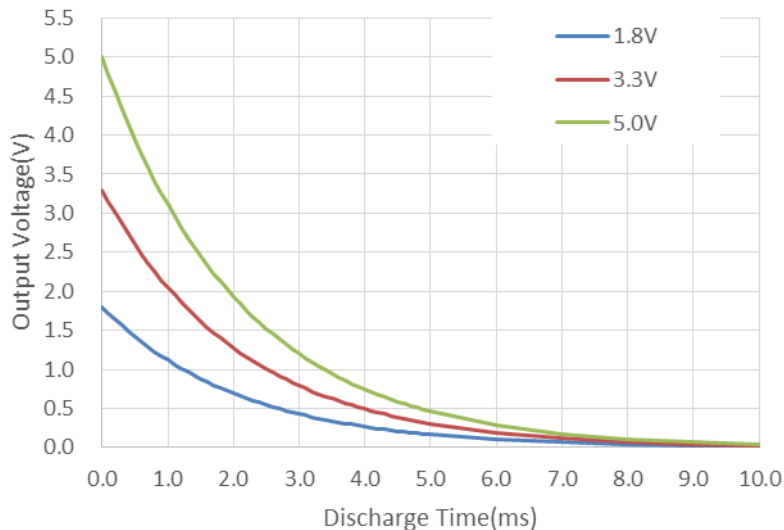
R<sub>DCHG</sub>: Low resistance value of the C<sub>L</sub> discharge resistance.

However, this changes depending on the voltage.



Output Voltage Discharge characteristics

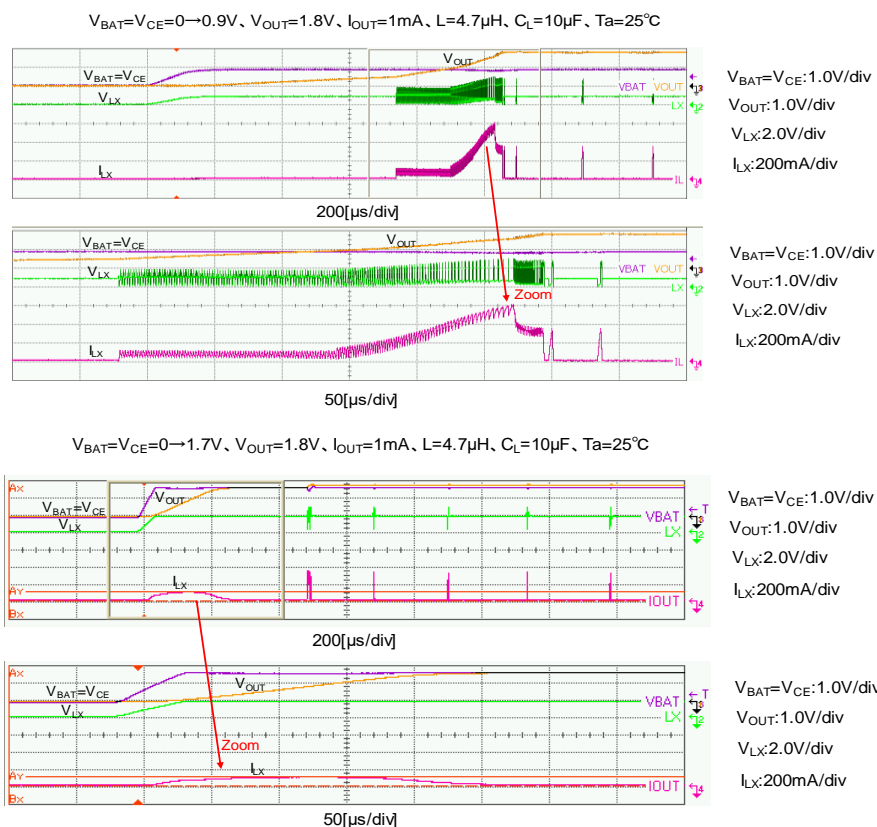
R<sub>DCHG</sub> = 210Ω (TYP.), C<sub>L</sub> = 10μF





## 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<sub>OUT</sub> pin. When an excessive current comes from the V<sub>OUT</sub> 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 4.7  $\mu$ H to 10  $\mu$ H, but 4.7  $\mu$ H 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 4.7  $\mu$ H 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)



15. If a different power supply is connected from an external source to the IC could be destroyed.  
Refer to the table below for external voltage availability for each product type and operating conditions.

|                                      | TYPE       | $0.9V \leq V_{BAT} \leq 5.5V$         |        | $V_{BAT} < 0.9V$ |        |
|--------------------------------------|------------|---------------------------------------|--------|------------------|--------|
|                                      |            | CE="L"                                | CE="H" | CE="H"           | CE="L" |
| Applied Voltage to the $V_{OUT}$ pin | XC9140Axx1 | Yes                                   | Yes    | No               | No     |
|                                      | XC9140Bxx1 | No<br>(CL Discharge Operation)        |        |                  |        |
|                                      | XC9140Cxx1 | No<br>(Reverse Flow toward the input) |        |                  |        |

|                                      | TYPE                  | $0.9V \leq V_{BAT} \leq 5.5V$<br>(UVLO Release State) |        | $0.9V \leq V_{BAT} < V_{RELEASE(E)}$<br>(UVLO Detect State) |                                | $V_{BAT} < 0.9V$ |        |
|--------------------------------------|-----------------------|---|--------|---|--------------------------------|------------------|--------|
|                                      |                       | CE="L"  | CE="H" | CE="H"  | CE="L"                         | CE="H"           | CE="L" |
| Applied Voltage to the $V_{OUT}$ pin | Other than XC9140Axx1 | Yes   | Yes    | Yes   | Yes                            | No               | No     |
|                                      | Other than XC9140Bxx1 | No<br>(CL Discharge Operation)                        |        | No<br>(CL Discharge Operation)                              | No<br>(CL Discharge Operation) |                  |        |
|                                      | Other than XC9140Cxx1 | No<br>(Reverse Flow toward the input)                 |        | Yes   | Yes                            |                  |        |

## ■ NOTE ON USE (Continued)

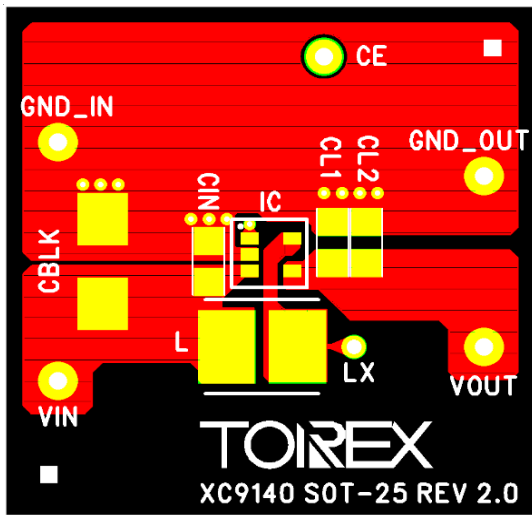
16. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.
17. Torex places an importance on improving our products and their reliability.  
We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.
18. When the  $V_{BAT}$  power supply or  $V_{CE}$  power supply is input, if the  $V_{OUT}$  pin voltage does not exceed  $V_{BAT} - 0.35V$ , which can happen due to the load current being more than the inrush protection current, by pass mode operations won't function correctly.
19. In the case of products with the UVLO function that do not have  $C_L$  discharge, the output voltage may occasionally rise due to leakage current from the Pch synchronous switch  $T_r$  when high-temperature UVLO mode operates.

