Synchronous Step-Up PFM DC/DC Converter

FEATURES

- **Operating Input Voltage Range**: 0.9 V ~ 5.5 V
- **Output Voltage Range**: 1.8 V ~ 5.0 V with (0.1 V increments, accuracy ± 2.0%)
- **Built-in Switching NMOSFET** (0.6 Ω) and Synchronous Rectification PMOSFET (0.65 Ω)
- **Low Operating Supply Current**: 6.3 μA
- **High Speed Transient Response**
- **Load Disconnect Function (IXD2140A)**
- **Bypass Mode (IXD2140C)**
- **Small Package**: SOT-25 and USP-6EL
- **EU RoHS Compliant, Pb Free**

APPLICATION

- Mouse, Keyboards
- Cameras, VCRs
- Remote Control
- Game Consoles

DESCRIPTION

The IXD2140 IC is a step-up synchronous PFM DC/DC converter with internal 0.6 Ω N-channel switching and 0.65 Ω P-channel synchronous rectifier transistors. PFM control enables a low quiescent current, making the IXD2140 ideal for portable devices that require high efficiency.

This IXD2140 converter maintains stable operation with low ESR ceramic capacitors at input and output.

The IXD2140 converter can start from 0.9 V input voltage if the output voltage is set to 3.3 V and load current is less than 1 mA, which allows use of the IXD2140 converter in applications powered from a single alkaline or nickel-metal hydride battery.

The output voltage is factory preset from 1.8 V to 5.0 V (± 2.0%) in steps of 0.1 V.

The Load Disconnect Function to break continuity between the input and output at shutdown protects both battery and load from uncontrolled operation (IXD2140A).

A bypass mode function to maintain continuity between the input and output (IXD2140C) keeps battery connected to load, if it is important.

TYPICAL APPLICATION CIRCUIT

![TYPICAL APPLICATION CIRCUIT](image)

TYPICAL PERFORMANCE CHARACTERISTIC

**Efficiency vs. Output Current**
IXD2140A331MR-G, \( V_{OUT} = 3.3 \) V
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>RATINGS</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>V&lt;sub&gt;OUT&lt;/sub&gt; Voltage</td>
<td>V&lt;sub&gt;OUT&lt;/sub&gt;</td>
<td>−0.3 ~ 7.0</td>
<td>V</td>
</tr>
<tr>
<td>Lx Pin Voltage</td>
<td>V&lt;sub&gt;Lx&lt;/sub&gt;</td>
<td>−0.3 ~ V&lt;sub&gt;OUT&lt;/sub&gt; + 0.3 or 7.0 V&lt;sup&gt;1&lt;/sup&gt;</td>
<td>V</td>
</tr>
<tr>
<td>Lx Pin Current</td>
<td>I&lt;sub&gt;Lx&lt;/sub&gt;</td>
<td>700 mA</td>
<td></td>
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<tr>
<td>BAT Pin Voltage</td>
<td>V&lt;sub&gt;BAT&lt;/sub&gt;</td>
<td>−0.3 ~ 7.0</td>
<td>V</td>
</tr>
<tr>
<td>CE Pin Voltage</td>
<td>V&lt;sub&gt;CE&lt;/sub&gt;</td>
<td>−0.3 ~ 7.0</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>P&lt;sub&gt;D&lt;/sub&gt;</td>
<td>250 mW</td>
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<tr>
<td>Operating Temperature Range</td>
<td>T&lt;sub&gt;OPR&lt;/sub&gt;</td>
<td>−40 ~ +85 °C</td>
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</tr>
<tr>
<td>Storage Temperature Range</td>
<td>T&lt;sub&gt;STG&lt;/sub&gt;</td>
<td>−55 ~ +125 °C</td>
<td></td>
</tr>
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</table>

Note:  
* All voltages measured in respect to GND.  
1) The maximum value should be either V<sub>OUT</sub> + 0.3 V, or +7.0 V, which is the lowest.

