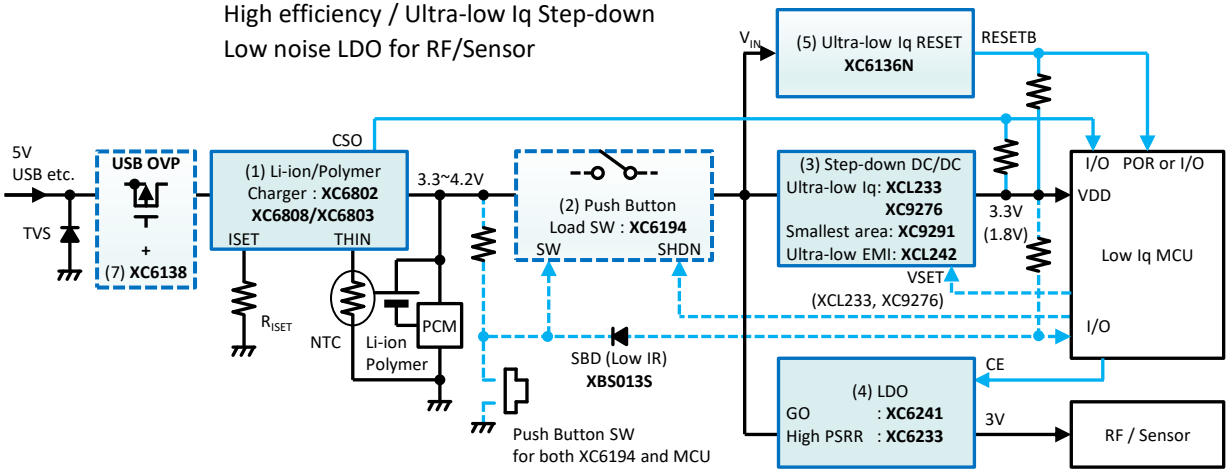
Li Rechargeable Battery : Small and Low Power Consumption Solutions

■ Products using Li-ion/Polymer rechargeable battery : IoT Sensor/Wearable etc.

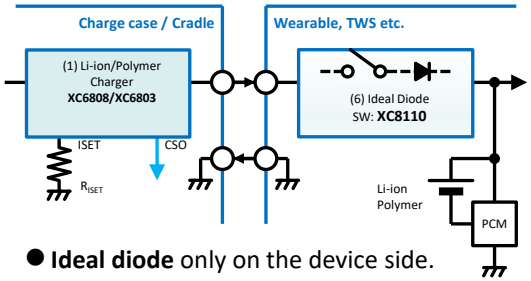
● Challenges : Prevention of discharge after shipment
High efficiency / Ultra-low Iq Step-down
Low noise LDO for RF/Sensor



	Product	Features
(1) Li Charger IC	**XC6808 / XC6803**	CC/CV Charger, CC=~280/40mA, Battery Temperature Monitor
(2) Push button SW	**XC6194**	I_{STB}=1nA, Shutdown function(Ship/Main power SW) For system freeze
(3) Step-down DC/DC	**XCL233**	Built-in inductor, Iq=200nA, PFM, 150mA, VSET(V_{OUT} selectable)
	XCL242	Built-in inductor, HiSAT-COT, Ultra-low EMI, PWM/PFM, 1.2MHz, 500mA
	XC9291	HiSAT-COT, Smallest area, PWM/PFM, 4MHz/6MHz, 600mA
	XC9276	Iq=200nA, PFM, 150mA, VSET(V_{OUT} selectable)
(4) LDO	**XC6241**	Iq=0.6μA, PSRR=60dB, GO, 150mA
	XC6233	High-speed PSRR=75dB, 200mA, Inrush prevention
(5) RESET IC	**XC6136**	Iq=100nA class Ultra-low Iq
(6) Ideal diode SW	**XC8110 / XC8111**	True Reverse current prevention Ideal Diode Load SW VF=20mV, 500mA (XC8110), 1A (XC8111), IEC 62368-1 certified
(7) Reset IC	**XC6138**	High Voltage Sense pin: 76V, Wide hysteresis

(6) Example of charge control by the case/cradle

Configuration for charging control of Li batteries in **Wearable/Hearable/TWS**, etc. **by the charging case/cradle side**.



