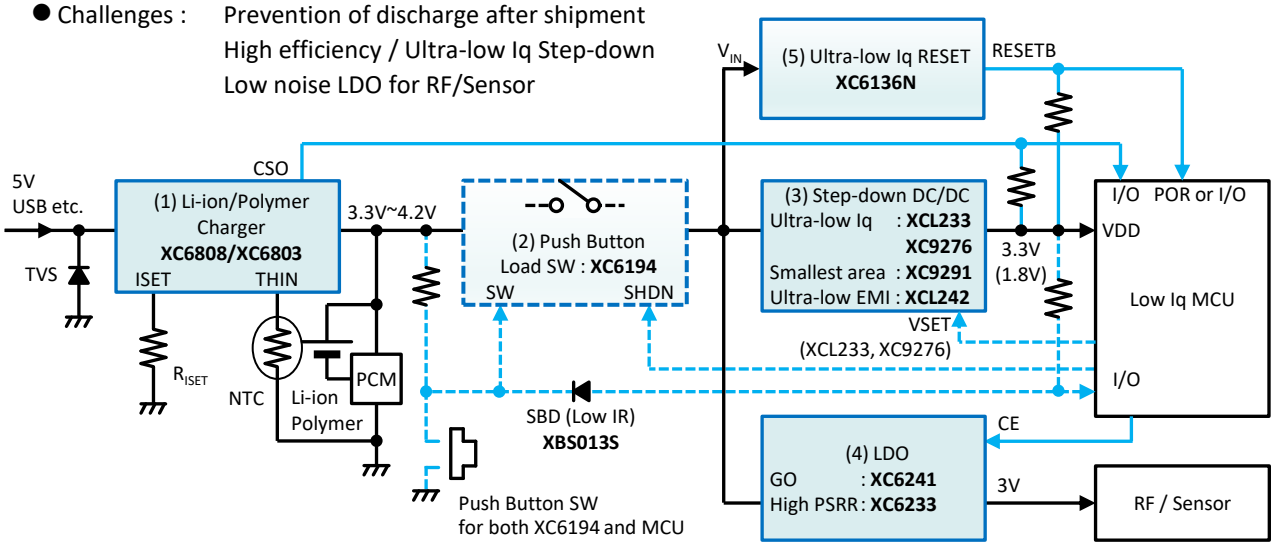
Li Rechargeable Battery : Small and Low Power Consumption Solutions

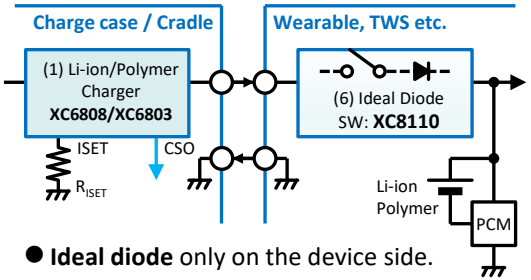
Products using Li-ion/Polymer rechargeable battery : IoT Sensor/Wearable etc.

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



(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.

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

(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 solution XC9291 with ultra low EMI.
XCL242 for ultra-low EMI to further reduce noise to the Sensors.