### ELECTRICAL OPERATING CHARACTERISTICS

**IXD2140A/C**  
Ta = 25 °C

#### PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNIT | CIRCUIT
---|---|---|---|---|---|---|---
Input Voltage | V<sub>BAT</sub> | | 5.5 | V | | |
Output Voltage | V<sub>OUT(T)</sub> | V<sub>FULL</sub> = 1.5 V, Voltage to start oscillations, while V<sub>OUT</sub> is decreasing | E1 | V | | |
Operating Start Voltage<sup>3)</sup> | V<sub>ST</sub> | I<sub>OUT</sub> = 1 mA, | - | 0.9 | V | | |
Operating Stop Voltage<sup>4)</sup> | V<sub>HS</sub> | - | 0.7 | V | | |
Supply Current | I<sub>Q</sub> | Oscillations stop, V<sub>OUT</sub> = V<sub>OUT(T)</sub> + 0.5 V<sup>1)</sup> | E2 | µA | | |
Input Pin Current | I<sub>BAT</sub> | | - | 0.25 | 1.0 µA | | |
Standby Current | I<sub>STBA</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> = 0 | - | 0.1 | 1.0 µA | | |
| | I<sub>STBC</sub> | V<sub>BAT</sub> = V<sub>Lx</sub> = 5.5 V, V<sub>CE</sub> = 0 | - | 3.5 | 6.1 µA | | |
Lx Leakage Current | I<sub>LX</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> = 0 | - | 0.1 | 1.0 µA | | |
Switching Current Limit | I<sub>PM</sub> | I<sub>OUT</sub> = 3 mA | 295 | 350 | 405 mA | | |
Maximum ON Time | I<sub>ON MAX</sub> | V<sub>FULL</sub> = 1.5 V, V<sub>OUT</sub> = V<sub>OUT(T)</sub> + 0.98<sup>1)</sup> | 3.1 | 4.6 | 6.0 µs | | |
Lx P-Channel Switch ON Resistance<sup>3)</sup> | R<sub>LXP</sub> | V<sub>BAT</sub> = V<sub>Lx</sub> = V<sub>CE</sub> = V<sub>OUT(T)</sub> + 0.5 V<sup>1)</sup> | E3 | Ω | | |
| | | I<sub>OUT</sub> = 200 mA | | | | |
Lx N-Channel Switch ON Resistance<sup>3)</sup> | R<sub>LNN</sub> | V<sub>BAT</sub> = V<sub>CE</sub> = 3.3 V, V<sub>OUT</sub> = 1.7 V | 0.6 | Ω | | |
CE “High” Voltage | V<sub>CEH</sub> | V<sub>BAT</sub> = V<sub>FULL</sub> = 1.5 V, V<sub>OUT</sub> = V<sub>OUT(T)</sub> + 0.98<sup>1)</sup> | 0.75<sup>5)</sup> | 5.5 | V | | |
| | | I<sub>OUT</sub> = 30 mA | | | | |
CE “Low” Voltage | V<sub>CEL</sub> | V<sub>BAT</sub> = V<sub>FULL</sub> = 1.5 V, V<sub>OUT</sub> = V<sub>OUT(T)</sub> + 0.98<sup>1)</sup> | 0 | 0.3<sup>7)</sup> V | | |
CE “High” Current | I<sub>CEH</sub> | V<sub>BAT</sub> = V<sub>CE</sub> = V<sub>Lx</sub> = V<sub>OUT</sub> = 5.5 V | -0.1 | 0.1 µA | | |
CE “Low” Current | I<sub>CEL</sub> | V<sub>BAT</sub> = V<sub>CE</sub> = V<sub>Lx</sub> = V<sub>OUT</sub> = 5.5 V, V<sub>CE</sub> = 0 V | -0.1 | 0.1 µA | | |
Efficiency<sup>4)</sup> | EFFI | V<sub>BAT</sub> = V<sub>CE</sub> = 1.8 V, V<sub>OUT(T)</sub> = 2.5 V<sup>1)</sup>, I<sub>OUT</sub> = 30 mA | 81 | % | | |
Efficiency<sup>4)</sup> | EFFI | V<sub>BAT</sub> = V<sub>CE</sub> = 1.8 V, V<sub>OUT(T)</sub> = 3.3 V<sup>1)</sup>, I<sub>OUT</sub> = 30 mA | 85 | % | | |
Efficiency<sup>4)</sup> | EFFI | V<sub>BAT</sub> = V<sub>CE</sub> = 1.8 V, V<sub>OUT(T)</sub> = 5.0 V<sup>1)</sup>, I<sub>OUT</sub> = 30 mA | 86 | % | | |

