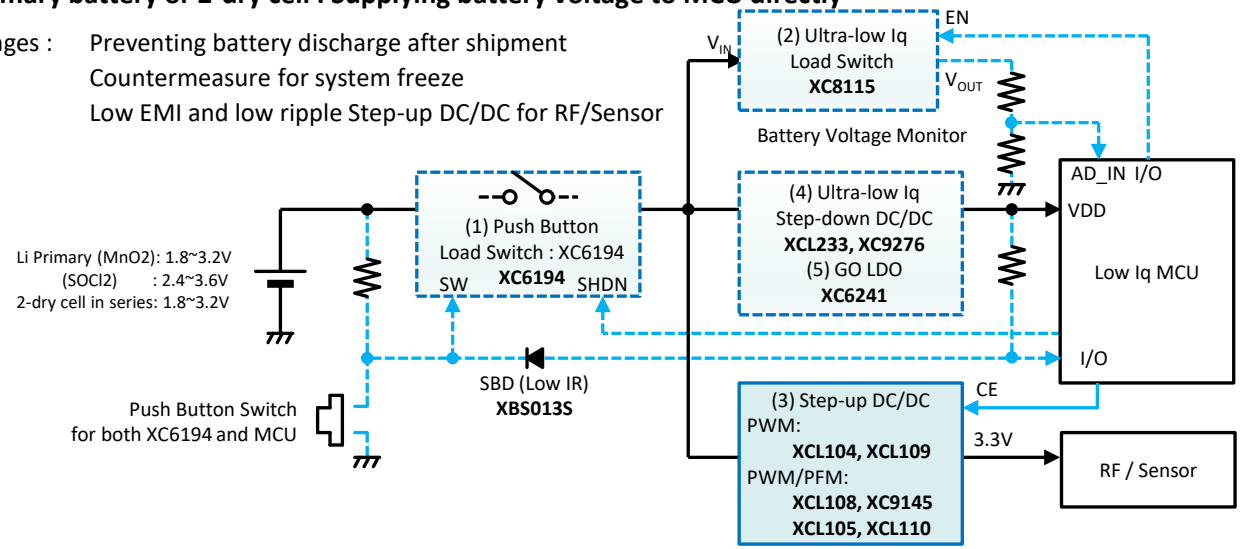
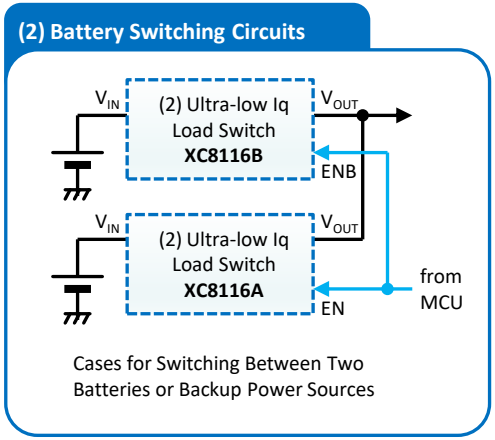
# Primary Battery : Small and Low Power Consumption Solutions (1)

## 3V Li Primary battery or 2-dry cell : Supplying battery voltage to MCU directly

● Challenges : Preventing battery discharge after shipment
Countermeasure for system freeze
Low EMI and low ripple Step-up DC/DC for RF/Sensor




| Block | Product | Features |
|---|---|---|
| (1) Push button switch | **XC6194** | $I_{STB}$=1nA, Shutdown function(Ship/Main power switch)<br>For system freeze (XC6194A), Preventing liquid leakage (UVLO) |
| (2) Load switch | **XC8115 / XC8116**<br>UNDER DEVELOPMENT | Ultra-low Iq=0μA, Adj. Soft-start, 1A<br>Reverse current prevention when OFF (XC8116) |
| (3) Step-up DC/DC | **XCL109 / XCL110**<br>FEATURED | Built-in inductor, Small but high current, F-PWM, PWM/PFM<br>3MHz, 610mA@3.3V→5V<br>**Others: XCL104/XCL105**, Built-in inductor, 710mA@3.3V→5V<br>**XC9147/XC9148**, 1.2MHz/3MHz, 750mA@3.3V→5V |
| | **XCL108** FEATURED | Built-in inductor, Ultra-low Iq: 400nA, PWM/PFM<br>1.2MHz, 300mA@3.3V→5V, $V_{ST}$=1.6V<br>**Other: XC9145**, 1.2MHz, 430mA@3.3V→5V |
| (4) Step-down DC/DC | **XCL233** FEATURED | Built-in inductor, Iq=200nA, PFM, 150mA, VSET($V_{OUT}$ selectable)<br>**Other: XC9276**, 150mA |
| (5) LDO | **XC6241** | Iq=0.6μA, PSRR=60dB, GO, 150mA |

**(1) Push Button Load Switch with Shutdown function : XC6194**

Shutdown at shipment **to reduce the discharge current from the battery to 1nA**. For Main power / Forced shut-down at system freeze / Prevention of battery liquid leakage.