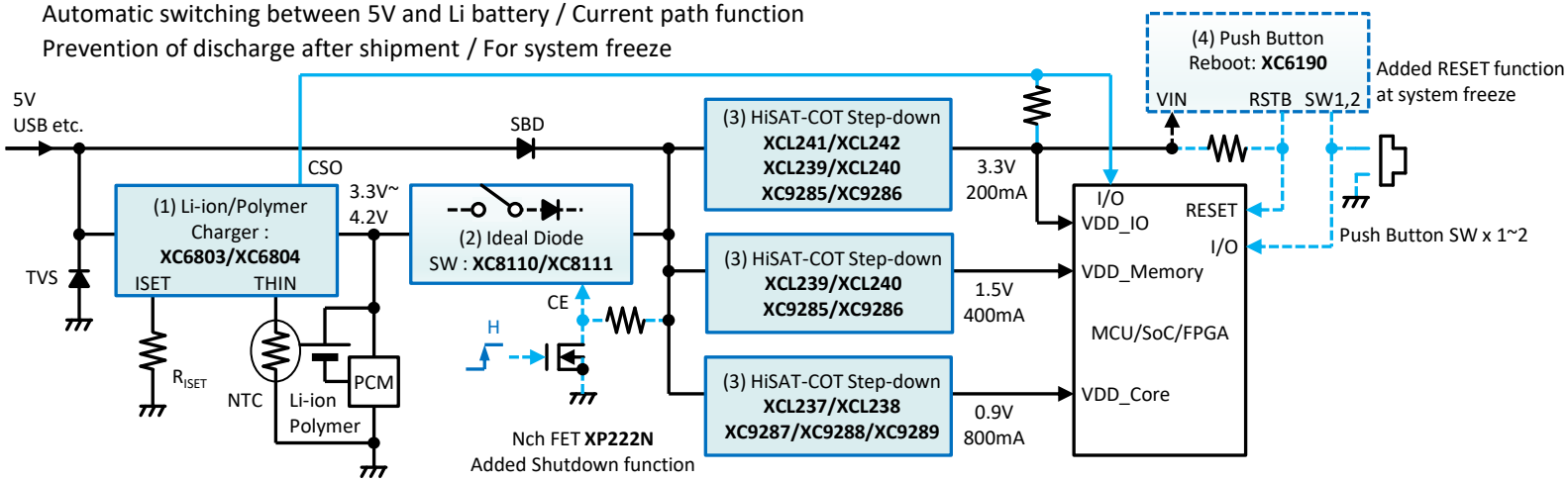
(4) LDO for RF/Sensor : XC6241

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

Li Rechargeable Battery : Multiple Power Rail Solutions

Products that requires multi-voltage from Li-ion/Polymer Rechargeable battery

● Challenges : Small / High efficiency / High-speed response / Low EMI Step-down DC/DC
Automatic switching between 5V and Li battery / Current path function
Prevention of discharge after shipment / For system freeze



Block	Product	Features
(1) Li Charger IC	**XC6803 / XC6804**	CC/CV Charger, CC=~280/800mA,Battery Temperature Monitor
(2) Ideal diode SW	**XC8110 / XC8111** FEATURED	True Reverse current prevention Ideal Diode Load SW VF=20mV, 500mA (XC8110), 1A (XC8111), IEC 62368-1 certified
(3) Step-down DC/DC	**XCL241 / XCL242** NEW	Built-in inductor, HiSAT-COT, F-PWM, PWM/PFM 1.2MHz, 500mA, Ultra-low EMI
	XCL239 / XCL240 NEW	Built-in inductor, HiSAT-COT, F-PWM, PWM/PFM 3MHz, 1A
	XCL237 / XCL238 NEW	Built-in inductor, HiSAT-COT, F-PWM, PWM/PFM 3MHz, 1.5A
	XC9285 / XC9286 NEW	HiSAT-COT, F-PWM, PWM/PFM 1.2MHz, 1A
	XC9287 / XC9288 XC9289 NEW	HiSAT-COT, F-PWM, PWM/PFM, Selectable by MODE 1.2MHz/3MHz, 1.5A
(4) Reboot IC	**XC6190**	For system freeze, Hold SW 1 and 2 "L" to output reset signal

(2) Ideal Diode Load SW : XC8110/XC8111

Ideal Diode achieves **automatic switching between 5V input and Li battery**
VF loss is also reduced. Adding Nch FET enables Shutdown function at shipment.

(3) Step-down DC/DC for MPU/Memory/FPGA (POL converter)

HiSAT-COT controlled DC/DC with high-speed transient response
arranged as POL power supply.
Built-in inductor Micro DC/DC achieves miniaturization and low EMI.
(XCL241/XCL242, XCL239/XCL240, XCL237/XCL238)

(4) Push Button Reboot controller : XC6190

Added Push Button Reboot IC that can **reboot the system by long pressing the physical SW** for freeze countermeasure.
Physical SW can be shared with other uses.

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

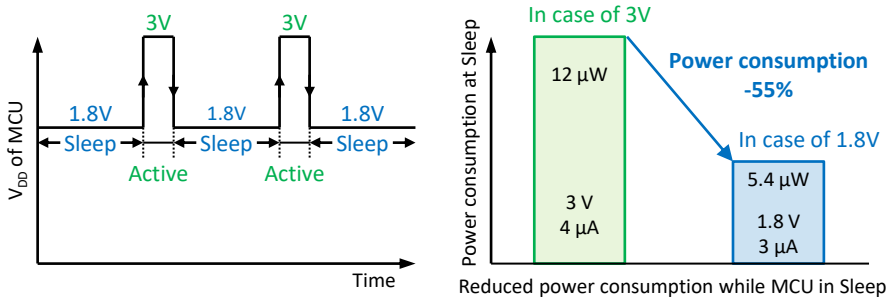
Technical trend and challenges

- 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

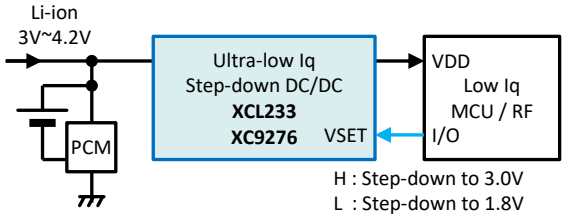
- Dynamically changing output voltage according to MCU/SoC operation, greatly reducing power consumption in standby state.