**NOTE:**  
1) V<sub>OUT(T)</sub> - Nominal Output Voltage  
2) V<sub>OUT(T)</sub> - Effective Output Voltage, ripple component including.  
3) R<sub>LXX</sub> = (V<sub>Lx</sub> - V<sub>CE</sub>) / 200 mA  
4) EFFI = [(Output Voltage) × (Output Current)] / [(Input Voltage) × (Input Current)] × 100%  
5) R<sub>LXX</sub> measurement method is shown in the circuit diagram.  
6) Minimum Input voltage, at which output voltage reach programmed value  
7) Maximum Input voltage, at which output voltage falls below programmed value
## ELECTRICAL OPERATING CHARACTERISTICS (Continued)

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>OUTPUT VOLTAGE</th>
<th>SUPPLY CURRENT</th>
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<td>UNITS, µA</td>
<td>UNITS, Ω</td>
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<td>5.0</td>
<td>4.900</td>
<td>5.100</td>
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</table>

### PIN CONFIGURATION

The dissipation pad for the USP-6EL package should be solder-plated in recommended mount pattern and metal masking to enhance mounting strength and heat release. If the pad needs to be connected to other pins, it should be connected to the pin No.6 (GND).

### PIN ASSIGNMENT

<table>
<thead>
<tr>
<th>PIN NUMBER</th>
<th>USP-6EL</th>
<th>SOT-25</th>
<th>PIN NAME</th>
<th>FUNCTIONS</th>
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<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>1</td>
<td>L&lt;sub&gt;x&lt;/sub&gt;</td>
<td>Switching Node</td>
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<td>2</td>
<td>4</td>
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<td>V&lt;sub&gt;out&lt;/sub&gt;</td>
<td>Output Voltage</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>V&lt;sub&gt;bat&lt;/sub&gt;</td>
<td>Power Input</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>4</td>
<td>CE</td>
<td>Chip Enable; CE = LOW – standby mode, CE = High – Active mode</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>5</td>
<td>NC</td>
<td>No Connection</td>
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<td>6</td>
<td>2</td>
<td>6</td>
<td>GND</td>
<td>Ground</td>
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</tbody>
</table>
Diodes inside the circuits are ESD protection diodes and parasitic diodes. The IXD2140A and IXD2140C do not have the $C_L$ discharge function. The IXD2140Axx1 and IXD2140Cxx1 do not have the UVLO function.

**BASIC OPERATION**

The IXD2140 IC consists of a Reference Voltage source, a PFM comparator; an N-channel switching transistor, a P-channel synchronous rectifier transistor, a current sense circuit, a PFM control circuit, a CE control circuit, and other blocks (refer to the block diagram).

The IXD2140 operates in a burst mode to maximize efficiency at wide range of the input voltages and output currents. In addition, this mode guarantees excellent transient response, which allows use of small ceramic capacitors to create a compact, high-performance boost DC/DC converter.

The synchronous rectification allows utilize maximum energy stored in inductor to achieve high efficiency at low and high load.

However, burst mode is associated with ripple noise at the output voltage required to trip PFM comparator. Therefore, effective output voltage $V_{OUT(E)}$ includes ripple component that should be taken into consideration by designers and carefully evaluated before using in the actual product. Typical curves for $L_X$ and $V_{OUT}$ pins shown below.

$V_{BAT} = V_{CE} = 2.0 \, V$, $V_{OUT} = 3.3 \, V$, $I_{OUT} = 20 \, mA$, $L = 4.7 \, \mu H$, $C_L = 10 \, \mu F$, $T_a = 25^\circ C$

$V_{BAT} = V_{CE} = 2.0 \, V$, $V_{OUT} = 3.3 \, V$, $I_{OUT} = 70 \, mA$, $L = 4.7 \, \mu H$, $C_L = 10 \, \mu F$, $T_a = 25^\circ C$

**Reference Voltage Source ($V_{REF}$)**

The Reference Voltage source provides the internal reference to ensure stable output voltage of the DC/DC converter.
**PFM Comparator**

The PFM Comparator compares reference voltage with feedback signal, which is an output voltage divided by internal resistive divider. If value of the feedback signal falls below $V_{REF}$, PFM Comparator turns on PFM Controller to start pulse sequence and charge output capacitor $C_L$. When value of the feedback signal becomes higher than $V_{REF}$, PFM Comparator turns off PFM Controller, which stops pulse sequence.

**Current Sense circuit**

The current sense circuit monitors the inductor current flowing through the N-channel transistor connected to the $L_X$ pin, when this transistor is ON.

