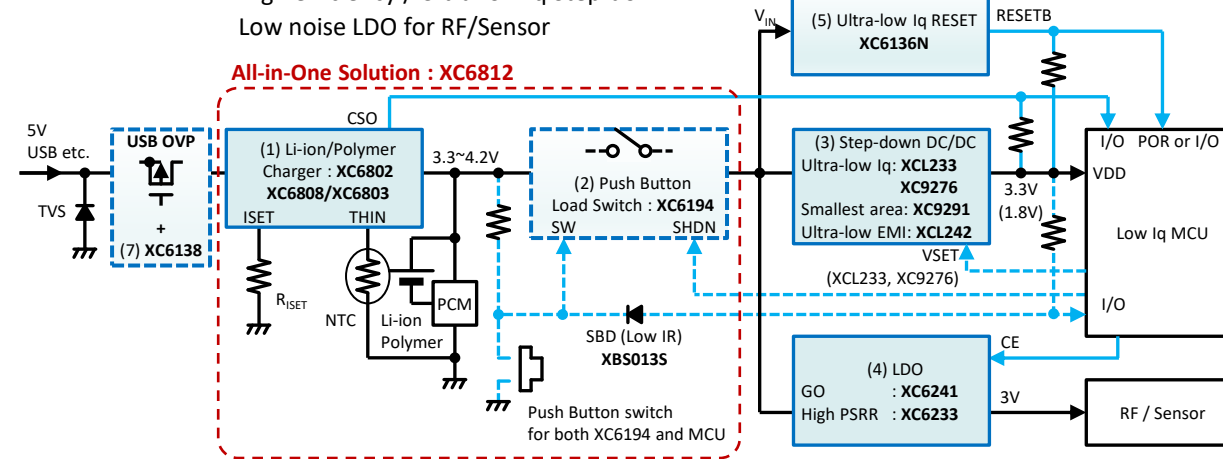


Li Rechargeable Battery : Small and Low Power Consumption Solutions

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

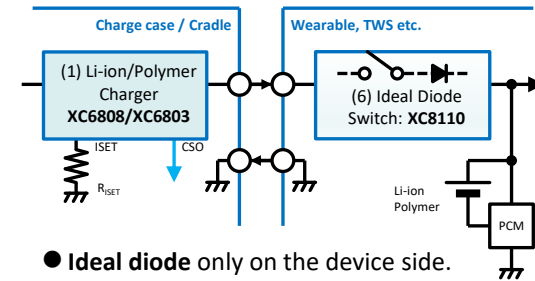
- Challenges : Prevention of discharge after shipment
High efficiency / Ultra-low Iq Step-down
Low noise LDO for RF/Sensor



	Product	Features
(1) Li Charger IC	XC6808 / XC6803	CC/CV Charger, CC~280/40mA, Battery Temperature Monitor
(2) Push button switch	XC6194 FEATURED	I _{STB} =1nA, Shutdown function(Ship/Main power switch) For system freeze
(3) Step-down DC/DC	XCL233 FEATURED	Built-in inductor, Iq=200nA, PFM, 150mA, VSET(V _{OUT} selectable) Other: XC9276 , 150mA
	XCL242 FEATURED	Built-in inductor, HiSAT-COT , Ultra-low EMI, PWM/PFM, 1.2MHz, 500mA
	XC9291 FEATURED	HiSAT-COT , Smallest area, PWM/PFM, 4MHz/6MHz, 600mA
(4) LDO	XC6241 FEATURED	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 switch	XC8110 / XC8111 FEATURED	True Reverse current prevention Ideal Diode Load Switch VF=20mV, 500mA (XC8110), 1A (XC8111), IEC 62368-1 certified
(7) Reset IC	XC6138 FEATURED	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 Switch with Shutdown function : XC6194

Shutdown at shipment **to reduce the discharge current from the battery to 1nA**.
Main power switch / 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

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

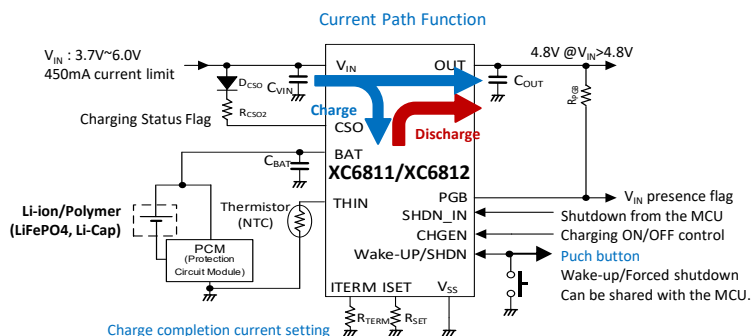
■ All-in-one Charger IC with Push Button Control and Current Path

● 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.

