Product Information for Wearable Devices
Expanding use of wearable devices

Why is Torex power supply solution chosen?

- Small package profile realizes smaller and thinner devices.
- High-efficiency power supply allows longer battery life.
- High-efficiency power supply reduces heat generation.
- Plentiful lineup ensures you to find the right power supply IC.

Micro DC/DC

Ultra small DC/DC converters with integrated coil based on Torex's unique technology. Our exacting standards as a power IC manufacturer have created this product line without sacrificing DC/DC converter characteristics.

DC/DC Converters

DC/DC converters that enable configuration of a power supply with high efficiency. Torex has original technology that has been cultivated over many years of product development. Step-down DC/DC converters with an efficiency of over 90%. Step-Up DC/DC converters which only consume 6.3μA in operation. Our lineup of power saving products is ideal for wearable devices due to their small size and high efficiency.

LDO

Electronic devices require a stable power source. We have a high performance lineup of LDO products that let you place the right power source in the right place, from low voltage/low current to high voltage/high current applications. Naturally, these LDOs are small and power saving.

Example of a power supply configuration solution for the periphery of a microcontroller in a wearable device

Power supply solutions for wearable devices

Li-ion Battery Linear Charger IC

A battery is a typical input for a power IC. In particular, Li-ion-polymer batteries are essential for portable devices. Torex has a product lineup specifically designed for use with low capacity Li-ion-polymer batteries as used in wearable devices.

Load Switch

An essential item for configuration of power circuits in most devices. Our line/load switches incorporate a variety of functions such as current limiting and CL discharge, narrowing usage value and providing low impedance.

Reset IC

A reset IC is a voltage detector that monitors voltage and sends a signal to the microcontroller. A low voltage/current enables non-stop monitoring of either input voltage or output voltage. High accuracy and stable operation make this IC suitable for microprocessor reset use. A delay time can also be set externally.

Reboot IC

This is a convenient IC for forced microprocessor reset or system reboot by long press of a button. During normal system operation, the XC6190 sits in standby, consuming just 0.05μA, and when needed, it is ready to operate.

IC cards (smart cards) have come into common use in recent years. The number of cards issued continues to increase dramatically, and use extends over diverse fields, including official identification documents (licenses, passports, ID cards), access control (employee ID cards, student ID cards, restricted area access), medical cards (health insurance cards, consultation tickets), payment cards (credit, debit, and bank cards), and information security (Internet transactions, data access control).

The dimensions and thickness (6.4mm x 85.6mm x 0.7mm) of smart cards is determined by the ISO/IEC7810 international standard.

The IC chip in a smart card incorporates an antenna, and is equipped with a recording function, calculation functions, and wireless modules such as RFID and BT. An increasing number of models have a display, and cards with an Li-ion secondary battery are becoming common. These cards use a DC/DC converter, and an LDO and charger IC.

Power solution for smart card

Small and thin package supports smart cards

1. Clear height restrictions with our many products of height 0.4 mm or less.
2. Passes bending, strength, and other reliability tests.
3. The low supply current and high efficiency of the power supply IC contribute to a longer battery life.
4. High withstand voltage during non-contact charging.

(Top charge voltage may be supplied at some distances and in some positions.)
XC9265
Ultra Low Power Synchronous Step-Down PFM DC/DC Converter

- **Typical Application Circuit**

- **Product Features**

  The new XC9265 series consumes only 0.5 μA during operation making it ideal for applications that run from batteries for long periods of time. This ultra low quiescent current is achieved by implementing a synchronous PFM architecture to minimize the switching losses during low loads. Developed using Torex’s proprietary CMOS process, the XC9265 integrates a 0.5 Ω P-ch driver transistor and a 0.5 Ω synchronous N-ch switching transistor to ensure high levels of efficiency and superior performance for demanding battery powered applications. Only an inductor and two ceramic capacitors are needed externally and the XC9265 is able to operate from 6.0V down to 2.0V inputs pin to turn the IC on and off and an optional CL discharge function that can quickly discharge the output capacitor when the IC is turned off. During stand-by, all circuits are shutdown to reduce consumption to less than 0.1 μA.