When inductor current becomes equal $I_{PFM}$ value, Current Sense circuit sends signal to the PFM Controller, which turns OFF the N-channel transistor and turns ON the P-channel synchronous rectifier transistor. However, if the load becomes much larger than the energy provided by converter, the $V_{OUT}$ voltage falls below $V_{BAT}$ voltage. At this condition, controller cannot regulate inductor current, which may exceed $I_{PFM}$ value and destroy P-channel transistor.

**PFM Controller**

The PFM Controller operates N-channel and P-channel transistors through Buffer Driver to keep output voltage stable, adjusting on/off time dynamically in respect to load. If energy provided to the load in a single pulse is enough to trigger PFM comparator, PFM controller stops generating pulses until output voltage falls below PFM Comparator's threshold. After that, PFM controller generates next pulse. Pulse frequency depends on load, increasing with the load current. However, at high load, energy provided to the load in a single pulse may be not enough to trigger PFM comparator, and next pulse will be generated immediately after $V_{LX}$ pin voltage falls below $V_{OUT}$. At this condition, IXD2140 operates in continues conduction mode generating sequence of pulses until PFM Comparator will be triggered by rising output voltage.

**Load Disconnection Function, Bypass Mode**

When the CE pin is in a logic LOW state, the IXD2140 enters into standby mode and stops circuits required for the boost operation.

In the standby mode, the IXD2140A turns off both the N- and P-channel transistors, which cuts off the path for current between $L_X$ and $V_{OUT}$ pins, disconnecting load from voltage source. The parasitic diode control circuit connects the cathode of parasitic P-channel synchronous rectifier transistor's diode to the $L_X$ pin, preventing current flow into the load (See figure 1).

In the standby mode, the IXD2140C version turns the N-channel transistor off, but the P-channel synchronous rectifier transistor remains on, when $V_{LX} > V_{OUT}$, and the parasitic diode control circuit connects the cathode of parasitic P-channel synchronous rectifier transistor’s diode to the $V_{OUT}$ pin (See figure 2). If $V_{LX} < V_{OUT}$, the P channel synchronous rectifier transistor is OFF and the parasitic diode cathode connected to the $V_{OUT}$ pin prevents $C_L$ to discharge into $V_{BAT}$ source. However, during initial ~500 µs after power up, the IXD2140C parasitic diode is connected as shown at figure 1, even if CE pin is logic LOW. After that, normal operations start.

![Figure 1](image1.png)

**$V_{BAT}$ - $V_{OUT}$ 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 used as the IC power supply ($V_{DD}$).

In addition, if, during normal operation, the input voltage becomes higher than the output voltage, the PFM Controller turns N-channel transistor off and the P-channel synchronous rectifier transistor on so that the input...
voltage passes through to the output. 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 in the standby mode in IXD2140A version.

**Inrush Current Protection Circuitry**

This circuitry limits inrush current from the \( V_{\text{LX}} \) pin to the \( V_{\text{OUT}} \) pin, charging \( C_L \) capacitor with stable current after \( V_{\text{BAT}} \) voltage applied, until \( V_{\text{OUT}} \) voltage reaches close to \( V_{\text{BAT}} \). After that, Inrush Current Protection circuitry disables with several hundred \( \mu \text{s} \) ~ several ms delay time, and the IC becomes operational. The IXD2140C starts Inrush Current protection ~500 \( \mu \text{s} \) after power up disregard to CE pin logic state and the IXD2140A version starts Inrush Current protection only after CE pin is set logic High.

Inrush Current Protection Characteristics shown below.

\[
\begin{align*}
L &= 4.7 \, \mu\text{H (VLF302512M-4R7M)}, \\
C_{\text{IN}} &= 4.7 \, \mu\text{F (LMK107BJ475MA)}, \\
C_L &= 10 \, \mu\text{F (LMK107BJ106MA)}, \\
I_{\text{OUT}} &= 1 \, \text{mA}, \\
T_a &= 25^\circ\text{C}
\end{align*}
\]

**UVLO**

This function is under development now.

**\( C_L \) Discharge Function**

This function is under development now.