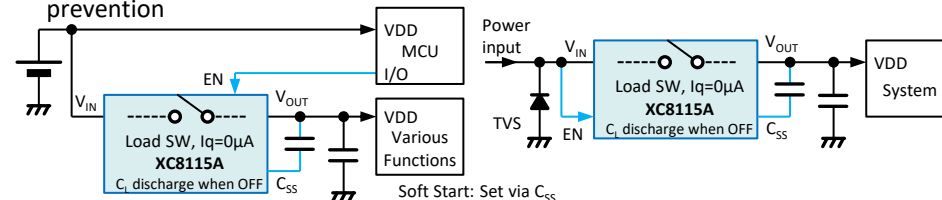
■ Ultra-Low Iq 0μA Load Switch

● Technical trend and challenges

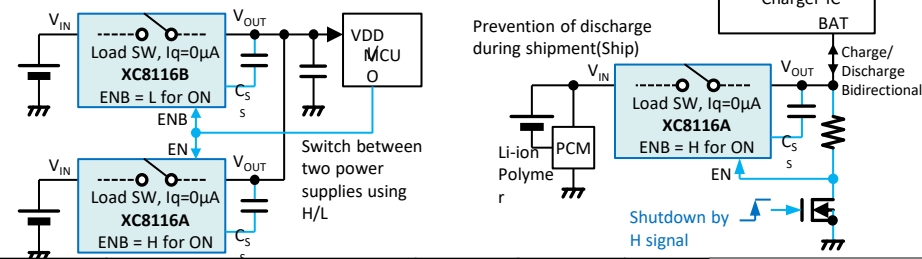
- Power distribution and line-by-line ON/OFF control with ultra-low power consumption.
- Inrush current prevention is essential to prevent voltage drops in battery or power lines.
- Battery/power line selection and battery disconnection (Ship mode) are essential for IoT devices.

● TOREX Proposal : Ultra-low Iq I_{STB} / $I_q = 0\mu A$ 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)	R_{on}	I_{OUT}	Package
XC8115 UNDER DEVELOPMENT	$I_{STB}/I_q = 0\mu A$ Externally adj. soft start C_L discharge	1.5 ~ 6.0	150mΩ	1.0A	DFN1515-6A (1.5x1.5x0.38mm) SOT-25 (2.8x2.9x1.3mm)
XC8116 UNDER DEVELOPMENT	$I_{STB}/I_q = 0\mu A$ Externally adj. soft start Reverse current prevention @OFF Both EN/ENB type available				