● **Ideal diode** only on the device side. Prevents terminal corrosion by reverse current prevention.

● Charging is controlled on the charging case side, **making it easy to stop output from the case** after charging is complete.

(2) Push Button Load SW with Shutdown function : XC6194

Shutdown at shipment **to reduce the discharge current from the battery to 1nA**.
Main power SW / Forced shut-down at system freeze

(3) Ultra-low Iq Step-down DC/DC for MCU

Ultra-low Iq DC/DC is suitable. **(XCL233, XC9276 : Iq=200nA)**
VSET function lowers V_{OUT} in sleep mode to achieve lower Iq.
World's smallest class solution XC9291 with ultra low EMI.
XCL242 for ultra-low EMI to further reduce noise to the Sensors.

(4) LDO for RF/Sensor : XC6241

GO function automatically switches between low Iq and high-speed according to the output current, achieving both low consumption and high-speed response.

(7) RESET IC for OVP (Over Voltage Protection) of USB input : XC6138

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

Ideal Diode to reduce power loss of diode

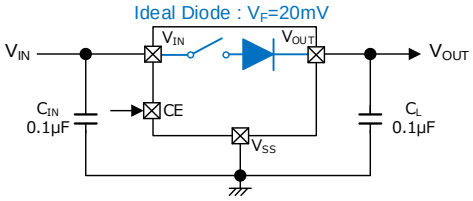
Technical trend and challenges

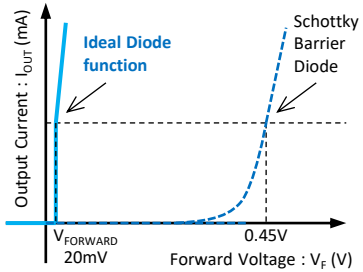
- Many diodes used in each power lines for reverse current prevention, etc.
- SBD generates about 0.4V of VF loss and reverse current due to leakage, and the loss is more than 0.4W at IF=1A, which is an obstacle to high efficiency and miniaturization.

TOREX Proposal : Significantly reducing VF loss

➢ **Ideal Diode Load SW: 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	VF=20mV 3.6µA (Forward bias) 0µA (Reverse bias) IEC 62368-1:2018 certified	1.5 ~ 6.0	120mΩ	500mA	WLP-4-02 (0.82x0.82x0.5mm) SOT-25 (2.9x2.8x1.3mm) USP-6B06 (1.8x1.5x0.33mm)
XC8111				1A	
XC8114			60mΩ	3A	WLP-4-04 (0.82x1.48x0.495mm) SOT-89-5 (4.5x4.6x1.6mm) DFN1820-6G (1.8x2.0x0.6mm)
XC8112	2ch (Parallel is allowed) VF=20mV 3.6µA (Forward bias) 0µA (Reverse bias) IEC 62368-1:2018 certified		2ch x 120mΩ	2 x 500mA	USP-8B06 (2.0x2.0x0.33mm)
XC8113				2 x 1A	

"Ship function" to prevent battery discharge during shipment.