**TYPICAL APPLICATION CIRCUIT**

External Components

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>VALUE</th>
<th>MANUFACTURER</th>
<th>PRODUCT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L )</td>
<td>4.7 ( \mu \text{H} )</td>
<td>TDK</td>
<td>VLF302512M-4R7</td>
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<tr>
<td>( C_{\text{IN}} )</td>
<td>4.7 ( \mu \text{F} )</td>
<td>TAIYO YUDEN</td>
<td>LMK107BJ475MA</td>
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<tr>
<td>( C_L )</td>
<td>10 ( \mu \text{F} )</td>
<td>TAIYO YUDEN</td>
<td>LMK107BJ106MA</td>
</tr>
</tbody>
</table>

**Note:**

1. Recommended Inductor’s value is 4.7 \( \mu \text{H} \); however, inductors from 4.7 \( \mu \text{H} \) to 10.0 \( \mu \text{H} \) can be used.
2. The ripple voltage will increase if tantalum or electrolytic capacitors with high ESR are used as the load capacitor \( C_L \). The operation could also become unstable, so carefully check this in the actual product.
LAYOUT AND USE CONSIDERATIONS

1. Do not exceed the value of stated absolute maximum ratings.
2. The IXD2140 performance is greatly influenced by not only the ICs’ characteristics, but also by those of the external components. Care must be taken when selecting external components.
3. Ensure that the PCB 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.
4. Mount each external component as close to the IC as possible and use thick, short connecting traces to reduce the circuit impedance.
5. An excessive current larger than the $I_{\text{PFM}}$ flowing in the N- or P-channel transistors could destroy the IC.
6. In the bypass mode, the internal P-channel synchronous rectifier transistor is in on state to allow current flow between $L_X$ and $V_{\text{OUT}}$ pins. However, an excessive current could destroy the P-channel synchronous rectifier transistor.
7. The CE pin does not have an internal pull-up or pull-down resistors, so, do not left this pin open.
8. The IXD2140 is optimized for 4.7 $\mu$H inductor; however, inductors in the range from 4.7 to 10 $\mu$H can be used. If inductors above 4.7 $\mu$H, but in this range, will be used, we recommend evaluate them before use in final product.
9. At high temperatures, the product performance could vary causing the efficiency to decline. Evaluate this carefully, if the product will be used at high temperatures.
10. Note that the standby leakage current of the P-channel synchronous rectifier transistor at high-temperature operations could charge $C_L$ capacitor, increasing output voltage of the IXD2140A.
11. The output voltage ripple effect from the load current causes the average output voltage to fluctuate, so carefully evaluate this in the actual product before use.
12. When the IXD2140 is activated at low input voltage, it may operate at discontinues conduction mode until the output voltage reaches about 1.7 V. The burst mode operations stats after that (See the figure below.)

$V_{\text{BAT}} = V_{\text{CE}} = 0 \rightarrow 0.9 \text{ V}$, $V_{\text{OUT}} = 1.8 \text{ V}$, $I_{\text{OUT}} = 1 \text{ mA}$, $L = 4.7 \mu\text{H}$, $C_L = 10 \mu\text{F}$, $T_a = 25^\circ\text{C}$

![Graph 1]

$V_{\text{BAT}} = V_{\text{CE}} = 0 \rightarrow 1.7 \text{ V}$, $V_{\text{OUT}} = 1.8 \text{ V}$, $I_{\text{OUT}} = 1 \text{ mA}$, $L = 4.7 \mu\text{H}$, $C_L = 10 \mu\text{F}$, $T_a = 25^\circ\text{C}$

![Graph 2]

13. If the $C_L$ capacitance or load current is excessively high, start-up time during which the IXD2140 operates in discontinues conduction mode will increase.
14. If after start-up the input voltage is higher than the output voltage due high load, then the circuit automatically enters mode with $L_X$ pin connected to $V_{\text{OUT}}$ pin through P-channel transistor in ON state. When the input...
voltage becomes equal output voltage, normal operation restores, but repeated switching between modes may cause the ripple voltage fluctuate. (Refer to the graphic below).

