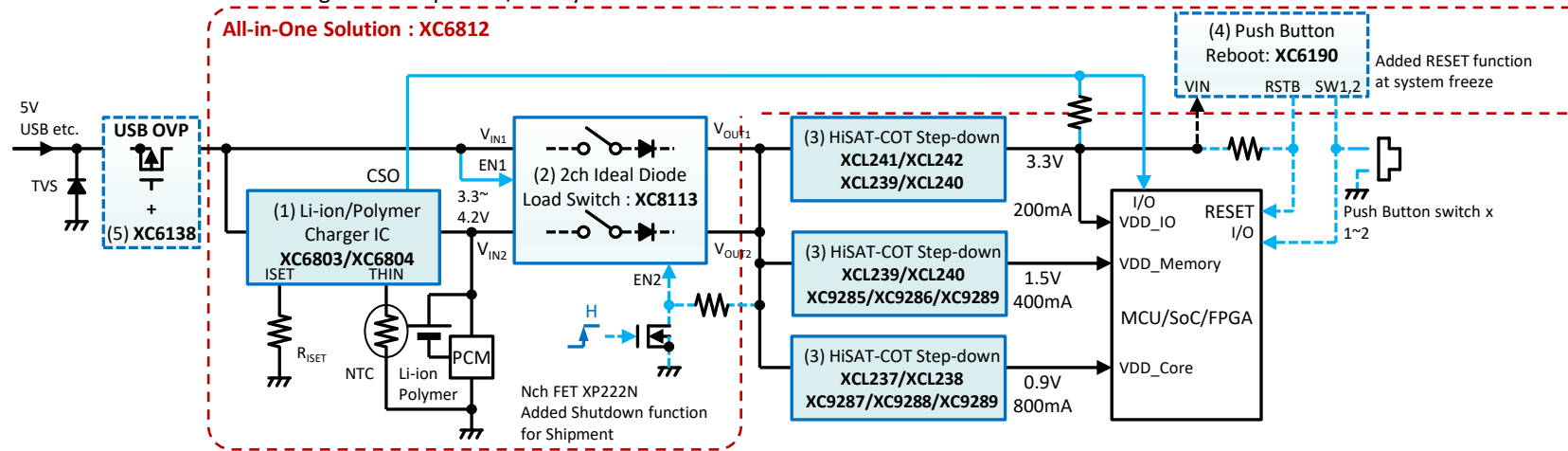


Li Rechargeable Battery : Multi-Function Solutions (1)

■ 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= $\sim$ 280/800mA, Battery Temperature Monitor
(2) Ideal diode load switch	XC8112 / XC8113 FEATURED	2ch True Reverse current prevention Ideal Diode SW, VF=20mV 2ch x 500mA (XC8110), 2ch x 1A (XC8111), IEC 62368-1 certified Others: XC8110/XC8111/XC8114 , 1ch x 500mA/1A/3A
(3) Step-down DC/DC	XCL241 / XCL242 FEATURED	Built-in inductor, HiSAT-COT , F-PWM, PWM/PFM 1.2MHz, 500mA, Ultra-low EMI
	XCL239 / XCL240 FEATURED	Built-in inductor, HiSAT-COT , F-PWM, PWM/PFM, 1A Others: XCL237/XCL238 , Built-in inductor, 1.5A
	XC9287 / XC9288 XC9289 FEATURED	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
(5) Reset IC	XC6138 FEATURED	High Voltage Sense pin: 76V, Wide hysteresis

(2) 2ch Ideal Diode Load switch : XC8112/XC8113

Ideal Diode achieves **automatic switching between 5V input and Li battery**
VF loss is also reduced. Adding Nch FET enables Shutdown function at shipment.
2ch type XC8112/XC8113 achieves low loss for both 5V input and Li-ion battery.

(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.