- **Application Examples to Improve Battery Life**

  - **Measurement Circuit**

- **Active/Stand-by Performance**

- **Battery driving life (Comparison when \( t=100 \))**

  - **XC9265A/C**
  - **XC9265B/D**

  \[
  \text{Battery driving life} = \frac{\text{Battery Capacity}}{\text{Average Current}} \times t 
  \]

  \[
  \text{Average Current} = \frac{\text{Total Energy}}{t} 
  \]

- **KEY FEATURES**

- **Series**

<table>
<thead>
<tr>
<th>SERIES</th>
<th>XC9265A/C</th>
<th>XC9265B/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiescent Current</td>
<td>0.5 μA</td>
<td>( \leq 5 ) μA</td>
</tr>
<tr>
<td>Output Current</td>
<td>20mA</td>
<td>50mA</td>
</tr>
<tr>
<td>PFM Switching Current</td>
<td>30mA</td>
<td>180mA</td>
</tr>
<tr>
<td>ON Resistance</td>
<td>P-Ch</td>
<td>0.4 Ω (TYP)</td>
</tr>
<tr>
<td></td>
<td>N-Ch</td>
<td>0.4 Ω (TYP)</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>2.5V – 6.0V</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Range</td>
<td>1.0V – 4.0V (0.1V increments)</td>
<td></td>
</tr>
<tr>
<td>Control Method</td>
<td>PFM Only</td>
<td></td>
</tr>
<tr>
<td>Protection Circuits</td>
<td>Short Circuit Protection UVLO</td>
<td></td>
</tr>
<tr>
<td>Additional Features</td>
<td>Optional C: Auto Discharge</td>
<td></td>
</tr>
<tr>
<td>Packages</td>
<td>SOT-25, USP-6EL</td>
<td></td>
</tr>
</tbody>
</table>

- **Product features**

  The XC9265/04/05 series are Constant-Voltage (CV) and Constant-Current (CC) type charging IC for linear charging of single-cell Li-ion and Li-polymer batteries. The basic charging cycle consists of trickle charge mode followed by main charge mode. An LED can be connected to the charge status output pin to allow confirmation of charging by LED illumination. The IC is housed in the small USP-6EL package with high heat dissipation, and a charge circuit can be configured using a minimum of external components. These IC also support temperature control based on JETAs, making it possible to safely charge Li-ion batteries by controlling the CV charge voltage and CC charge current according to the temperature.

- **Temperature Monitoring Function**

  The IC monitors the Li-ion battery temperature during charging by means of an NTC Thermistor connected to the THN pin. CC charging and CV charging are controlled based on the Li-ion battery temperature as shown below to enable safe charging.

- **XC6803/04/05 Series**

  One Cell Li-ion/Li-polymer Linear Charger IC

- **KEY FEATURES**

<table>
<thead>
<tr>
<th>SERIES</th>
<th>XC6803</th>
<th>XC6804</th>
<th>XC6805</th>
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<tr>
<td>Input Voltage</td>
<td>4.5V – 6.0V</td>
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<td></td>
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<tr>
<td>Charge Current</td>
<td>5mA – 20mA</td>
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</tr>
<tr>
<td>Supply Current (Stand-by)</td>
<td>50μA</td>
<td></td>
<td></td>
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<tr>
<td>Dropout Voltage Monitor Function</td>
<td>OPTIONAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge Judgment Function</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge Mode</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recharge Function</td>
<td>OPTIONAL</td>
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<td></td>
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<tr>
<td>Charge Protection Circuit</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Shutdown</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety Timer</td>
<td>5hrs</td>
<td></td>
<td></td>
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<tr>
<td>Function</td>
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<td></td>
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<tr>
<td>Packages</td>
<td>USP-6EL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **XC6806 Linear charger ID with current path function**

  An internal current path driver switch allows battery charging even while the system is being driven. This enables efficient charging by USB.
**XC6190** Push Button Reboot Controller

The XC6190 is an ultra low current, push-button reset timer. The XC6190 uses a long timing setup delay to provide the intended function during the release of the button. When the button is pressed, the delay time is fixed internally with a choice of two settings. When the TS pin is set to “H” level, the delay time is 12.5s. When the TS pin is set to “L” level, the delay time is 7.5s. The standby quiescent current is a very small 0.01 μA (TYP.).