## NOTE ON USE (Continued)

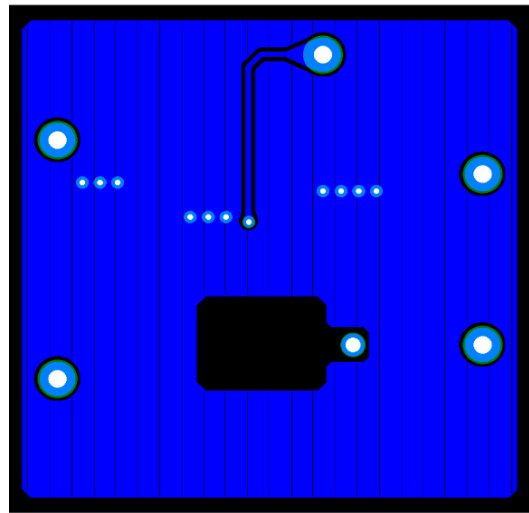
### ● Instructions of pattern layouts

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)

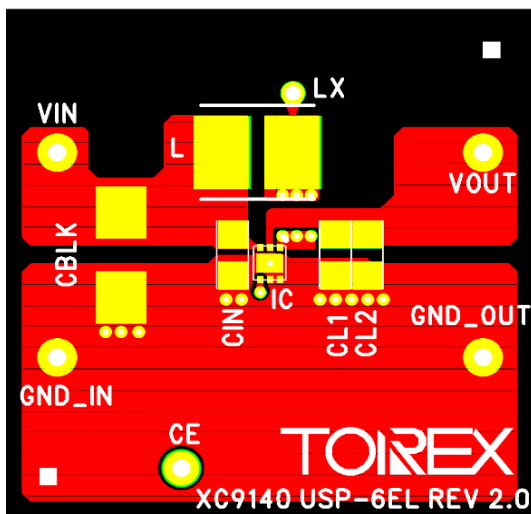


FRONT

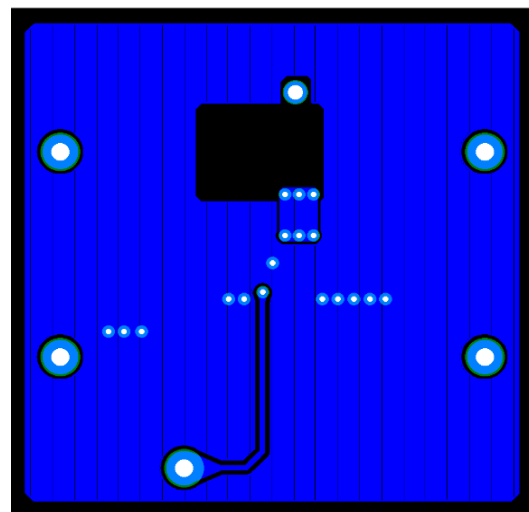


BACK

### ● Recommended Pattern Layout (USP-6EL)



FRONT

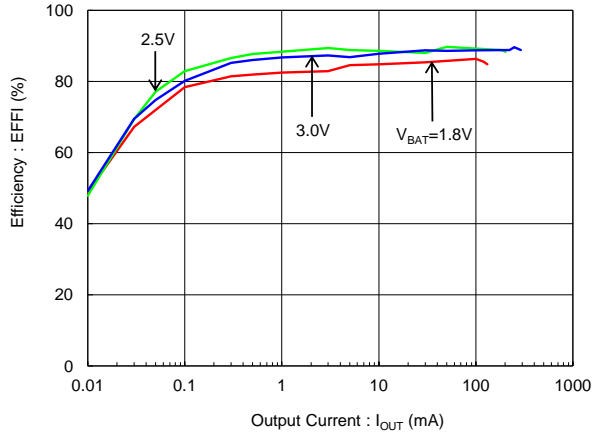


BACK

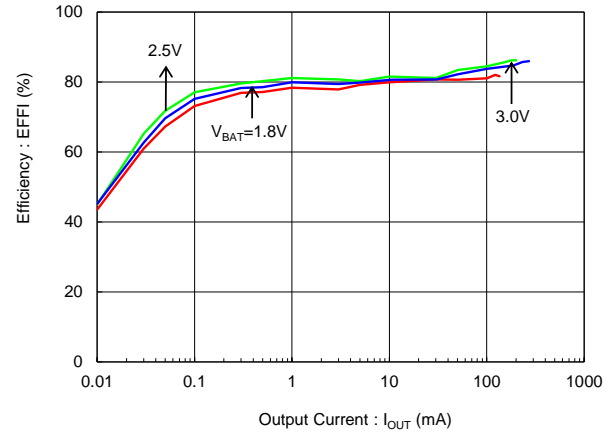
# TYPICAL PERFORMANCE CHARACTERISTICS

## (1) Efficiency vs. Output Current

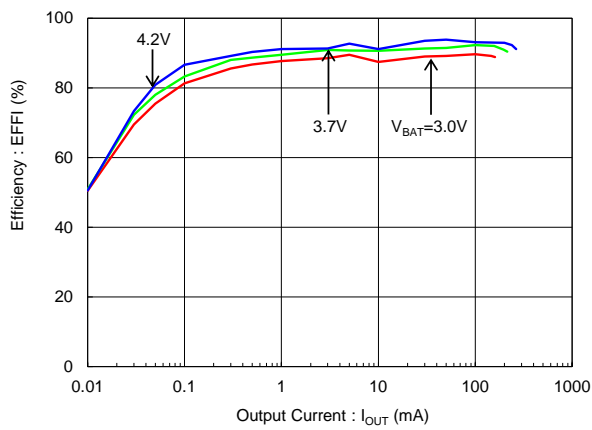
**XC9140A331MR-G(V<sub>OUT</sub>=3.3V)**  
L=4.7μH(VLF302512M-4R7M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA)



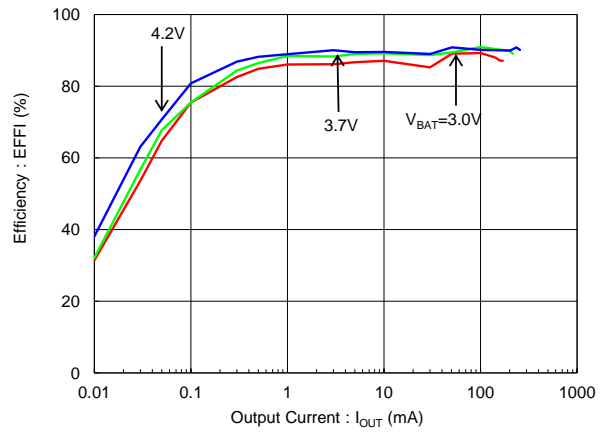
**XC9140A331MR-G(V<sub>OUT</sub>=3.3V)**  
L=10μH(VLF302512M-100M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA)



**XC9140A501MR-G(V<sub>OUT</sub>=5.0V)**  
L=4.7μH(VLF302512M-4R7M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA)