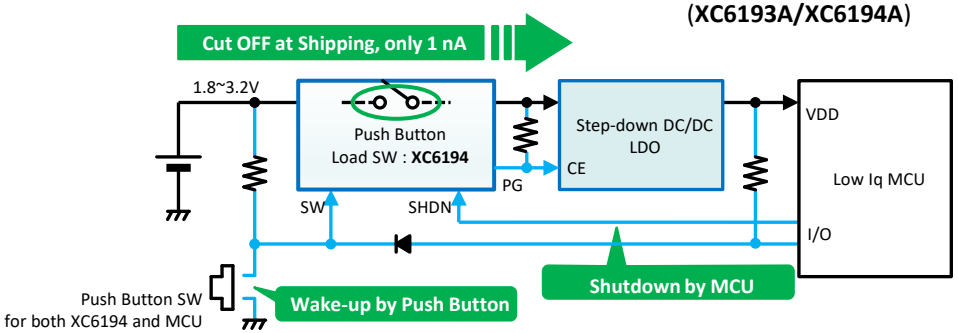
Technical trend and challenges

- 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 SW: 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	I_{STB}=1nA Shutdown function (Ship/Main power SW) For system freeze (XC6193A/XC6194A) UVLO: Prevents battery leakage	1.8 ~ 6.0	Internal 1A + External Pch FET		USP-8B06 (2.0x2.0x0.33mm)
XC6194			140mΩ	1A	

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

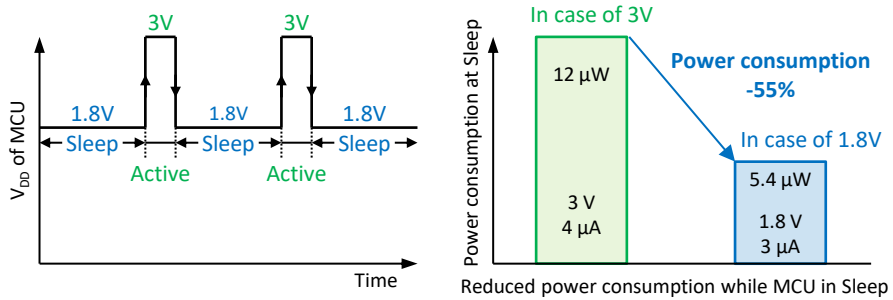
Technical trend and challenges

- 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

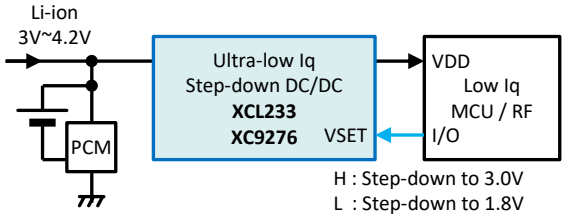
- Dynamically changing output voltage according to MCU/SoC operation, greatly reducing power consumption in standby state.

Change supply voltage according to MCU operation



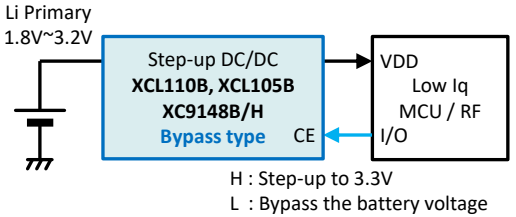
➢ Ultra-low Iq Step-down DC/DC with VSET function : XCL233, XC9276

- V_{OUT} can be switched by the VSET pin.
- 200nA Ultra-low Iq achieves always 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	Built-in inductor VSET(V_{OUT} selectable) Iq=200nA, PFM	1.8 ~ 6.0	0.5 ~ 3.6 2 values	150	CL-2025-03 (2.5x2.0x1.04mm)
XC9276	VSET(V_{OUT} selectable) Iq=200nA, PFM	1.8 ~ 6.0	0.5 ~ 3.6 2 values	150	USP-8B06 (2.0x2.0x0.33mm) SOT-26W (2.8x2.9x1.3mm) WLP-6-03 (1.72x1.07x0.33mm)

Bypass type Step-up DC/DC

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

Reset IC Application Examples

Monitoring of 12V/24V input lines with large voltage fluctuations

Technical trend and challenges

- It is necessary to monitor large voltage fluctuations in the power supply line due to loads such as motors and input impedance.
  Set the detect /release voltage to suit the application.