**Key Features**

- **Input Voltage Range**: 1.65V ~ 6.0V
- **Re-Boot Delay Time**: Adjustable / Fixed
- **Low power Consumption**: 0.01μA (TYP.)
- **Re-Boot Delay Time Accuracy**: ±5%
- **Re-Boot Time (Ts)**: 0.4μs to 3.5μs
- **Output Configuration**: Nch-Open Drain or CMOS
- **RSTB Pin SINK Current**: 30mA
- **Input Voltage Range**: 1.65V
- **SERIES**: XC6190A, XC6190B
- **Packages**: USPN-6, USPN-6B01

**Typical Application Circuit**

**Torex Advantages**

- **Height**: 0.33mm (MAX.)
- **Ultra-thin USP-6B06 package**
- **Ultra-low supply current / ultra small voltage regulators**
- **5% or less accuracy**
- **Higher accuracy** (resistance ±5% or less)
- **Greater accuracy** (resistance ±1% or less)
- **Capacitor-less XC6404 configuration**

**XC6216** 28V operation, low supply current regulators with an ON/OFF function

**Key Features**

- **Input Voltage Range**: 2.0V ~ 28V
- **Output Voltage Range**: 2.0V ~ 12.0V (±2.0%, 0.1V increments)
- **Output Current**: 150mA
- **Dropout Voltage**: 280mV (IOUT=20mA, VIN=3.6V)
- **Low Power Consumption**: 5μA
- **Stand-by Current**: Less than 0.1μA
- **High Ripple Rejection**: 30dB@1kHz
- **Built-in Protection**: Current Limit Circuit / Short Protection / Thermal Shutdown Circuit
- **Other Functions**: Ceramic Capacitor Compatible / Capacitor Less
- **Packages**: USP-6B06 (1.8 × 1.8 × 0.33mm), SOT-24, SOT-89, SOT-89-5, USP-6C, SOT-223, TO-252

**XC6504** 0.6μA ultra-low supply current / ultra small voltage regulators

**Key Features**

- **Input Voltage Range**: 1.4V ~ 6.0V
- **Output Voltage Range**: 1.1V ~ 5.0V (±1.0%, 0.1V increments)
- **Output Current**: 150mA
- **Dropout Voltage**: 500mV (IOUT=150mA, VIN=3.0V)
- **Low Power Consumption**: 2.0μA
- **Stand-by Current**: Less than 0.01μA
- **High Ripple Rejection**: 25dB@1kHz
- **Built-in Protection**: Current Limit Circuit / Short Protection
- **Other Functions**: Ceramic Capacitor Compatible / Capacitor Less
- **Packages**: USP-6B06 (1.8 × 1.8 × 0.33mm), USP-4B02 (0.95 × 0.75 × 0.44mm), SOT-24, SOT-25

**Mounting area comparison**

- **Ultra-thin USP-6B06**
- **XC6504**

**XC6216 Supply Current vs. Input Voltage (VOUT=5.0V, IOUT = 0mA)**

**XC6504 Supply Current vs. Input Voltage (VOUT=3.0V)**

**XC6504 Input Current vs. Input Voltage (VOUT=5.0V, IOUT = 0mA)**
**KEY FEATURES**

- Quiescent current of only 6.3 μA even with synchronous rectification
- Fast transient response
- Load disconnect and input bypass function options
- Supports ceramic capacitors
- Synchronous rectification provides high efficiency

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**KEY FEATURES**

- Ultra fast transient response
- \( I_{IoR}=1.5A \), World’s smallest mounting space
- Even though the control method is COT control, switching frequency fluctuations due to load/input are small
- A switching frequency of 3 MHz can also be selected

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**USP-4803**

- \( I_{VDD}=1.5A \)
- \( I_{VSS}=0.4 \) μA
- \( I_{VCC}=0.8 \) μA

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**KEY FEATURES**

- Quiescent Current (Q) 6.3 μA
- Output Current (Q) 100 mA (Vout = 1.8 V, Vcc = 3.3 V)
- Off Resistance (Roff) 0.65 Ω
- Input Voltage Range 0.65 V – 5.5 V
- Output Voltage 1.8 V – 5.5 V (1.8 V, 3.3 V step)
- Control Method PFM (Current = 350 mA)
- Optional Type A Type
- Coating Type B Type
- Input Bypass Function
- Op. Ambient Temperature
- Additional Features
- Low ESR Ceramic Capacitors
- Packages USP-6EL, SOT-25