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

■ Ideal Diode to reduce power loss of diode

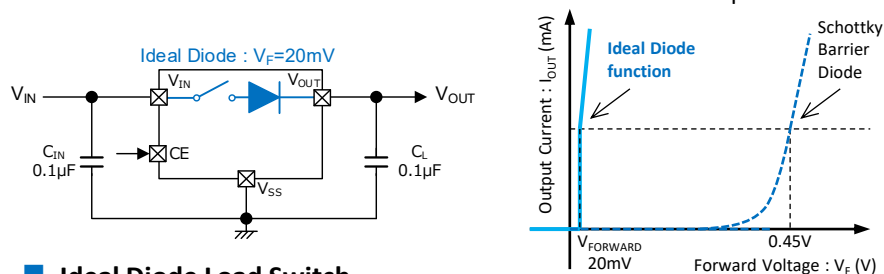
● Technical trend and challenges

- 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 μ A, 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)	R _{on}	I _{OUT}	Package
XC8110 FEATURED	VF=20mV 3.6 μ A (Forward bias)	1.5 ~ 6.0	120m Ω	500mA	WLP-4-02 (0.82x0.82x0.5mm)
XC8111	0 μ A (Reverse bias) IEC 62368-1:2023 certified (XC8110/XC8111)			1A	SOT-25 (2.9x2.8x1.3mm) USP-6B06 (1.8x1.5x0.33mm)
XC8114 FEATURED			45m Ω	3A	WLP-4-04 (0.82x1.48x0.495mm) SOT-89-5 (4.5x4.6x1.6mm) DFN1820-6G (1.8x2.0x0.6mm)
XC8112 FEATURED	2ch (Parallel is allowed) VF=20mV 3.6 μ A (Forward bias)		2ch x 120m Ω	2 x 500mA	USP-8B06 (2.0x2.0x0.33mm)
XC8113 FEATURED	0 μ A (Reverse bias) IEC 62368-1:2023 certified			2 x 1A	

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

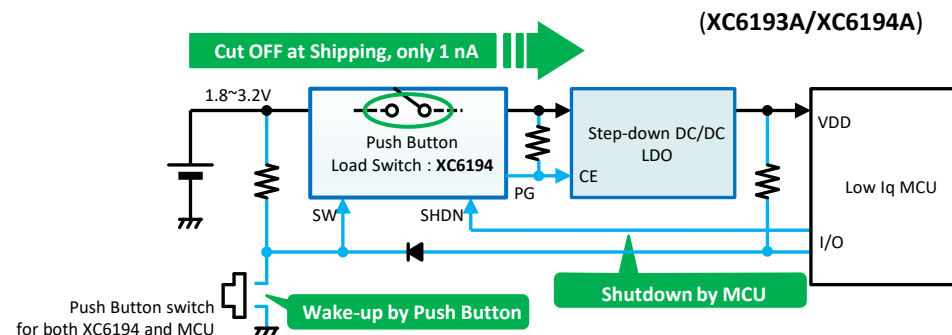
● Technical trend and challenges

- 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.**



■ Push Button Load Switch with Ship function

Product	Features	V _{IN} (V)	R _{on}	I _{OUT}	Package
XC6193 FEATURED	I _{STB} =1nA Shutdown function (Ship/Main power switch) For system freeze (XC6193A/XC6194A)	1.8 ~ 6.0	Internal 1A + External Pch FET		USP-8B06 (2.0x2.0x0.33mm)
XC6194 FEATURED	UVLO: Prevents battery leakage		140m Ω	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

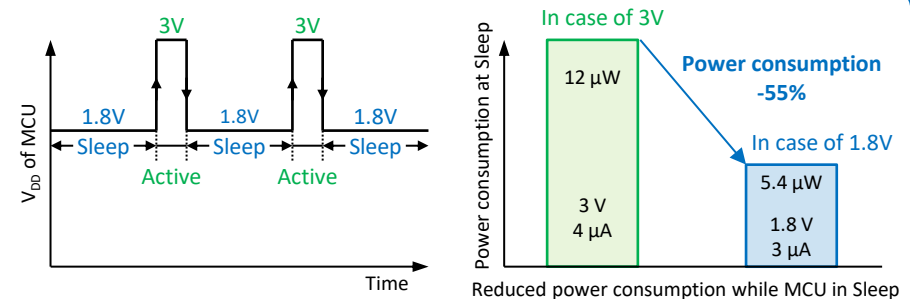
● Technical trend and challenges

- 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

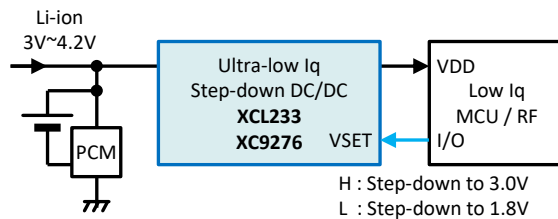
- Dynamically changing output voltage according to MCU/SoC operation, greatly reducing power consumption in standby state.