**(2) Ultra-low Iq=0μA, Load Switch**

$Iq/I_{STB}$=0μA for Battery Voltage Monitor ON/OFF Control : **XC8115**
Dual Battery Switching with Reverse Current Prevention in OFF State and EN/ENB Control : **XC8116**

**(3) Step-up DC/DC with Load Disconnect Function for RF/Sensor**

- **Built-in inductor Micro DC/DC** is suitable due to small size and low EMI. **(XCL104/XCL105, XCL108, XCL109/XCL110)**
- For RF/sensors always operating **400nA Ultra-low Iq PWM/PFM step-up XCL108 and XC9145**
- **PWM Step-up Converters** for Low Ripple **XCL104, XCL110, XC9147**

**(4), (5) Step-down DC/DC and LDOs for Supplying Power to MCUs**

- **Built-in Inductor Step-down XCL233, Low-Power, High-Speed LDO XC6241**

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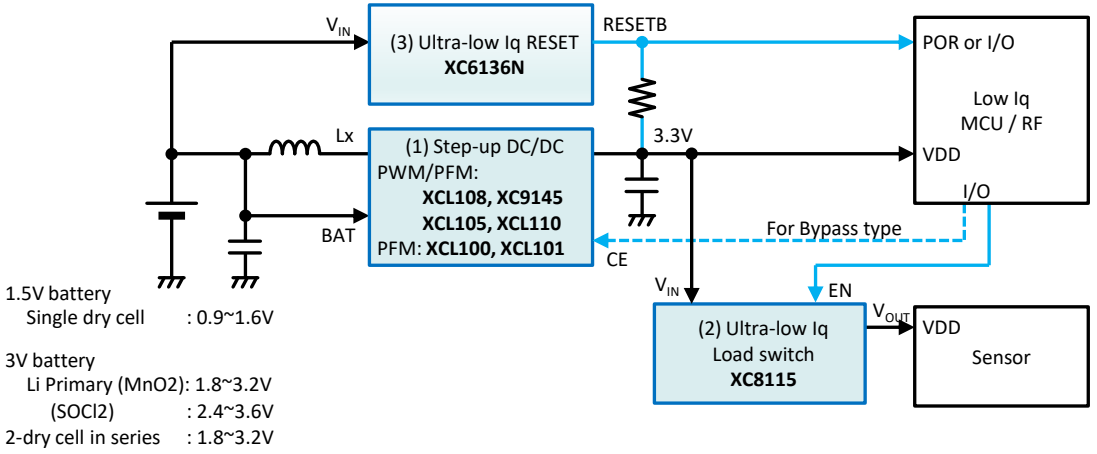
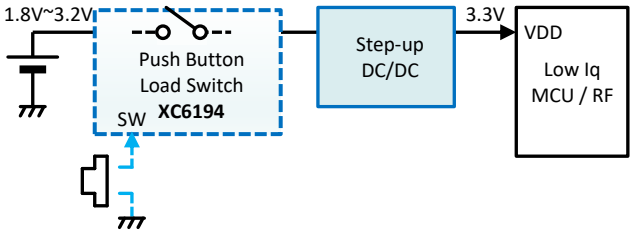
# Primary Battery : Small and Low Power Consumption Solutions (2)

## From 3V Li Primary battery, 1 or 2-dry cell : Supplying boosted voltage to MCU

● Challenges : High efficiency / low EMI / Low ripple Step-up DC/DC
Small / Low Iq / Long battery life