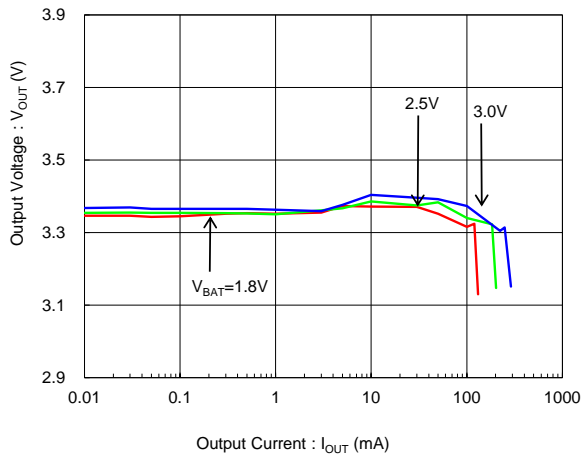


**XC9140A501MR-G(V<sub>OUT</sub>=5.0V)**  
L=10μH(VLF302512M-100M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA)

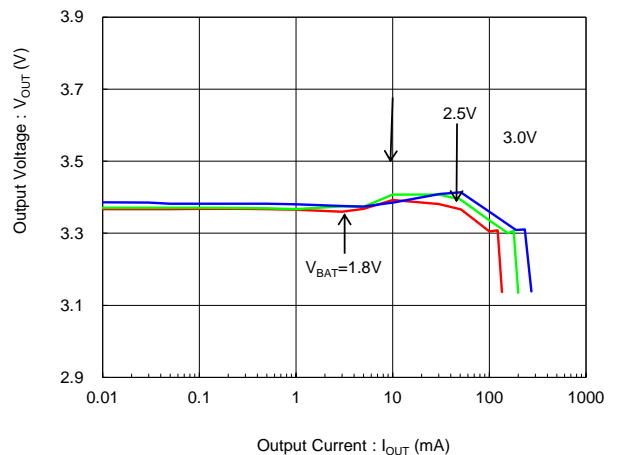


## (2) Output Voltage vs. Output Current

**XC9140A331MR-G(V<sub>OUT</sub>=3.3V)**  
L=4.7μH(VLF302512M-4R7M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA)

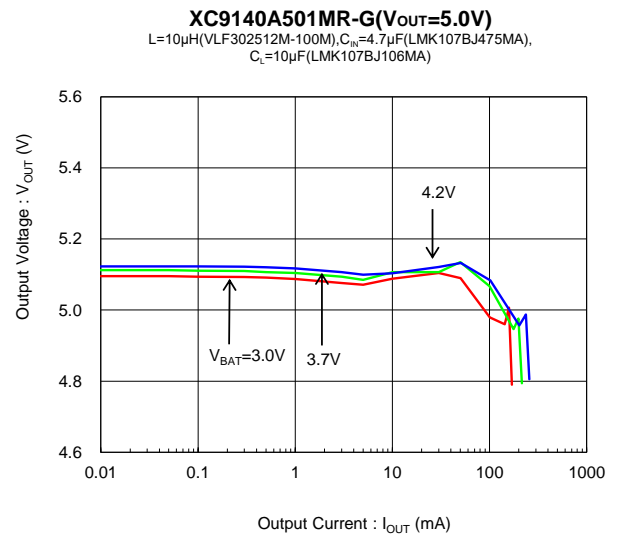
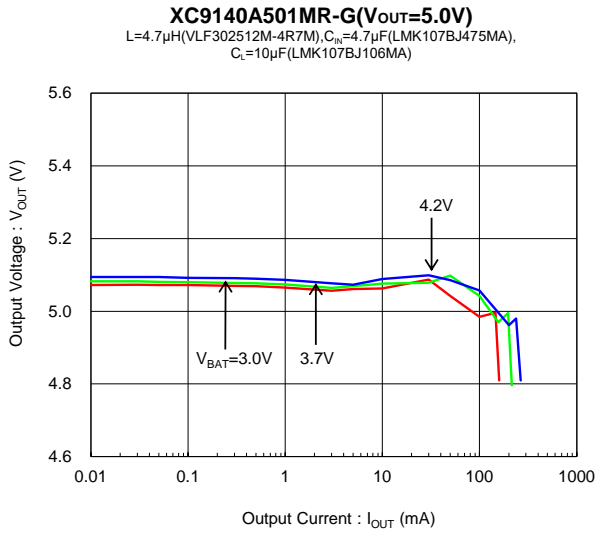


**XC9140A331MR-G(V<sub>OUT</sub>=3.3V)**  
L=10μH(VLF302512M-100M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA)

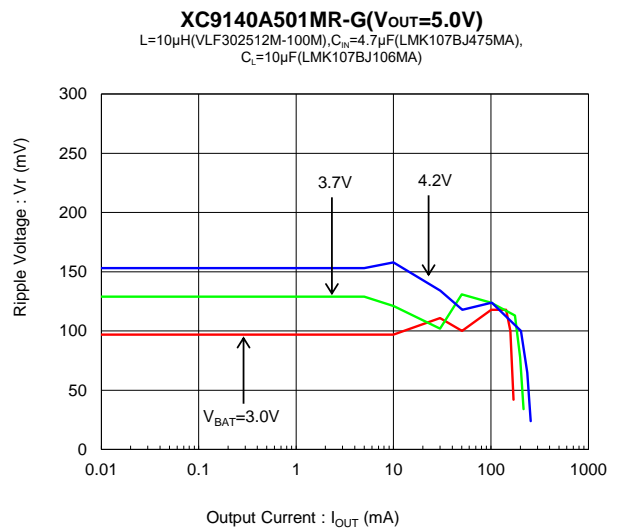
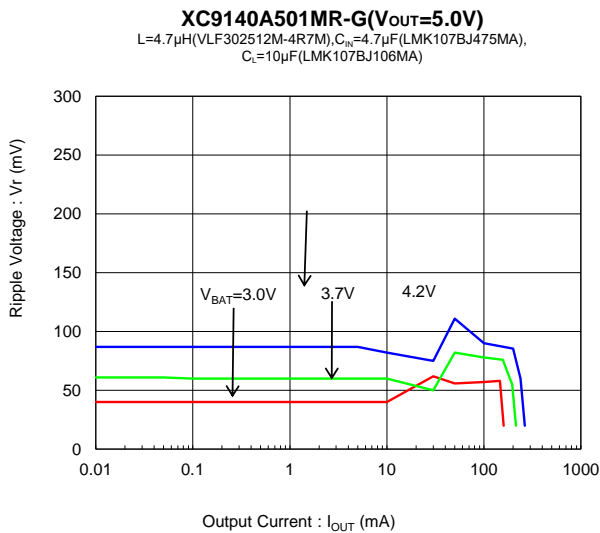
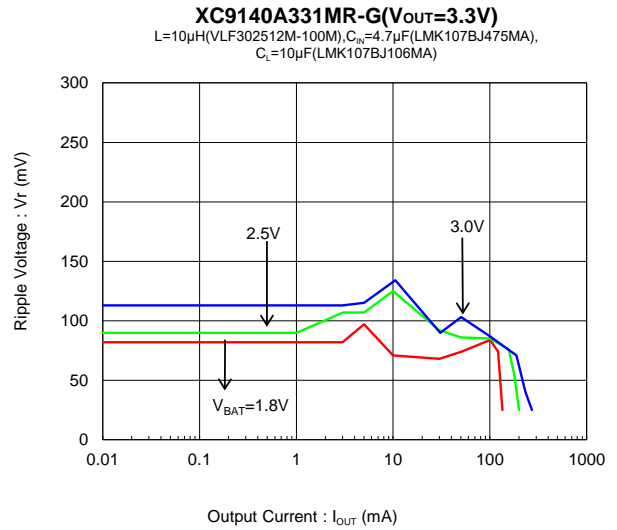
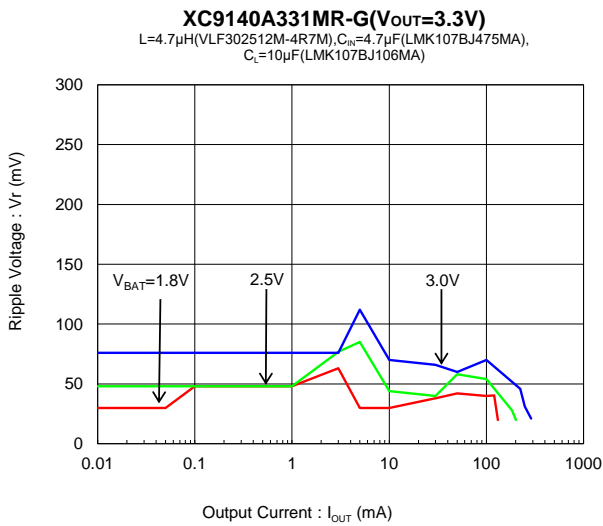