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**USP-4803**

- Quiescent Current (Q) 15 μA (1.2 MHz), 25 μA (3 MHz)
- Output Current (Q) 150 mA
- Switching Frequency 1.2 MHz and 3.0 MHz
- Off Resistance (Roff) 0.14 Ω
- Duty Cycle 0.01 Ω
- Input Voltage Range 2.7 V to 3.3 V
- Output Voltage 0.8 V – 3.6 V (1.2 V, 0.05 V step)
- Control Method
- Protection Circuit
- Op. Ambient Temperature
- Additional Features
- Low ESR Ceramic Capacitors
- Packages USP-6C, SOT-25, LGA-8801

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**USP6233**

- Output Current
- Dropout Voltage (Vout = 0.30 V)
- Input Voltage Range
- Output Voltage
- Operating Voltage Range
- Output Current
- Quiescent Current (Q)
- Stand-by Current (Q)
- Pulse Rejection
- Current Limit Threshold
- Short Circuit Current Threshold
- Inrush Current Protection
- Thermal Shutdown
- Additional Features
- Smallest Package

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**USP-Q8**

- Quiescent Current (Q) 0.42 μA
- Output Current (Q) 100 mA
- Off Resistance (Roff) 0.65 Ω
- Input Voltage Range 0.65 V – 5.5 V
- Output Voltage 1.8 V – 5.5 V (1.8 V, 3.3 V step)
- Control Method
- Protection Circuit
- Op. Ambient Temperature
- Additional Features
- Low ESR Ceramic Capacitors
- Packages USP-6C, SOT-25, LGA-8801

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**USPQ-4803**

- Power Dissipation (Pd) 550 mW @ 25°C

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**LGA-4B01**

- Power Dissipation (Pd) 600 mW @ 25°C
Torex “micro DC/DC” – Innovative Construction

Torex “micro DC/DC” converters are available in three different structures: an ultra-small, low EMI noise “Pocket Type” that supports currents up to 1A, a “Stack Type” that simplifies the manufacturing process and helps reduce costs, and a “Multiple Type” that is designed to support large currents (currently up to 2A). We are building the “micro DC/DC” XCL series from a variety of approaches based on coil capacity.

Ideal solutions for Noise Sensitive environments

When using a DC/DC converter, there is always a concern about noise. With wireless devices in particular, that concern is not only about noise from the power line, but EMI as well. Torex DC/DC converters are designed to be used with ceramic capacitors and with an appropriate switching speed to help create a stable power supply with low ripple voltage.

What’s more, the XCL series of “micro DC/DC” converters enables the reduction of EMI. The structure of the Pocket Type, which is Torex’s original technology, is designed so that the inductor covers the DC/DC converter IC, enabling suppression of externally emitted noise. The comparison between the XCL202 and the XCL201 is shown clearly in the diagram. The noise characteristics of the XCL201 are not particularly poor; the XCL202 is a typical product in terms of noise.

Selection Guide for the XCL Series

![Diagram of typical circuit](image1)

**XCL223/224 | 0.4A/0.7A Inductor Built-in "micro DC/DC" Converters**

**Product features**

The XCL223/XCL224 series are ultra-small, low-profile (2.25mm × 1.1mm, h=0.75mm MAX) step-down DC/DC converters with an integrated coil and control IC. A power supply circuit can be created by simply adding two external ceramic capacitors. The internal coil simplifies the board layout and makes it possible to minimize malfunctioning and noise due to component placement and wiring routing.

The output voltage is from 0.8V to 3.6V (accuracy ±2.0%), and can be set internally in steps of 0.05V. The switching frequency is 3.0MHz, and synchronous rectification is used for the circuit scheme. The operation mode is “HiSAT-COT” control, which has excellent transient response characteristics, and “PWM control” or “PWM/PFM auto switching control” can be selected as appropriate for the application. Either 400mA or 700mA can be selected for the maximum load current.