**Example of adding Shutdown Function**




**Added Push Button Load Switch : XC6194**

- For Prevention of discharge after shipment
- Main power switch
- Forced shut-down at freeze

| Block | Product | Features |
|---|---|---|
| (1) Step-up DC/DC | **XCL100 / XCL101** | Built-in inductor, Low Iq PFM<br>80mA@3.3V→5V, UVLO (XCL100) |
| | **XCL110** FEATURED | Built-in inductor, Small but high current, PWM/PFM<br>3MHz, 610mA@3.3V→5V<br>**Others: XCL105**, Built-in inductor, 1.2MHz, 710mA@3.3V→5V<br>**XC9148**, 1.2MHz/3MHz, 750mA@3.3V→5V |
| | **XCL108** FEATURED | Built-in inductor, Ultra-low Iq: 400nA, PWM/PFM<br>1.2MHz, 180mA@3.3V→5V, $V_{ST}$=1.6V<br>**Other: XC9145**, 1.2MHz, 430mA@3.3V→5V |
| (2) Load switch | **XC8115** UNDER DEVELOPMENT | Ultra-low Iq=0μA, Externally adjustable Soft-Start, 1A |
| (3) RESET IC | **XC6136** | Iq=100nA class Ultra-low Iq |

### (1) Step-up DC/DC for MCU

### (a) For low power consumption

- General use - Supply with always boosting at high efficiency
  For 3V battery : **Iq=400nA PWM/PFM step-up DC/DC XCL108 and XC9145**
  High efficiency 89.9%@10μA
  For 1.5V battery : **Built-in inductor PFM Step-up Micro DC/DC XCL101**
- Low Iq power technique - Boost only when MCU is active
  **Use products with "Bypass" function** to boost only when necessary, and supply through battery voltage when the MCU is in sleep mode for even lower power consumption. **(XCL101C, XCL110B, XCL105B/E/H/K, XC9148B/E/H/K)**

### (b) For Small / Low EMI

Use **Built-in inductor Micro DC/DC(XCL101, XCL110, XCL105, XCL108)**

### (2) For Power Distribution to Sensors : Load switch XC8115

$I_{STB}$/Iq = 0 μA, ON/OFF Control with Externally Adjustable Soft-Start

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# Low Power Consumption by Utilizing Operation Range of MCU/SoC : VSET, Bypass

## Achieving longer battery life & low power consumption by changing the output voltage based on an operation of MCU/SoC

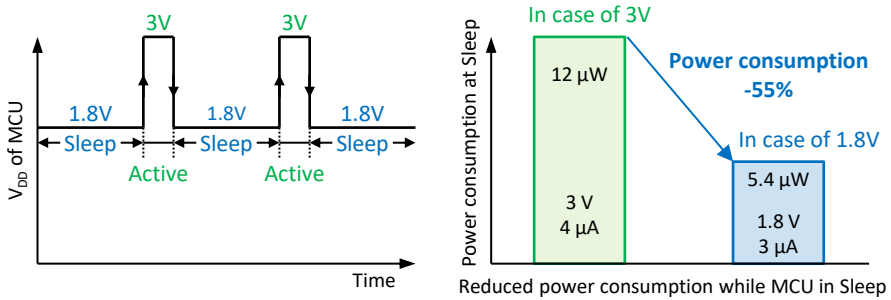
### Technical trend and challenges

- Current MCU/SoC can operate in a wide voltage range (e.g. 1.6 to 3.8V).
- 3V is required for the analog part and high-speed processing, but a low supply voltage such as 1.8V can be used during sleep mode. This results in lower power consumption.

### TOREX Proposal : Low power consumption by changing output voltage

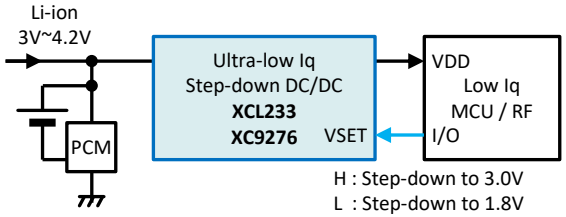
- Dynamically changing output voltage according to MCU/SoC operation, greatly reducing power consumption in standby state.

**Change supply voltage according to MCU operation**



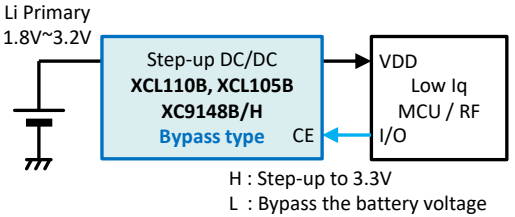

### ➢ Ultra-low Iq Step-down DC/DC with VSET function : XCL233, XC9276

- $V_{OUT}$ can be switched by the VSET pin.
- 200nA Ultra-low Iq achieves constant high efficiency: 85.5%@10µA




### ➢ Step-up DC/DC with Bypass function : XCL110B, XCL105B, XC9148B/H

- Switching between voltage boost and battery voltage through
- During MCU sleep, supplying through battery voltage, and Iq of the IC is 0µA.