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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

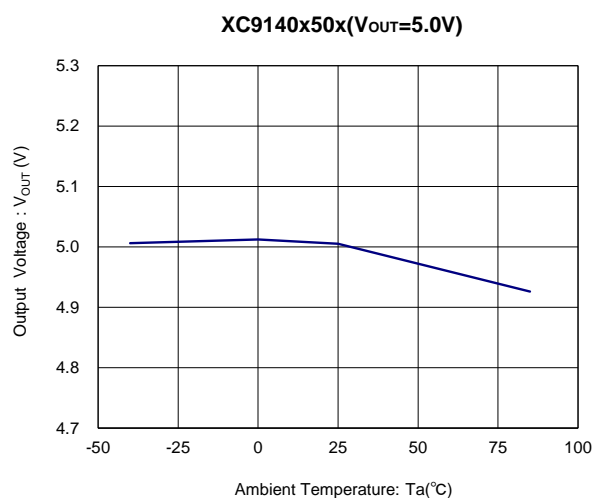


### (3) Ripple Voltage vs. Output Current

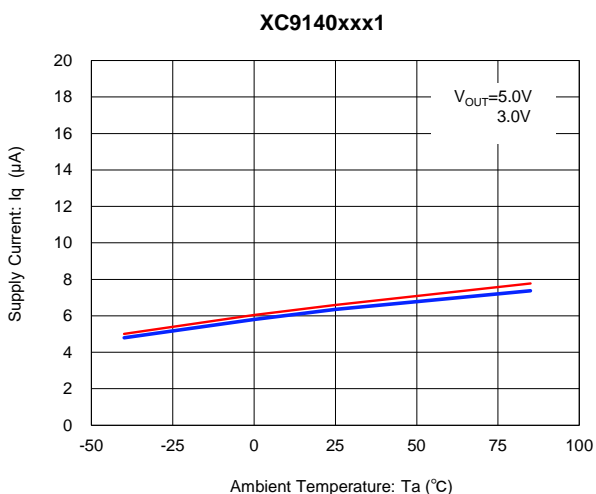


## ■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(4) Output Voltage vs. Ambient Temperature



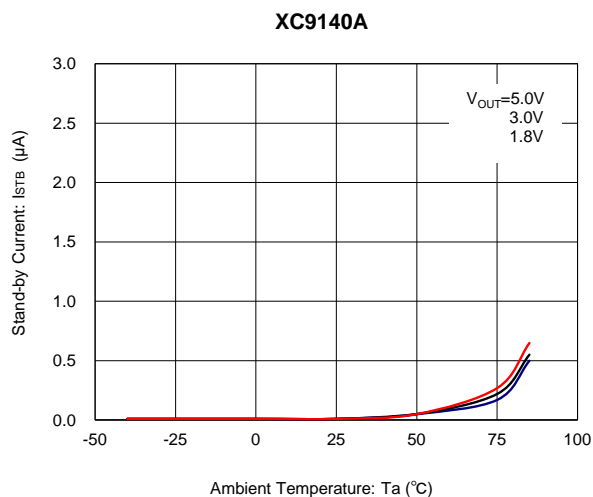
(5) Supply Current vs. Ambient Temperature



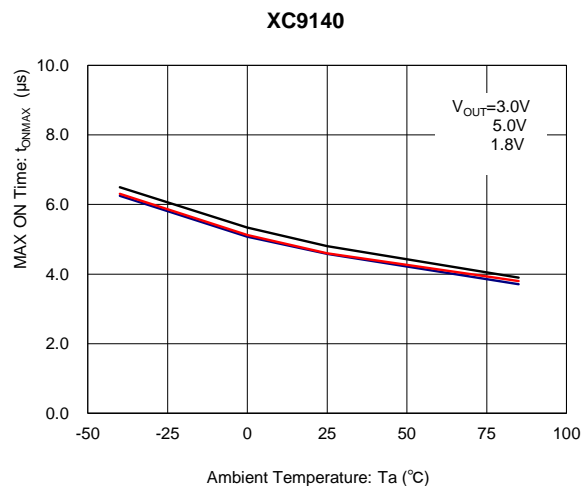
(6) Input Pin Current vs. Ambient Temperature



(7) Stand-by Current vs. Ambient Temperature



(8) MAX. ON Time vs. Ambient Temperature

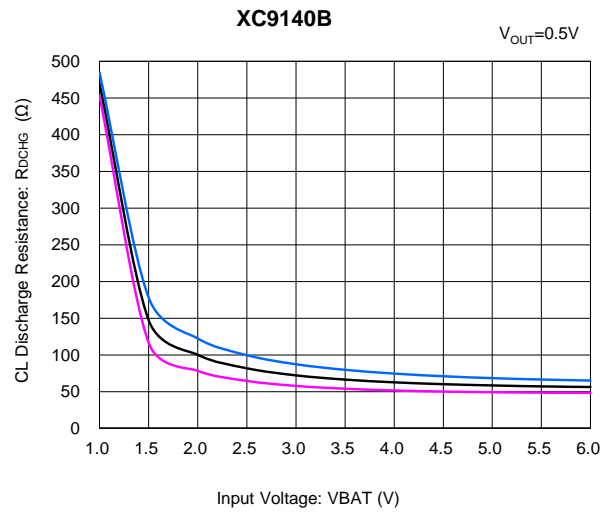


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

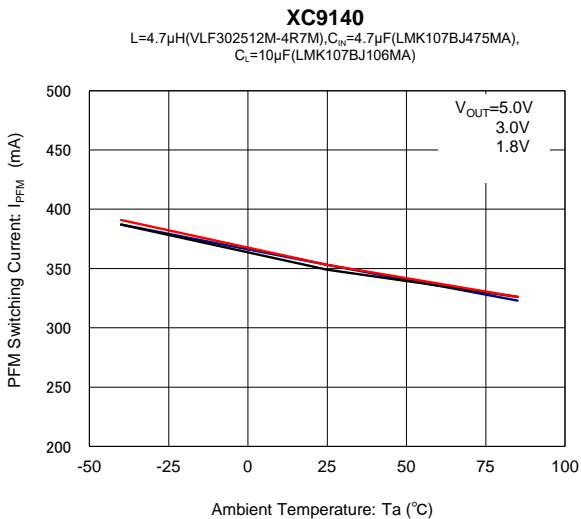
(9) CL Discharge Resistance  $R_{DCHG}$  vs. Output Voltage



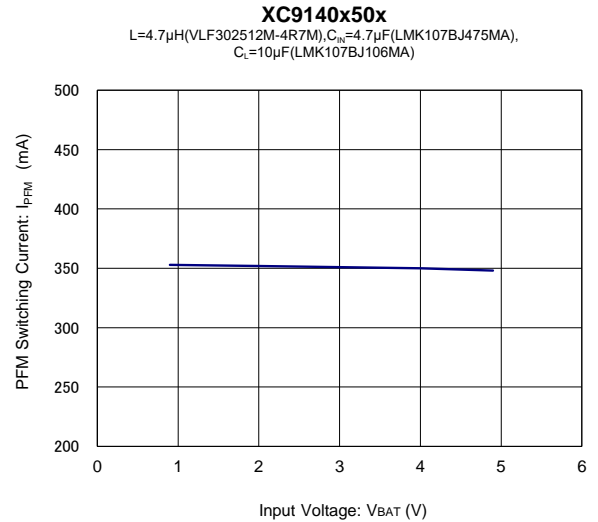
(10) CL Discharge Resistance  $R_{DCHG}$  vs. Input Voltage