15. If another power supply is connected to the IXD2140A/IXD2140C V_OUT pin, the IC could be destroyed.
16. Transitional voltage drop or rise should not exceed IC limits to prevent its damage.
17. The IXD2140A version may not start operate properly, if load current exceeds inrush current limit and output voltage does not rise above V\textsubscript{BAT} – 0.35 V. Also at this condition, the IXD2140C version bypass mode will not operate too.
TEST CIRCUITS

External Components, where applicable

- \( C_{IN} = 4.7 \mu F \), (ceramic)
- \( L = 4.7 \mu H \)
- \( C_L = 10 \mu F \), (ceramic)

Circuit ⊙
- \( R_{PULL} = 100 \Omega \)

Circuit ⊖
- \( R_{PULL} = 4.7 \Omega \)

Circuit ⊗: \( L_x \) N-channel transistor ON Resistance Measurement
- Adjust \( V_{PULL} \) until \( L_x \) pin voltage becomes 100 mV, when the N-channel transistor is ON, and measure \( V_1 \) voltage.

\[
R_{LXN} = \frac{V_{LX}}{V_1 - V_{LX}} + R_{PULL} = \frac{0.1}{V_1 - 0.1} \times 4.7, \Omega
\]

Use an oscilloscope or other instrument to measure the \( L_x \) and \( V_1 \) voltage.
TYPICAL PERFORMANCE CHARACTERISTICS

(1) Efficiency vs. Output Current

IXD2140A331MR-G (V_{out} = 3.3 V)

L = 4.7 μH (VLF302512M-4R7M), C_{in} = 4.7 μF (LMK107BJ475MA), C_{out} = 10μF (LMK107BJ106MA)

IXD2140A331MR-G (V_{out} = 3.3 V)

L = 10 μH (VLF302512M-4R7M), C_{in} = 4.7 μF (LMK107BJ475MA), C_{out} = 10μF (LMK107BJ106MA)

(2) Output Voltage vs. Output Current

IXD2140A331MR-G (V_{out} = 3.3 V)

L = 4.7 μH (VLF302512M-4R7M), C_{in} = 4.7 μF (LMK107BJ475MA), C_{out} = 10μF (LMK107BJ106MA)

IXD2140A331MR-G (V_{out} = 3.3 V)

L = 10 μH (VLF302512M-4R7M), C_{in} = 4.7 μF (LMK107BJ475MA), C_{out} = 10μF (LMK107BJ106MA)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Output Current

<table>
<thead>
<tr>
<th>Device</th>
<th>Voltage (V)</th>
<th>Inductor (μH)</th>
<th>Capacitor (μF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IXD2140A501MR-G (V_{OUT} = 5.0 V)</td>
<td>5.0</td>
<td>4.7 μH (VLF302512M-4R7M), 10μF (LMK107BJ106MA)</td>
<td></td>
</tr>
<tr>
<td>IXD2140A501MR-G (V_{OUT} = 5.0 V)</td>
<td>5.0</td>
<td>10 μH (VLF302512M-4R7M), 10μF (LMK107BJ106MA)</td>
<td></td>
</tr>
</tbody>
</table>

(3) Ripple Voltage vs. Output Current

<table>
<thead>
<tr>
<th>Device</th>
<th>Voltage (V)</th>
<th>Inductor (μH)</th>
<th>Capacitor (μF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IXD2140A331MR-G (V_{OUT} = 3.3 V)</td>
<td>3.3</td>
<td>4.7 μH (VLF302512M-4R7M), 10μF (LMK107BJ106MA)</td>
<td></td>
</tr>
<tr>
<td>IXD2140A331MR-G (V_{OUT} = 3.3 V)</td>
<td>3.3</td>
<td>10 μH (VLF302512M-4R7M), 10μF (LMK107BJ106MA)</td>
<td></td>
</tr>
<tr>
<td>IXD2140A501MR-G (V_{OUT} = 5.0 V)</td>
<td>5.0</td>
<td>4.7 μH (VLF302512M-4R7M), 10μF (LMK107BJ106MA)</td>
<td></td>
</tr>
<tr>
<td>IXD2140A501MR-G (V_{OUT} = 5.0 V)</td>
<td>5.0</td>
<td>10 μH (VLF302512M-4R7M), 10μF (LMK107BJ106MA)</td>
<td></td>
</tr>
</tbody>
</table>
(4) Output Voltage vs. Ambient Temperature

IXD2140x33x (V_{out} = 3.3 V)

IXD2140x50x (V_{out} = 5.0 V)

(5) Supply Current vs. Ambient Temperature

(6) Input Pin Current vs. Ambient Temperature

(7) Standby Current vs. Ambient Temperature

IXD2140A
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Switching Current vs. Ambient Temperature
IXD2140
L = 4.7 μH (VLF302512M-4R7M), C_s = 4.7 μF (LMK107BJ475MA), C_L = 10μF (LMK107BJ106MA)