## Ultra-low Iq VSET ($V_{OUT}$ selectable) function Step-down DC/DC

| Product | Features | $V_{IN}$ (V) | $V_{OUT}$ (V) | $I_{OUT}$ (mA) | Package |
|---|---|---|---|---|---|
| **XCL233** FEATURED | Built-in inductor<br>VSET($V_{OUT}$ selectable)<br>Iq=200nA, PFM | 1.8 ~ 6.0 | 0.5 ~ 3.6<br>2 values | 150 | CL-2025-03<br>(2.5x2.0x1.04mm) |
| **XC9276** | VSET($V_{OUT}$ selectable)<br>Iq=200nA, PFM | 1.8 ~ 6.0 | 0.5 ~ 3.6<br>2 values | 150 | USP-8B06 (2.0x2.0x0.33mm)<br>SOT-26W (2.8x2.9x1.3mm)<br>WLP-6-03 (1.72x1.07x0.33mm) |

## Bypass type Step-up DC/DC

| Product | Features | $V_{IN}$ (V) | $V_{OUT}$ (V) | $I_{OUT}$(mA)<br>@3.3V→5V | Package |
|---|---|---|---|---|---|
| **XCL110B** FEATURED | Built-in inductor<br>PWM/PFM, 3MHz | 0.65 ~ 6.0<br>$V_{ST}$ = 0.9 | 1.8 ~ 5.5 | 610 | CL-2025-02<br>(2.5x2.0x1.04mm) |
| **XCL105B** | Built-in inductor<br>PWM/PFM, 1.2MHz | 0.65 ~ 6.0<br>$V_{ST}$ = 0.9 | 1.8 ~ 5.5 | 710 | DFN3030-10B<br>(3.0x3.0x1.7mm) |
| **XC9148B/H** | PWM/PFM<br>1.2MHz/3MHz | 0.65 ~ 6.0<br>$V_{ST}$ = 0.9 | 1.8 ~ 5.5 | 750 | USP-6C (1.8x2.0x0.6mm)<br>SOT-89-5 (4.5x4.6x1.6mm) |

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# Further Lower Consumption / Battery Life : Ideal Diode, Push Button Load Switch

## Ideal Diode to reduce power loss of diode

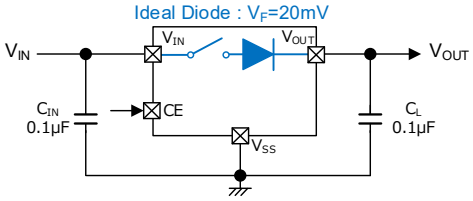
### Technical trend and challenges

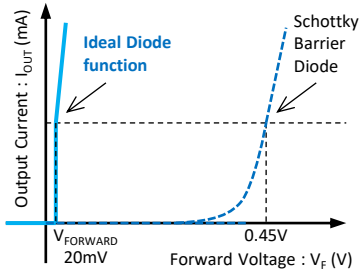
- Many diodes used in each power lines for reverse current prevention, etc.
- SBD generates about 0.4V of VF loss and reverse current due to leakage, and the loss is more than 0.4W at IF=1A, which is an obstacle to high efficiency and miniaturization.

### TOREX Proposal : Significantly reducing VF loss

➢ **Ideal Diode Load Switch: XC8110 / XC8111, XC8112 / XC8113**

- Achieving **VF=20mV. Loss is 1/20 of SBD**@200mA or less and 1/6@500mA. Parallel connection of XC8112/XC8113 halves VF at high current. Leakage current is 0 µA, preventing reverse current harmful to batteries.
- **IEC 62368-1:2018 certified** with current limit and other protections.