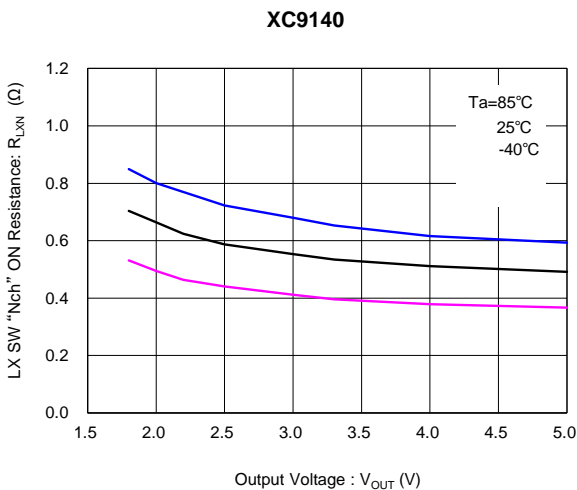
(11) PFM Switching Current vs. Ambient Temperature



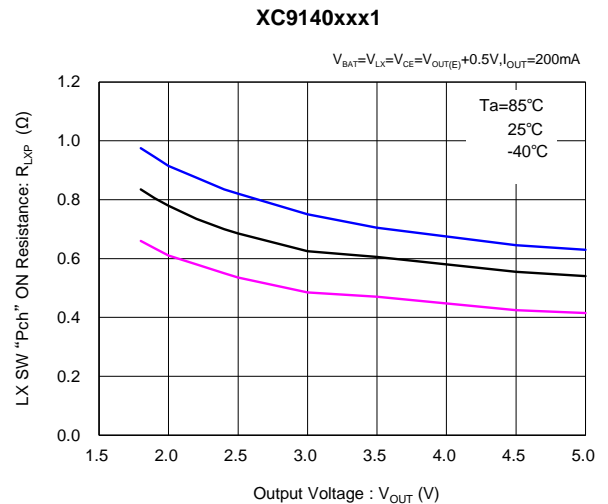
(12) PFM Switching Current vs. Input Voltage



(13) LX SW "Nch" ON Resistance vs. Output Voltage



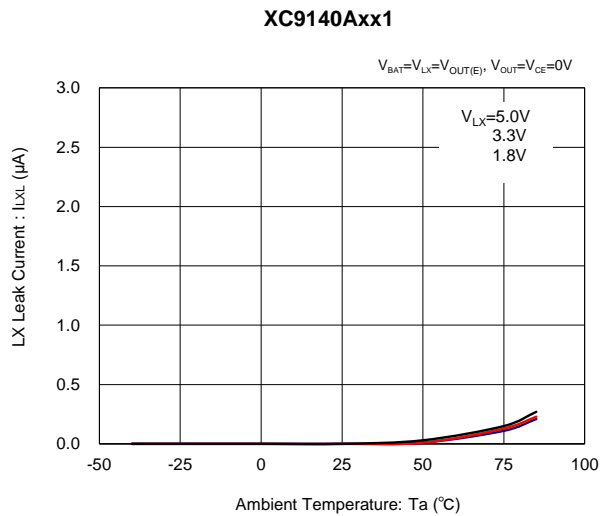
(14) LX SW "Pch" ON Resistance vs. Output Voltage



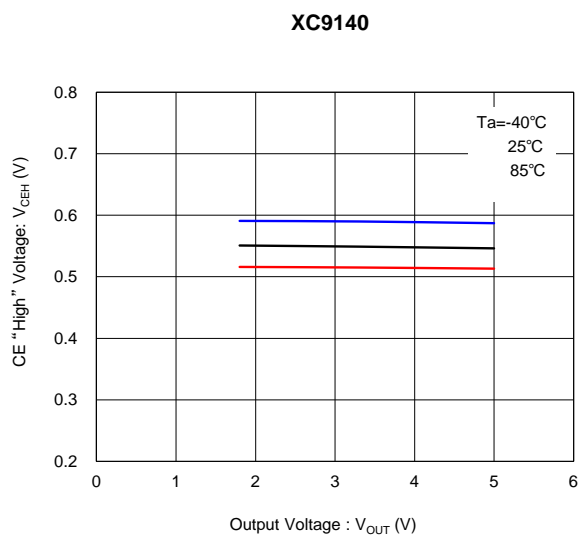


**TYPICAL PERFORMANCE CHARACTERISTICS (Continued)**

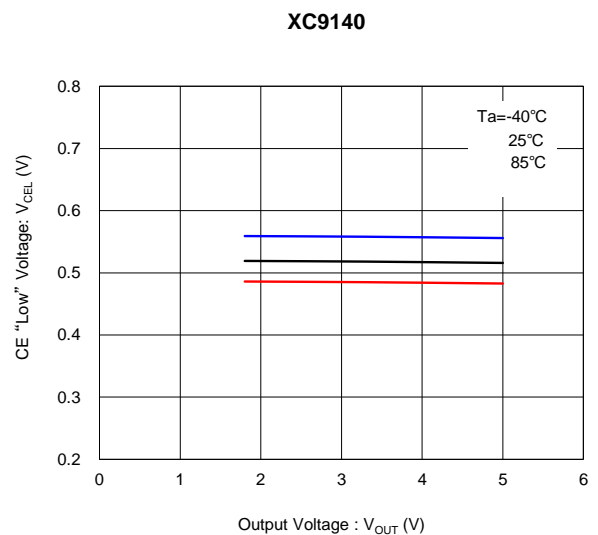
(15) Lx Leak Current vs. Ambient Temperature