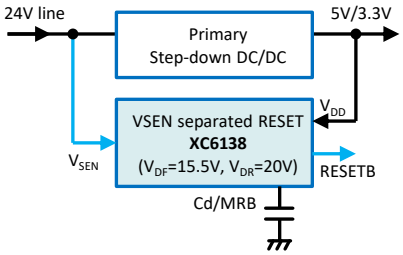
TOREX Proposal : Reset IC with high voltage tolerance and a wide range of detect/release voltages

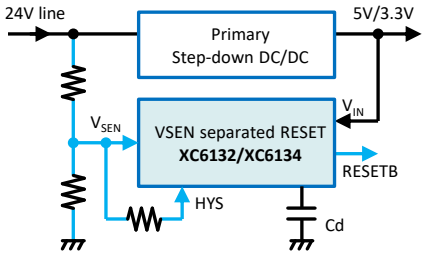
➢ **Wide range of detect/release voltage difference (hysteresis) supported**

- Separate sense pin type, monitoring 12V/24V lines.
- Select a release voltage high enough to ensure a stable rise and select a detect voltage sufficiently different from the release voltage.

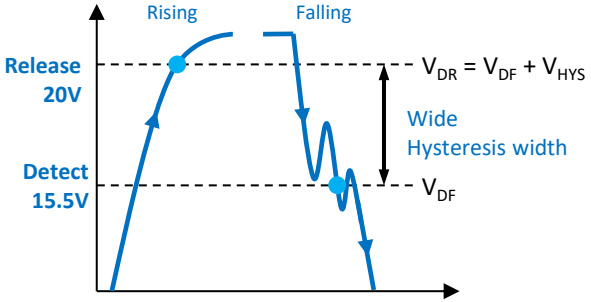
XC6138
76V High voltage Sense pin
Wide hysteresis range selectable.

XC6132/XC6134
Detect and release voltages are set using external resistors.
(**XC6132** has V_{SEN} pin surge protection)





Example of 24V line voltage monitoring



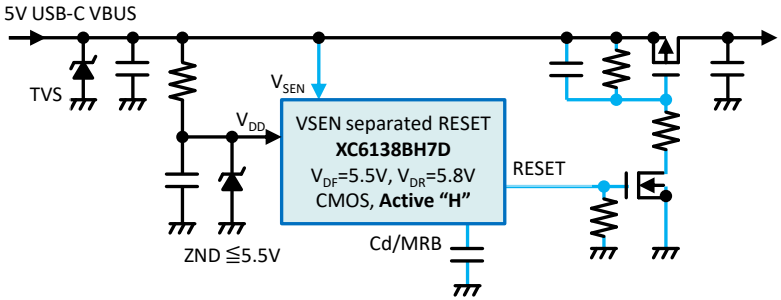
USB port Overvoltage protection (OVP)

Technical trend and challenges

- 5V USB overshoot is an issue due to the spread of low-cost USB-PD adapters.

TOREX Proposal : Overvoltage protection with a reset IC suitable for 5V USB

➢ **Simple implementation with XC6138BH7D + external FETs.**



Simple MPPT using an ultra-low Iq reset IC and a step-up DC/DC

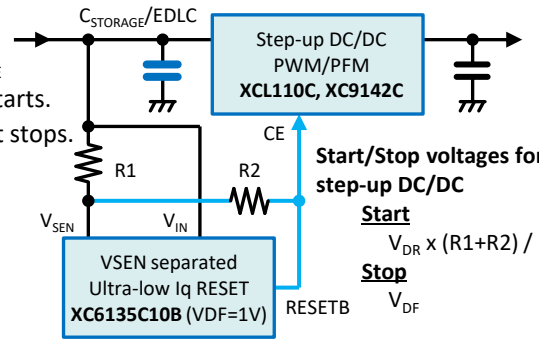
Technical trend and challenges

- ON/OFF control of step-up DC/DC in response to changes in input voltage is important for energy harvesting and backup power supply from EDLC.

TOREX Proposal : Input voltage monitoring using an ultra-low Iq reset IC

➢ **Creating hysteresis with XC6135 + resistors**

- **Energy Harvesting**
  When voltage of $C_{STORAGE}$ rises enough, boosting starts. When the voltage falls, it stops.
- **EDLC for backup**
  When the EDLC voltage rises enough, backup supply starts. When the voltage falls, it stops.



Start/Stop voltages for step-up DC/DC
Start
V_{DR} x (R1+R2) / R2
Stop
V_{DF}