**KEY FEATURES**

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<thead>
<tr>
<th>SERIES</th>
<th>XCL223 / XCL224 Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiescent Current</td>
<td>25μA (3.05mA)</td>
</tr>
<tr>
<td>Output Current</td>
<td>700mA (A type) / 400mA (B type)</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>3.0MHz</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>2.7V ～ 5.5V</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>0.8V ～ 3.6V (±2%, 0.05V step)</td>
</tr>
<tr>
<td>Control Method</td>
<td>HiSAT-COT Control (100% Duty Cycle)</td>
</tr>
<tr>
<td>XCL223: PWM, XCL224: PWM/PFM Auto Switch</td>
<td></td>
</tr>
<tr>
<td>Protection Circuit</td>
<td>Thermal Shutdown</td>
</tr>
<tr>
<td>Current Limit</td>
<td>Short Circuit Protection</td>
</tr>
<tr>
<td>Op. Ambient Temperature</td>
<td>–40°C ～ +105°C</td>
</tr>
<tr>
<td>Additional Features</td>
<td>UVLO, Soft Start, C Discharge</td>
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<tr>
<td>Low ESR Ceramic Capacitors</td>
<td></td>
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<tr>
<td>Packages</td>
<td>USP-8B04 (2.25 × 1.5mm, h=0.75mm MAX)</td>
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</tbody>
</table>

**Mount space-saving**

Mounting area including C0 and C1:

![Example of surface temperature characteristics during mounting](image2)

Sample number: XCL223A0M3DR, VOUT = 0.95V

![Diagram of typical circuit](image3)
XCL210 | Ultra-low supply current, step-down, synchronous “micro DC/DC” converters

- IC supply current is 0.5μA
- High efficiency even with light loads
  - 80% @ 3.6V → 1.8V/10μA
  - 90% @ 3.6V → 1.8V/10mA

**KEY FEATURES**

<table>
<thead>
<tr>
<th>SERIES</th>
<th>XCL210A/C</th>
<th>XCL210B/D</th>
</tr>
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<tbody>
<tr>
<td>Quiescent Current</td>
<td>0.5μA</td>
<td>50mA</td>
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<tr>
<td>Output Current</td>
<td>200mA</td>
<td>50mA</td>
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<tr>
<td>Input Voltage Range</td>
<td>2.0V → 6.0V</td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>1.0V → 4.0V (± 2%, 0.05V step)</td>
<td></td>
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<tr>
<td>Control Method</td>
<td>PFM Control</td>
<td></td>
</tr>
<tr>
<td>PFM Switching Current</td>
<td>180mA/330mA</td>
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<tr>
<td>Functions</td>
<td>Short Circuit Protection</td>
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</tr>
<tr>
<td></td>
<td>UVLO</td>
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</tr>
<tr>
<td></td>
<td>C. Discharge (XCL210C/XCL210D)</td>
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<tr>
<td>Op. Ambient Temperature</td>
<td>−40°C → +85°C</td>
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<td>Low ESR Ceramic Capacitors</td>
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<tr>
<td>Packages</td>
<td>CL-2025</td>
<td></td>
</tr>
</tbody>
</table>

XCL210 Output Current vs. Efficiency (VIN=3.6V, VOUT=1.8V)

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XCL101 | Integrated coil, step-up synchronous “micro DC/DC” converters

- Operation starts from an input voltage of 0.9V
- IC supply current is 6.3μA
- Operates at 0.9V with one battery

**KEY FEATURES**

<table>
<thead>
<tr>
<th>SERIES</th>
<th>XCL101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiescent Current</td>
<td>6.3μA</td>
</tr>
<tr>
<td>Output Current</td>
<td>100mA (VIN=1.8V, VOUT=3.3V)</td>
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<tr>
<td>Input Voltage Range</td>
<td>0.9V → 5.5V</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>1.8V → 5.0V (± 2%, 0.1V step)</td>
</tr>
<tr>
<td>Control Method</td>
<td>PFM Control</td>
</tr>
<tr>
<td>PFM Switching Current</td>
<td>350mA</td>
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<tr>
<td>Optional Type</td>
<td>A Type: Load Disconnection Function</td>
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<td></td>
<td>G Type: Input Bypass Function</td>
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<tr>
<td>Op. Ambient Temperature</td>
<td>−40°C → +85°C</td>
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<tr>
<td>Low ESR Ceramic Capacitors</td>
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<tr>
<td>Packages</td>
<td>CL-2025</td>
</tr>
</tbody>
</table>

XCL101 Output Current vs. Efficiency (VOUT=5.0V)

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**Our standard pocket type**

**Our standard pocket type**

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**TOREX SEMICONDUCTOR LTD.**

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