(9) Switching Current vs. Input Voltage
Topr = 25 °C
IXD2140x50x
L = 4.7 μH (VLF302512M-4R7M), C_s = 4.7 μF (LMK107BJ475MA), C_L = 10μF (LMK107BJ106MA)

(10) Max ON Time vs. Ambient Temperature
IXD2140

(11) LX Switch N-Channel ON resistance vs. Output Voltage
IXD2140

(12) LX Switch P-Channel ON resistance vs. Output Voltage
IXD2140
V_BAT = V_X = V_CE = V_OUT(E) + 0.5 V, I_OUT = 200 mA

(13) LX Leakage Current vs. Ambient Temperature
IXD2140A
V_BAT = V_X = V_OUT(E), V_OUT = V_CE = 0 V
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(14) CE “High” Voltage vs. Output Voltage

IXD2140

(15) CE “Low” Voltage vs. Output Voltage

IXD2140

Topr = 25 °C

(16) Operation Start Voltage vs. Ambient Temperature

IXD2140 xxx1

L = 4.7 μH (VLF302512M-4R7M), C<sub>IN</sub> = 4.7 μF (LMK107BJ475MA), C<sub>L</sub> = 10μF (LMK107BJ106MA)

R<sub>L</sub> = V<sub>OUT(E)</sub>/1 mA

(17) Operation Stop Voltage vs. Ambient Temperature

IXD2140 xxx1

L = 4.7 μH (VLF302512M-4R7M), C<sub>IN</sub> = 4.7 μF (LMK107BJ475MA), C<sub>L</sub> = 10μF (LMK107BJ106MA)

R<sub>L</sub> = 1 kΩ

(18) Output Voltage V<sub>OUT</sub> at Start-up

IXD2140x331

V<sub>OUT</sub> = 3.3 V, V<sub>CE</sub> = 0 → 1.8 V, R<sub>L</sub> = 330 Ω

L = 4.7 μH (VLF302512M-4R7M), C<sub>IN</sub> = 4.7 μF (LMK107BJ475MA), C<sub>L</sub> = 10μF (LMK107BJ106MA)

IXD2140x331

V<sub>OUT</sub> = 3.3 V, V<sub>CE</sub> = 0 → 1.8 V, R<sub>L</sub> = 3300 Ω

L = 4.7 μH (VLF302512M-4R7M), C<sub>IN</sub> = 4.7 μF (LMK107BJ475MA), C<sub>L</sub> = 10μF (LMK107BJ106MA)
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) Output Voltage $V_{OUT}$ at Start-up (Continue)

**IXD2140x501**

$V_{OUT} = 5.0 \text{ V}$, $V_{BAT} = V_{CE} = 0 \rightarrow -3.3 \text{ V}$, $R_L = 500 \Omega$

$L = 4.7 \mu\text{H (VLF302512M-4R7M)}, C_s = 4.7 \mu\text{F (LMK107BJ475MA)}, C_i = 10\mu\text{F (LMK107BJ106MA)}$

**Topr = 25^\circ \text{C}**

(V) $V_{OUT} = 5.0 \text{ V}$, $V_{BAT} = V_{CE} = 0 \rightarrow -5.5 \text{ V}$, $R_L = 500 \Omega$

$L = 4.7 \mu\text{H (VLF302512M-4R7M)}, C_s = 4.7 \mu\text{F (LMK107BJ475MA)}, C_i = 10\mu\text{F (LMK107BJ106MA)}$

---

(19) Load Transient Response

**IXD2140x181**

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

$L = 4.7 \mu\text{H (VLF302512M-4R7M)}, C_s = 4.7 \mu\text{F (LMK107BJ475MA)}, C_i = 10\mu\text{F (LMK107BJ106MA)}$

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

$L = 4.7 \mu\text{H (VLF302512M-4R7M)}, C_s = 4.7 \mu\text{F (LMK107BJ475MA)}, C_i = 10\mu\text{F (LMK107BJ106MA)}$

---

**IXD2140x331**

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

$L = 4.7 \mu\text{H (VLF302512M-4R7M)}, C_s = 4.7 \mu\text{F (LMK107BJ475MA)}, C_i = 10\mu\text{F (LMK107BJ106MA)}$