## Ideal Diode Load Switch

| Product | Features | $V_{IN}$ (V) | Ron | $I_{OUT}$ | Package |
|---|---|---|---|---|---|
| XC8110 FEATURED | VF=20mV<br>3.6µA (Forward bias)<br>0µA (Reverse bias)<br>IEC 62368-1:2023 certified<br>(XC8110/XC8111) | 1.5 ~ 6.0 | 120mΩ | 500mA | WLP-4-02 (0.82x0.82x0.5mm)<br>SOT-25 (2.9x2.8x1.3mm)<br>USP-6B06 (1.8x1.5x0.33mm) |
| XC8111 | | | | 1A | |
| XC8114 FEATURED | | | 45mΩ | 3A | WLP-4-04 (0.82x1.48x0.495mm)<br>SOT-89-5 (4.5x4.6x1.6mm)<br>DFN1820-6G (1.8x2.0x0.6mm) |
| XC8112 FEATURED | 2ch (Parallel is allowed)<br>VF=20mV<br>3.6µA (Forward bias)<br>0µA (Reverse bias)<br>IEC 62368-1:2023 certified | | 2ch x 120mΩ | 2 x 500mA | USP-8B06 (2.0x2.0x0.33mm) |
| XC8113 FEATURED | | | | 2 x 1A | |

## "Ship function" to prevent battery discharge during shipment.

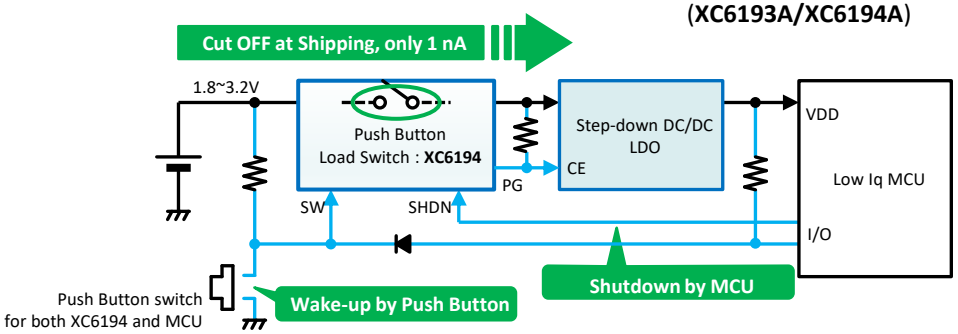
### Technical trend and challenges

- Discharge current from the battery after shipment is so large that the battery may not be usable at the time of usage.
- Due to an increase in the number of devices with built-in batteries and the need to ensure water resistance, the conventional method of preventing discharge by using plastic insulating tabs has become difficult.

### TOREX Proposal : Preventing battery discharge by Ship function

➢ **Push Button Load Switch: XC6194 (1A) / XC6193 (1A + External Pch FET)**

- **Ship function** greatly reduces discharge after shipment to 1nA.
- **Useful as main power switch as well.**
  Turn ON by the push-button, and OFF by the signal from MCU to SHDN after processing termination. Safety shutdown is possible.
- **At system freeze**, long pressing the push button forces OFF.
  **(XC6193A/XC6194A)**




## Push Button Load Switch with Ship function

| Product | Features | $V_{IN}$ (V) | Ron | $I_{OUT}$ | Package |
|---|---|---|---|---|---|
| XC6193 FEATURED | $I_{STB}$=1nA<br>Shutdown function<br>(Ship/Main power switch)<br>For system freeze<br>(XC6193A/XC6194A)<br>UVLO: Prevents battery leakage | 1.8 ~ 6.0 | Internal 1A<br>+ External Pch FET | | USP-8B06<br>(2.0x2.0x0.33mm) |
| XC6194 FEATURED | | | 140mΩ | 1A | |

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# All-in-one Charger IC and Ultra-Low Iq Load Switch

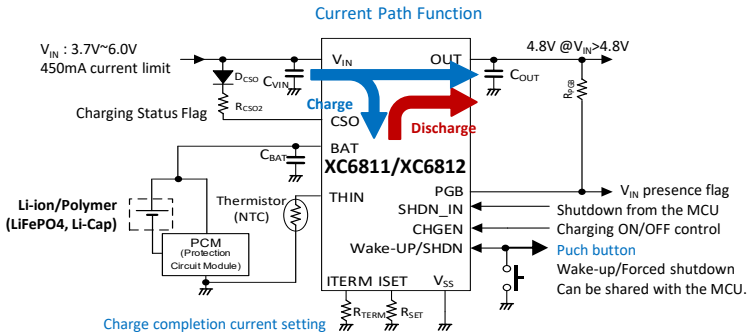
## All-in-one Charger IC with Push Button Control and Current Path