(4) Push Button Reboot controller : XC6190

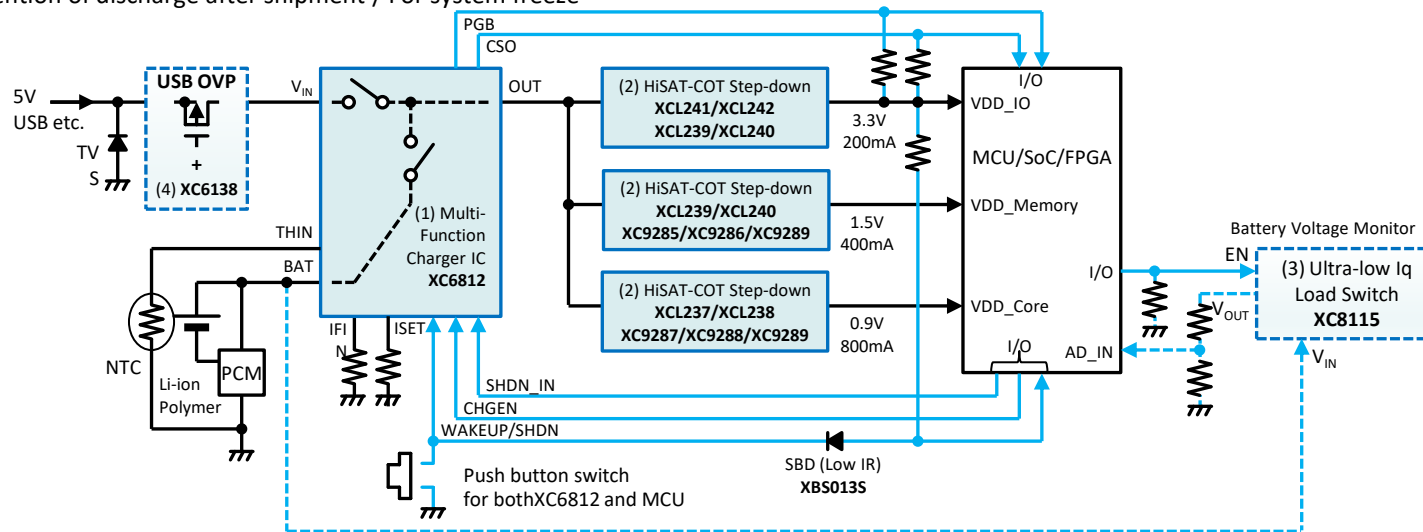
Added Push Button Reboot IC that can **reboot the system by long pressing the physical switch** for freeze countermeasure.
Physical switch can be shared with other uses.

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

Li Rechargeable Battery : Multi-Function Solutions (2)

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

- Challenges : 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	XC6812 UNDER DEVELOPMENT	CV=3.10V~4.50V, CC=25mA~400mA Battery Temperature Monitor, Charge ON/OFF, Current path Shutdown(SHDN, Push button)/Wake-up Other: XC6811 , CC=1mA~50mA
	XCL241 / XCL242 FEATURED	Built-in inductor, HiSAT-COT , F-PWM, PWM/PFM 1.2MHz, 500mA, Ultra-low EMI
(2) Step-down DC/DC	XCL239 / XCL240 FEATURED	Built-in inductor, HiSAT-COT , F-PWM, PWM/PFM Others: XCL237/XCL238 , Built-in inductor, 1A
	XC9287 / XC9288 FEATURED	HiSAT-COT , F-PWM, PWM/PFM, Selectable by MODE 1.2MHz/3MHz, 1.5A Other: XC9289 , Ultra-small/Selectable by MODE
	XC8115 UNDER DEVELOPMENT	Ultra-low Iq Iq=0μA, Adj. soft start, 1A
(4) Reset IC	XC6138 FEATURED	High Voltage Sense pin: 76V, Wide hysteresis

(1) All-in-one Charger IC suitable for small and small-capacity Li batteries : XC6811/XC6812

- Available in CC=1mA~50mA and 25mA~400mA to match battery capacity.
- **Current path** for split charge & system power; convenient for use during charging
- Shutdown via SHDN_IN to **prevent post-shipment Li discharge (Ship mode)**
- Wakeup by **push button** or V_{IN} application
- Forced shutdown by long-press of **push button** for freeze recovery

(2) 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.

(3) Ultra-Low Iq 0μA Load Switch for Battery Voltage Monitoring : XC8115

ON only during monitoring and feeds battery voltage to the MCU A/D

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

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

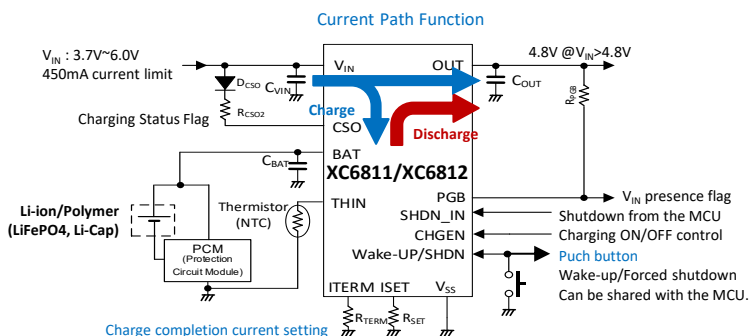
■ All-in-one Charger IC with Push Button Control and Current Path

● 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.