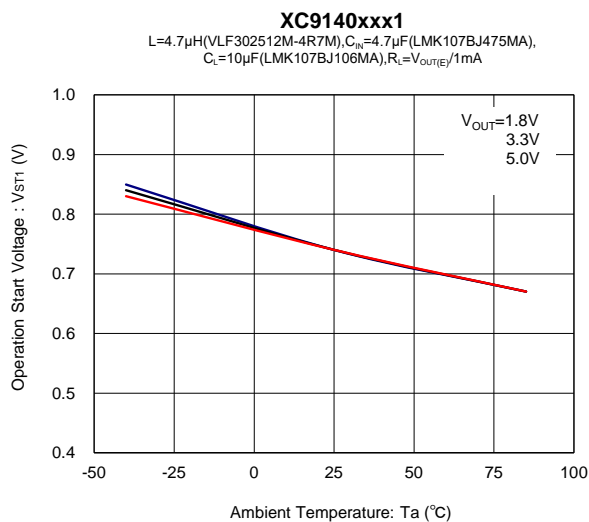
(16) CE "H" Voltage vs. Output Voltage



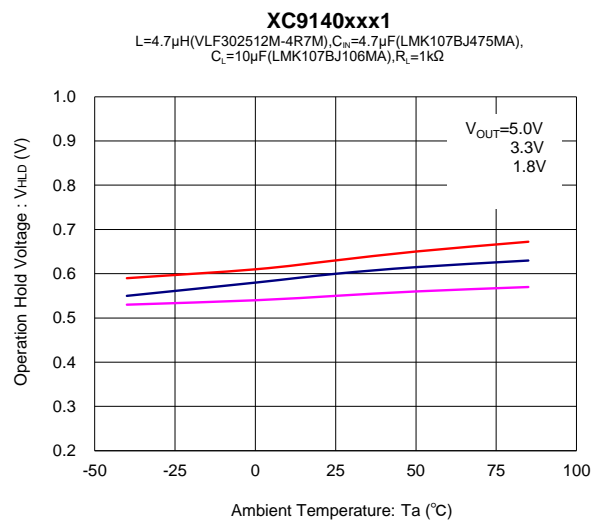
(17) CE "L" Voltage vs. Output Voltage



(18) Operation Start Voltage vs. Ambient Temperature



(19) Operation Hold Voltage vs. Ambient Temperature



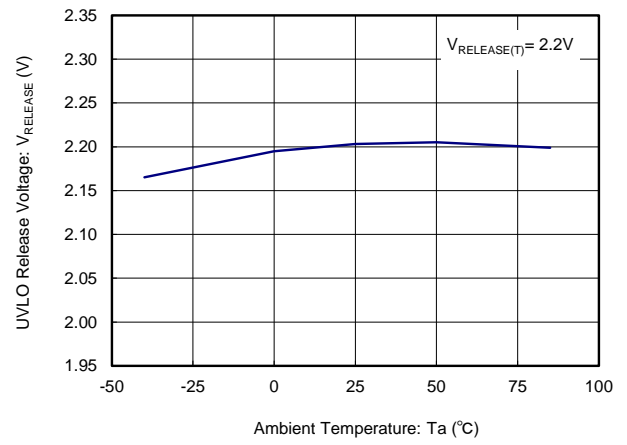
## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(20) UVLO Release Voltage vs. Ambient Temperature

**XC9140x18x(V<sub>OUT</sub>=1.8V)**



**XC9140x50x(V<sub>OUT</sub>=5.0V)**

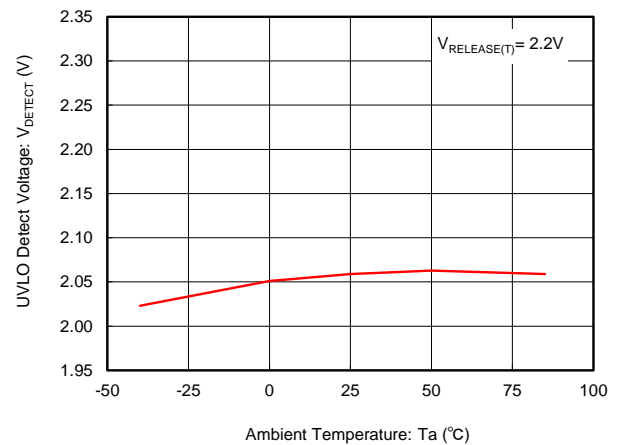


(21) UVLO Detect Voltage vs. Ambient Temperature

**XC9140x18x(V<sub>OUT</sub>=1.8V)**

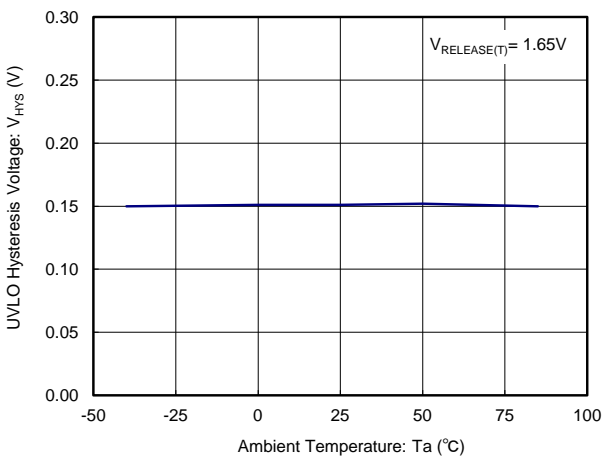


**XC9140x50x(V<sub>OUT</sub>=5.0V)**

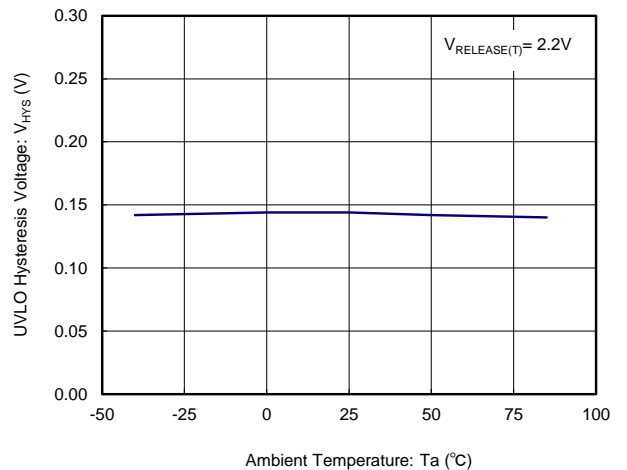


(22) UVLO Hysteresis Voltage vs. Ambient Temperature

**XC9140x18x(V<sub>OUT</sub>=1.8V)**



**XC9140x50x(V<sub>OUT</sub>=5.0V)**

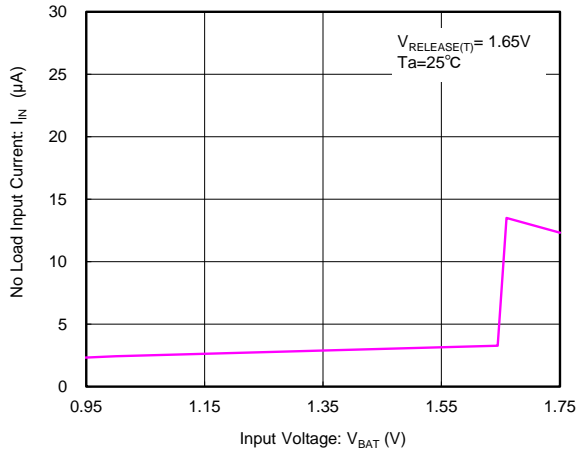


## ■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(23) No Load Input Current vs. Input Voltage

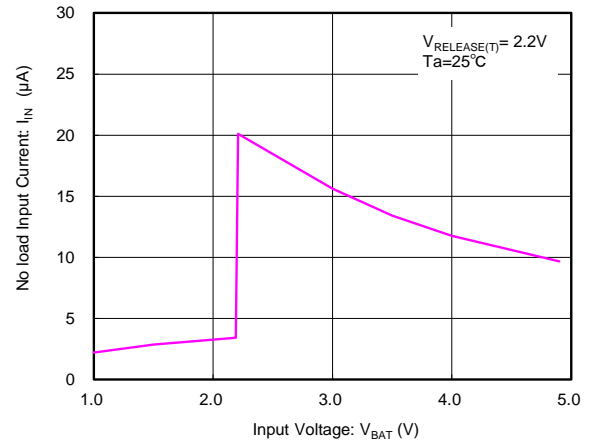
**XC9140x18x(V<sub>OUT</sub>=1.8V)**

L=4.7μH(VLF302512M-4R7M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA), V<sub>BAT</sub>= V<sub>CE</sub>, I<sub>OUT</sub>=0mA



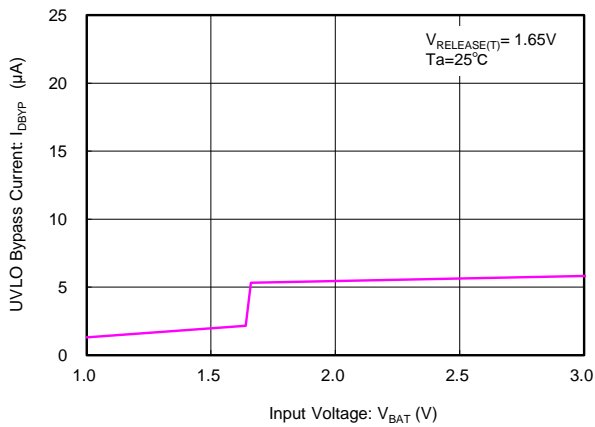
**XC9140x50x(V<sub>OUT</sub>=5.0V)**

L=4.7μH(VLF302512M-4R7M), C<sub>IN</sub>=4.7μF(LMK107BJ475MA),  
C<sub>L</sub>=10μF(LMK107BJ106MA), V<sub>BAT</sub>= V<sub>CE</sub>, I<sub>OUT</sub>=0mA