### Technical trend and challenges

- Miniaturization and higher performance in IoT sensors, wearables, and trackers
- Longer battery life and stable operation getting more critical: Precise charge control, discharge prevention(Ship Mode), and freeze-recovery measures

### TOREX Proposal : All-in-one Charge Control in an Ultra-Compact Package

➢ **All-in-one Charger IC with Integrated Power-Path & Push-Button Control : XC6811/XC6812** UNDER DEVELOPMENT




**Precise Charge Settings**

CV : 3.1V~4.5V, **supports solid-state batteries, LiFePO4, and Li-Cap**
Externally Adj. CC : 1mA~50mA **(XC6811)**, 25mA~400mA **(XC6812)**。
**Externally Adj. charge completion current** : 0.1mA~10mA **(XC6811)**, 1mA~50mA **(XC6812)** Enables wide battery coverage and long-life design

**Current Path**

**Separate control of battery charging and power supply to OUT**
After full charge, powers OUT from $V_{IN}$ without drawing from the battery

**Wake-Up / Shutdown**

Wake-up: Push button, or $V_{IN}$ applied.
Shutdown: Signal from MCU to SHDN_IN. Also supports Ship mode.
Push button long press, as a countermeasure during freeze.

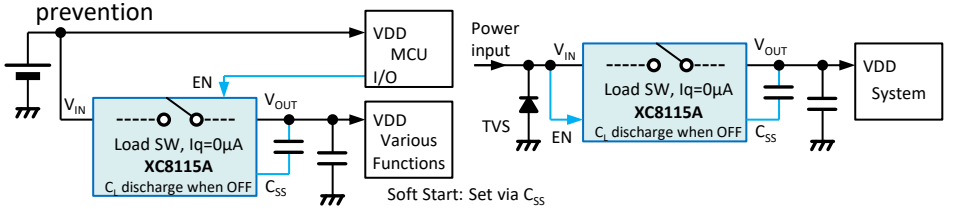
## Ultra-Low Iq 0μA Load Switch

### Technical trend and challenges

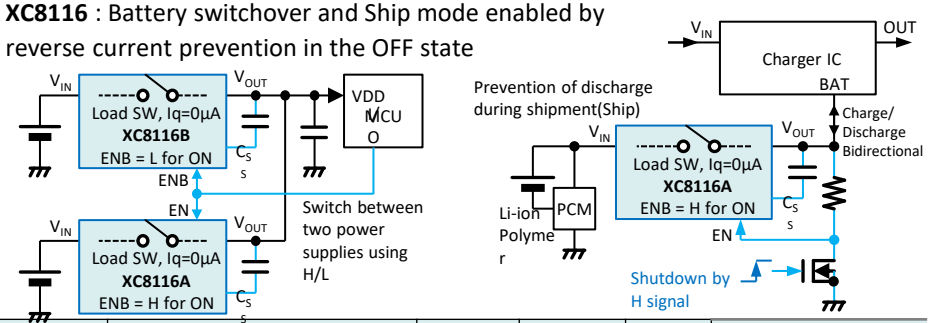
- Power distribution and line-by-line ON/OFF control with ultra-low power consumption.
- Inrush current prevention is essential to prevent voltage drops in battery or power lines.
- Battery/power line selection and battery disconnection (Ship mode) are essential for IoT devices.

### TOREX Proposal : Ultra-low Iq $I_{STB}$ / Iq = 0μA Load Switch IC : XC8115/XC8116

**XC8115** : Power line ON/OFF and externally adj. soft start for inrush current prevention




**XC8116** : Battery switchover and Ship mode enabled by reverse current prevention in the OFF state




| Product | Features | $V_{IN}$ (V) | Ron | $I_{OUT}$ | Package |
|---|---|---|---|---|---|
| **XC8115** UNDER DEVELOPMENT | $I_{STB}$/Iq = 0μA<br>**Externally adj. soft start**<br>**$C_L$ discharge** | 1.5 ~ 6.0 | 150mΩ | 1.0A | DFN1515-6A<br>(1.5x1.5x0.38mm)<br>SOT-25<br>(2.8x2.9x1.3mm) |
| **XC8116** UNDER DEVELOPMENT | $I_{STB}$/Iq = 0μA<br>**Externally adj. soft start**<br>**Reverse current prevention @OFF**<br>Both EN/ENB type available | | | | |

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