Change supply voltage according to MCU operation



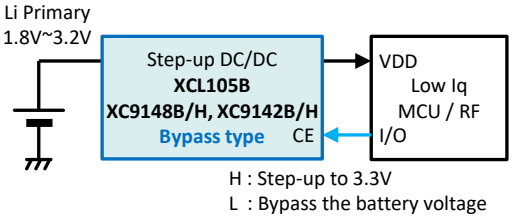
➢ Ultra-low Iq Step-down DC/DC with VSET function : XCL233, XC9276

- 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 : XCL105B, XC9148B/H, XC9142B/E

- 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 NEW	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 FEATURED	VSET(V_{OUT} selectable) Iq=200nA, PFM	1.8 ~ 6.0	0.5 ~ 3.6 2 values	150	USP-8B06 (2.0x2.0xh0.33mm) SOT-26W (2.8x2.9x1.3mm) WLP-6-03 (1.72x1.07xh0.33mm)

Bypass type Step-up DC/DC

Product	Features	V_{IN} (V)	V_{OUT} (V)	I_{OUT}(mA) @3.3V→5V	Package
XCL105B FEATURED	Built-in inductor PWM/PFM, 1.2MHz	0.65 ~ 6.0 V_{ST} = 0.9	1.8 ~ 5.5	710	DFN3030-10B (3.0x3.0xh1.7mm)
XC9148B/H FEATURED	PWM/PFM 1.2MHz/3MHz	0.65 ~ 6.0 V_{ST} = 0.9	1.8 ~ 5.5	750	USP-6C (1.8x2.0xh0.6mm) SOT-89-5 (4.5x4.6xh1.6mm)
XC9142B/E	PWM/PFM 1.2MHz/3MHz	0.65 ~ 6.0 V_{ST} = 0.9	1.8 ~ 5.5	500	SOT-25 (2.9x2.8xh1.3mm) USP-6C (1.8x2.0xh0.6mm) WLP-6-01 (1.08x1.28xh0.4mm)

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

Ideal Diode to reduce power loss of diode

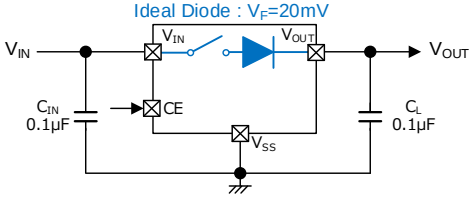
Technical trend and challenges

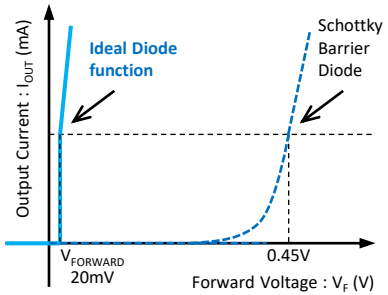
- Many diodes used in each power lines for reverse current prevention, etc.
- SBD generates about 0.4V of VF loss and reverse current due to leakage, and the loss is more than 0.4W at IF=1A, which is an obstacle to high efficiency and miniaturization.

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 FEATURED	VF=20mV 3.6µA (Forward bias) 0µA (Reverse bias) IEC 62368-1:2018 certified	1.5 ~ 6.0	120mΩ	500mA	WLP-4-02 (0.82x0.82xh0.5mm) SOT-25 (2.9x2.8xh1.3mm) USP-6B06 (1.8x1.5xh0.33mm)
XC8111 FEATURED				1A	
XC8112 UNDER DEVELOPMENT	2ch (Parallel is allowed) VF=20mV 3.6µA (Forward bias) 0µA (Reverse bias) IEC 62368-1:2018 certified	1.5 ~ 6.0	2ch x 120mΩ or 1ch x 60mΩ	2 x 500mA or 1 x 1A	USP-8B06 (2.0x2.0xh0.33mm)
XC8113 UNDER DEVELOPMENT				2 x 1A or 1 x 2A	

"Ship function" to prevent battery discharge during shipment.

Technical trend and challenges

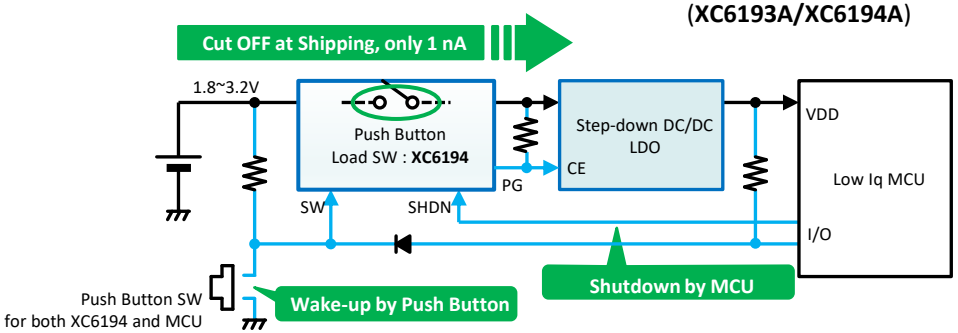
- Discharge current from the battery after shipment is so large that the battery may not be usable at the time of usage.
- Due to an increase in the number of devices with built-in batteries and the need to ensure water resistance, the conventional method of preventing discharge by using plastic insulating 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 FEATURED	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 (2.0x2.0xh0.33mm)
XC6194 FEATURED			140mΩ	1A	