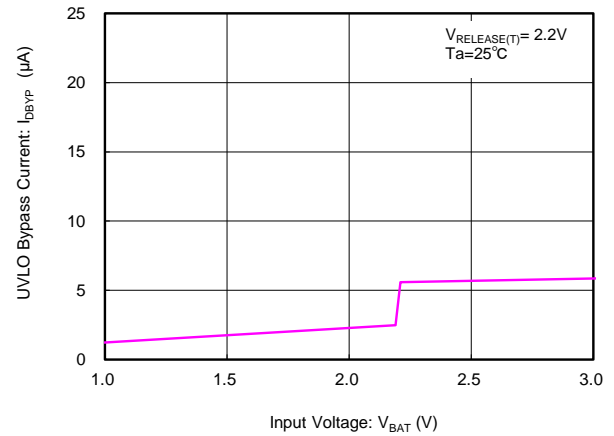


(24) UVLO Bypass Current vs. Input Voltage

**XC9140C18x(V<sub>OUT</sub>=1.8V)**



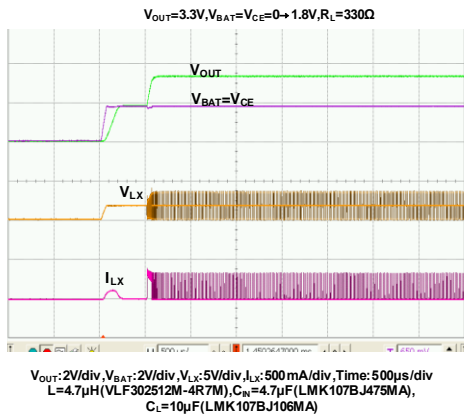
**XC9140C50x(V<sub>OUT</sub>=5.0V)**



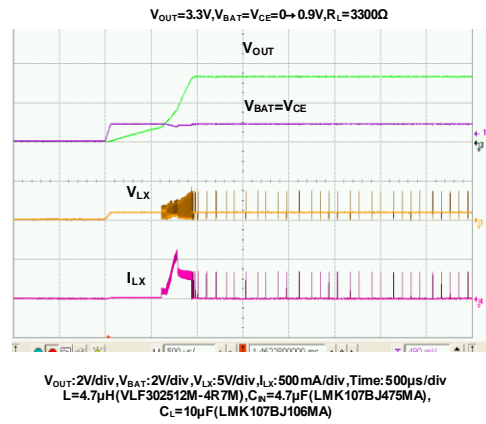
## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

### (25) Load Transient Response

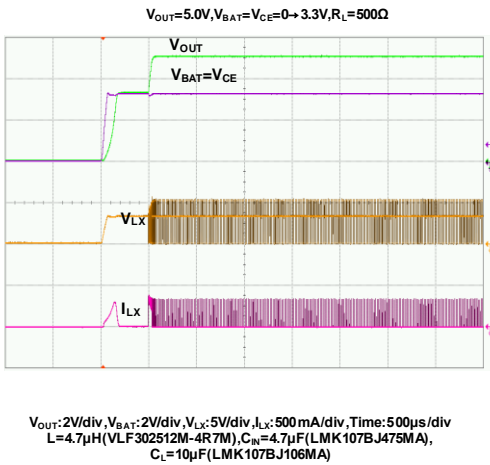
XC9140x331



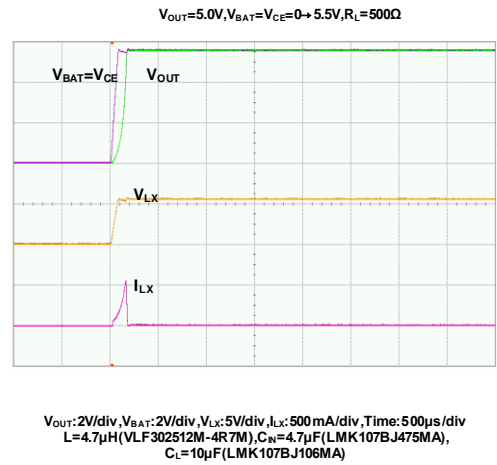
XC9140x331



XC9140x501



XC9140x501



## ■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

### (25) Load Transient Response

**XC9140x181**

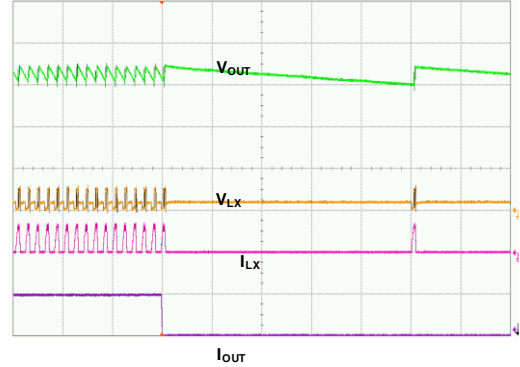
$V_{OUT}=1.8V, V_{BAT}=V_{CE}=0.9V, I_{OUT}=1mA \rightarrow 25mA$



$V_{OUT}: 100mV/div, V_{LX}: 5V/div, I_{LX}: 500mA/div, I_{OUT}: 25mA/div, Time: 50ns/div$   
 $L=4.7\mu H(VLF302512M-4R7M), C_N=4.7\mu F(LMK107BJ475MA),$   
 $C_L=10\mu F(LMK107BJ106MA)$

**XC9140x181**

$V_{OUT}=1.8V, V_{BAT}=V_{CE}=0.9V, I_{OUT}=25mA \rightarrow 1mA$



$V_{OUT}: 100mV/div, V_{LX}: 5V/div, I_{LX}: 500mA/div, I_{OUT}: 25mA/div, Time: 50\mu s/div$   
 $L=4.7\mu H(VLF302512M-4R7M), C_N=4.7\mu F(LMK107BJ475MA),$   
 $C_L=10\mu F(LMK107BJ106MA)$

**XC9140x331**

$V_{OUT}=3.3V, V_{BAT}=V_{CE}=1.8V, I_{OUT}=1mA \rightarrow 50mA$



$V_{OUT}: 100mV/div, V_{LX}: 5V/div, I_{LX}: 500mA/div, I_{OUT}: 50mA/div, Time: 50\mu s/div$   
 $L=4.7\mu H(VLF302512M-4R7M), C_N=4.7\mu F(LMK107BJ475MA),$   
 $C_L=10\mu F(LMK107BJ106MA)$

**XC9140x331**

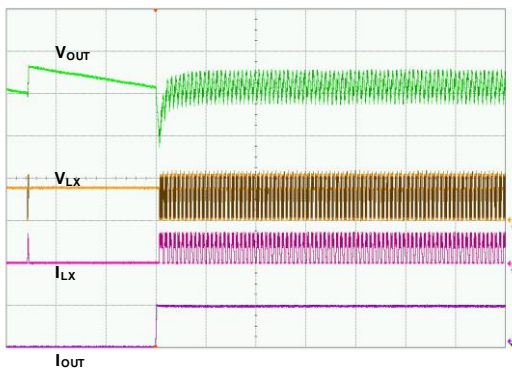
$V_{OUT}=3.3V, V_{BAT}=V_{CE}=1.8V, I_{OUT}=50mA \rightarrow 1mA$