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

$L = 4.7 \mu\text{H (VLF302512M-4R7M)}, C_s = 4.7 \mu\text{F (LMK107BJ475MA)}, C_i = 10\mu\text{F (LMK107BJ106MA)}$
**TYPICAL PERFORMANCE CHARACTERISTICS (Continued)**

(19) Load Transient Response

Topr = 25 °C

**IXD2140x501**

\[ V_{\text{OUT}} = 5.0 \, \text{V}, \quad V_{\text{BAT}} = V_{\text{CE}} = 3.7 \, \text{V}, \quad I_{\text{OUT}} = 100 \, \text{mA} \rightarrow 1 \, \text{mA} \]

**IXD2140x501**

\[ V_{\text{OUT}} = 5.0 \, \text{V}, \quad V_{\text{BAT}} = V_{\text{CE}} = 3.7 \, \text{V}, \quad I_{\text{OUT}} = 1 \, \text{mA} \rightarrow 100 \, \text{mA} \]

**ORDERING INFORMATION**

**IXD2140①②③④⑤⑥⑦**

<table>
<thead>
<tr>
<th>DESIGNATOR</th>
<th>DESCRIPTION</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>①①</td>
<td>Product Type</td>
<td>A</td>
<td>Load Disconnection Without C, Auto Discharge</td>
</tr>
<tr>
<td>②③②③</td>
<td>Output Voltage</td>
<td>C</td>
<td>( V_{\text{BAT}} ) Bypass Without C, Auto Discharge</td>
</tr>
<tr>
<td>④</td>
<td>UVLO Function</td>
<td>1</td>
<td>No UVLO</td>
</tr>
<tr>
<td>③③</td>
<td>Packages (Order Limit)</td>
<td>2</td>
<td>( V_{\text{UVLO}} = 2.15 , \text{V} ) (Under development)</td>
</tr>
</tbody>
</table>

Note:

1) The product with the \( C \) discharge function is a semi-custom product.
2) \( V_{\text{OUT}} = 3.3 \, \text{V} \) is a standard value
3) The “-G” suffix denotes halogen and antimony free, as well as being fully ROHS compliant.
PACKAGE DRAWING AND DIMENSIONS

Units: mm

SOT-25

USP-6EL

A part of the pin may appear from the side of the package because of its structure, but reliability of the package and strength will not be changed below the standard.
**MARKING**

SOT-25

① represents product series

<table>
<thead>
<tr>
<th>MARK</th>
<th>PRODUCT SERIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ⅳ</td>
<td>IXD2140Axx1xx-G</td>
</tr>
<tr>
<td>Ⅴ</td>
<td>IXD2140Cxx1xx-G</td>
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</table>

② represents output voltage

USP-6EL

<table>
<thead>
<tr>
<th>MARK</th>
<th>OUTPUT VOLTAGE</th>
<th>MARK</th>
<th>OUTPUT VOLTAGE</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1.8</td>
<td>9</td>
<td>2.7</td>
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<tr>
<td>1</td>
<td>1.9</td>
<td>A</td>
<td>2.8</td>
</tr>
<tr>
<td>2</td>
<td>2.0</td>
<td>B</td>
<td>2.9</td>
</tr>
<tr>
<td>3</td>
<td>2.1</td>
<td>C</td>
<td>3.0</td>
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<tr>
<td>4</td>
<td>2.2</td>
<td>D</td>
<td>3.1</td>
</tr>
<tr>
<td>5</td>
<td>2.3</td>
<td>E</td>
<td>3.2</td>
</tr>
<tr>
<td>6</td>
<td>2.4</td>
<td>F</td>
<td>3.3</td>
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<tr>
<td>7</td>
<td>2.5</td>
<td>H</td>
<td>3.4</td>
</tr>
<tr>
<td>8</td>
<td>2.6</td>
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<td>4.3</td>
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</table>

③ represents product function

<table>
<thead>
<tr>
<th>MARK</th>
<th>OUTPUT VOLTAGE</th>
<th>PRODUCT SERIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1.8 – 3.4 V</td>
<td>IXD2140Axx1xx-G</td>
</tr>
<tr>
<td>P</td>
<td>3.5 – 5.0 V</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>1.8 – 3.4 V</td>
<td>IXD2140Cxx1xx-G</td>
</tr>
<tr>
<td>U</td>
<td>3.5 – 5.0 V</td>
<td></td>
</tr>
</tbody>
</table>

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)
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