Change supply voltage according to MCU operation



➤ Ultra-low I_q Step-down DC/DC with VSET function : XCL233, XC9276

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

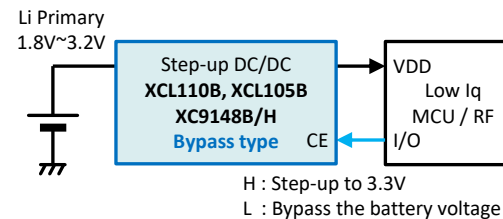


■ Ultra-low I_q VSET (V_{OUT} selectable) function Step-down DC/DC

Product	Features	V _{IN} (V)	V _{OUT} (V)	I _{OUT} (mA)	Package
XCL233 FEATURED	Built-in inductor VSET (V _{OUT} selectable) I _q =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) I _q =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)

➤ 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 I_q of the IC is 0μA.



■ Bypass type Step-up DC/DC

Product	Features	V _{IN} (V)	V _{OUT} (V)	I _{OUT} (mA) @3.3V→5V	Package
XCL110B FEATURED	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, XD6138

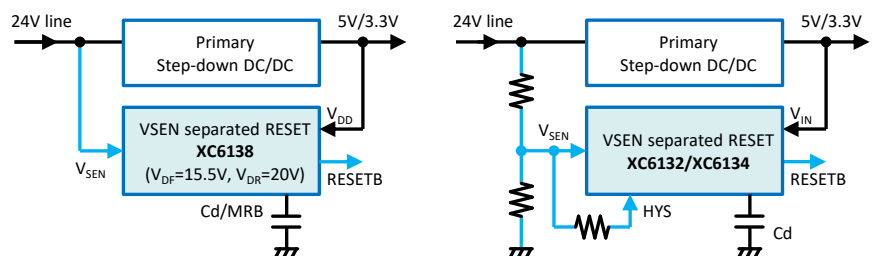
76V High voltage Sense pin

Wide hysteresis range selectable.

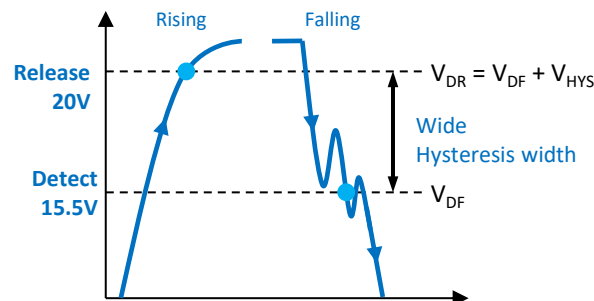
XC6132/XC6134, XD6132/XD6134

Detect and release voltages are set using external resistors.

(XC/XD6132 has V_{SEN} pin surge protection)



Example of 24V line voltage monitoring



■ USB port Overvoltage protection (OVP)

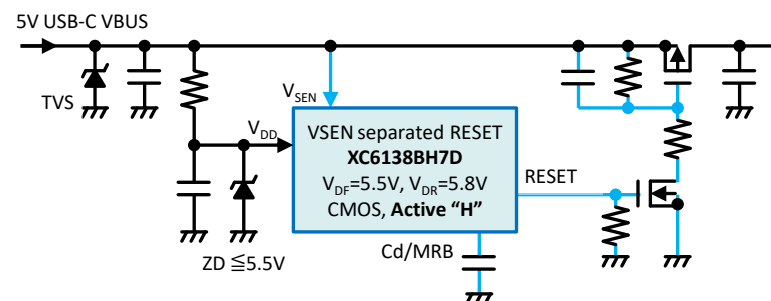
● Technical trend and challenges

- The proliferation of low-cost USB-PD adapters poses a challenge, as overshoot on 5V USB or the application of voltages exceeding specifications can damage downstream systems.

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

➤ Simple implementation with XC6138BH7D + external Pch FETs.

- XC6138BH7D** : Outputs 'L' at 5.8V, turning the Pch FET OFF
Outputs 'H' at 5.5V, turning the Pch FET ON
- TVS and each FET are selected to match the permissible input voltage.
- Apply <6V to the V_{DD} pin via ZD.
- To counter inrush current during start-up, implement a simple soft-start by adding capacitance between the gate and source of the Pch FET.



Block	Product	Features
RESET IC	XC6138 FEATURED	High Voltage Sense pin: 76V, Ultra-low $I_{q V_{DD}}$: 0.5μA, V_{SEN} : 0.15μA@12V Detect/Release Delay external adj., Selectable Hysteresis
	XC6118 XC6134	Separated Sense pin, Low I_{q} , Adj. Release delay, Hysteresis adj. (XC6134)