$V_{OUT}: 100mV/div, V_{LX}: 5V/div, I_{LX}: 500mA/div, I_{OUT}: 50mA/div, Time: 50\mu s/div$   
 $L=4.7\mu H(VLF302512M-4R7M), C_N=4.7\mu F(LMK107BJ475MA),$   
 $C_L=10\mu F(LMK107BJ106MA)$

**XC9140x501**

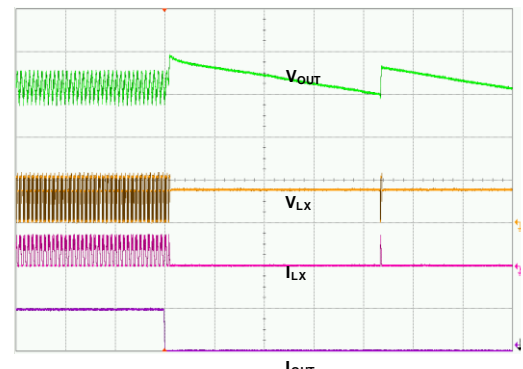
$V_{OUT}=5.0V, V_{BAT}=V_{CE}=3.7V, I_{OUT}=1mA \rightarrow 100mA$



$V_{OUT}: 100mV/div, V_{LX}: 5V/div, I_{LX}: 500mA/div, I_{OUT}: 100mA/div, Time: 50\mu s/div$   
 $L=4.7\mu H(VLF302512M-4R7M), C_N=4.7\mu F(LMK107BJ475MA),$   
 $C_L=10\mu F(LMK107BJ106MA)$

**XC9140x501**

$V_{OUT}=5.0V, V_{BAT}=V_{CE}=3.7V, I_{OUT}=100mA \rightarrow 1mA$



$V_{OUT}: 100mV/div, V_{LX}: 5V/div, I_{LX}: 500mA/div, I_{OUT}: 100mA/div, Time: 50\mu s/div$   
 $L=4.7\mu H(VLF302512M-4R7M), C_N=4.7\mu F(LMK107BJ475MA),$   
 $C_L=10\mu F(LMK107BJ106MA)$

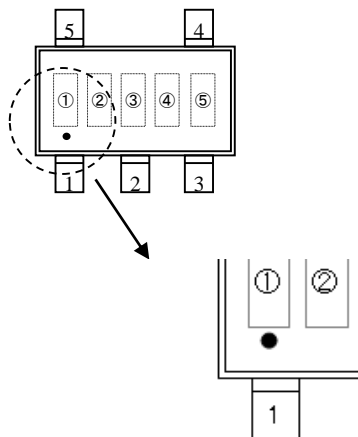
## ■ PACKAGING INFORMATION

For the latest package information go to, [www.torexsemi.com/technical-support/packages](http://www.torexsemi.com/technical-support/packages)

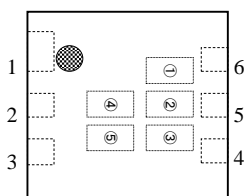
| PACKAGE | OUTLINE / LAND PATTERN      | THERMAL CHARACTERISTICS                   |
|---------|-----------------------------|---|
| SOT-25  | <a href="#">SOT-25 PKG</a>  | <a href="#">SOT-25 Power Dissipation</a>  |
| USP-6EL | <a href="#">USP-6EL PKG</a> | <a href="#">USP-6EL Power Dissipation</a> |

## MARKING RULE

● SOT-25 (with underline mark)



● USP-6EL



① represents product series

| MARK | PRODUCT SERIES                         | PKG               |
|------|--|-------------------|
| 4    | XC9140A**3/4/5/6/7/8/9/A/B/C/DM*-G     | SOT-25(under dot) |
| 3    | XC9140B**1/2/3/4/5/6/7/8/9/A/B/C/DM*-G | SOT-25(under dot) |
| 2    | XC9140C**3/4/5/6/7/8/9/A/B/C/DM*-G     | SOT-25(under dot) |
| 7    | XC9140A**3/4/5/6/7/8/9/A/B/C/D4*-G     | USP-6EL           |
| 3    | XC9140B**1/2/3/4/5/6/7/8/9/A/B/C/D4*-G | USP-6EL           |
| 2    | XC9140C**3/4/5/6/7/8/9/A/B/C/D4*-G     | USP-6EL           |

② represents output voltage

| MARK               |         | OUTPUT VOLTAGE |     | MARK               |         | OUTPUT VOLTAGE |     |
|--------------------|---------|----------------|-----|--------------------|---------|----------------|-----|
| XC9140A<br>XC9140C | XC9140B |                |     | XC9140A<br>XC9140C | XC9140B |                |     |
| 0                  | 5       | 1.8            | 3.5 | 9                  | R       | 2.7            | 4.4 |
| 1                  | 6       | 1.9            | 3.6 | A                  | S       | 2.8            | 4.5 |
| 2                  | 7       | 2.0            | 3.7 | B                  | T       | 2.9            | 4.6 |
| 3                  | 8       | 2.1            | 3.8 | C                  | U       | 3.0            | 4.7 |
| 4                  | 9       | 2.2            | 3.9 | D                  | V       | 3.1            | 4.8 |
| 5                  | L       | 2.3            | 4.0 | E                  | X       | 3.2            | 4.9 |
| 6                  | M       | 2.4            | 4.1 | F                  | Y       | 3.3            | 5.0 |
| 7                  | N       | 2.5            | 4.2 | H                  | Z       | 3.4            | -   |
| 8                  | P       | 2.6            | 4.3 |                    |         |                |     |

③ represents product function

| MARK | OUTPUT VOLTAGE | UVLO Release Voltage | PRODUCT SERIES  |
|------|----------------|----------------------|-----------------|
| 0    | 1.8~3.4V       | 2.20                 | XC9140***3**-G  |
| 1    | 3.5~5.0V       |                      |                 |
| 2    | 1.8~3.4V       | 2.00                 | XC9140***4**-G  |
| 3    | 3.5~5.0V       |                      |                 |
| 4    | 1.8~3.4V       | 1.80                 | XC9140***5**-G  |
| 5    | 3.5~5.0V       |                      |                 |
| 6    | 1.8~3.4V       | 1.65                 | XC9140***6**-G  |
| 7    | 3.5~5.0V       |                      |                 |
| 8    | 1.8~3.4V       | 1.70                 | XC9140***7**-G  |
| 9    | 3.5~5.0V       |                      |                 |
| A    | 1.8~3.4V       | 1.75                 | XC9140***8**-G  |
| B    | 3.5~5.0V       |                      |                 |
| C    | 1.8~3.4V       | 1.85                 | XC9140***9**-G  |
| D    | 3.5~5.0V       |                      |                 |
| E    | 1.8~3.4V       | 1.90                 | XC9140***A**-G  |
| F    | 3.5~5.0V       |                      |                 |
| H    | 1.8~3.4V       | 1.95                 | XC9140***B**-G  |
| K    | 3.5~5.0V       |                      |                 |
| L    | 1.8~3.4V       | 2.05                 | XC9140***C**-G  |
| M    | 3.5~5.0V       |                      |                 |
| N    | 1.8~3.4V       | 2.10                 | XC9140***D**-G  |
| P    | 3.5~5.0V       |                      |                 |
| R    | 1.8~3.4V       | No UVLO              | XC9140B***1**-G |
| S    | 3.5~5.0V       |                      |                 |
| T    | 1.8~3.4V       | 2.15                 | XC9140B***2**-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.