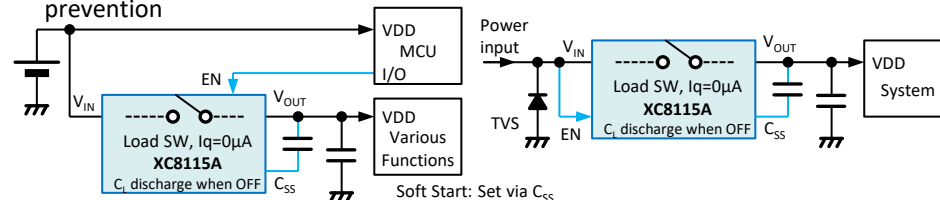
■ Ultra-Low Iq 0μA Load Switch

● Technical trend and challenges

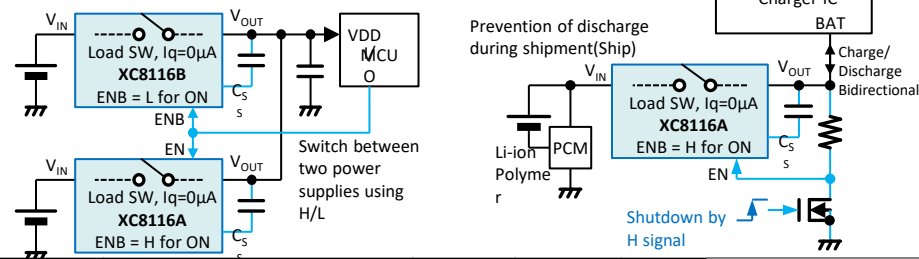
- Power distribution and line-by-line ON/OFF control with ultra-low power consumption.
- Inrush current prevention is essential to prevent voltage drops in battery or power lines.
- Battery/power line selection and battery disconnection (Ship mode) are essential for IoT devices.

● 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

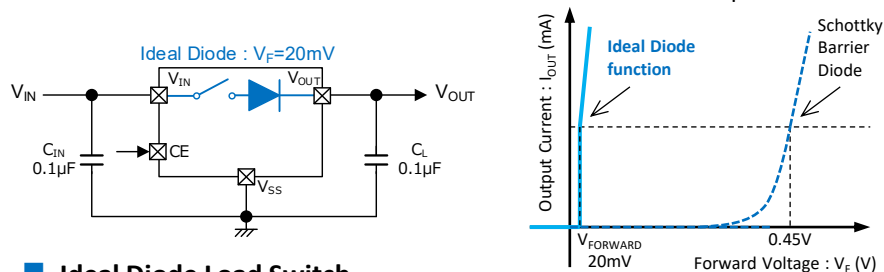
● Technical trend and challenges

- 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 3.6μA (Forward bias) 0μA (Reverse bias) IEC 62368-1:2023 certified (XC8110/XC8111)	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 FEATURED			45mΩ	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 3.6μA (Forward bias) 0μA (Reverse bias) 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.

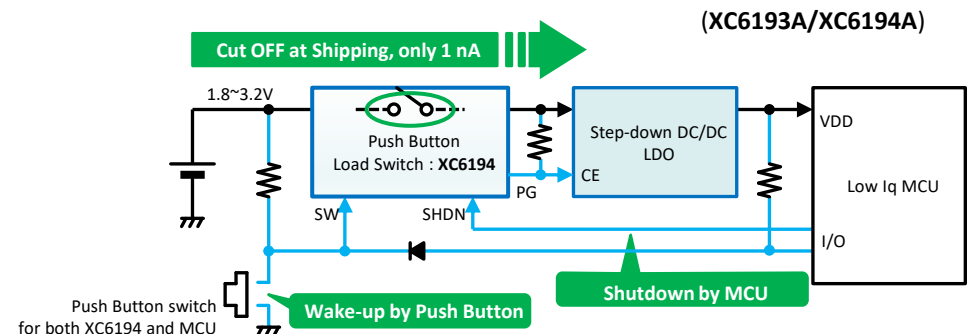
● Technical trend and challenges

- 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.**



■ 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) UVLO: Prevents battery leakage	1.8 ~ 6.0	Internal 1A + External Pch FET		USP-8B06 (2.0x2.0x0.33mm)
XC6194 FEATURED			140m Ω	1A	

Ideal Diode switch and Step-Up DC/DC Suitable for "OR" Connection

■ OR connection of power supply rails

● Technical trend and challenges

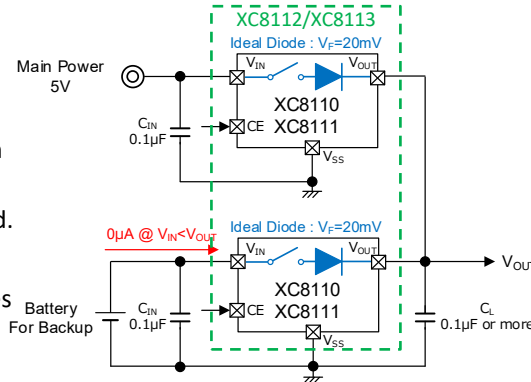
- For high efficiency and long battery life of the device, the circuit using SBD has large loss due to VF. Leakage current of reverse bias is also an issue.
- Difficult to supply stable voltage due to voltage drop and fluctuation caused by the VF characteristic of the diode which may cause unstable operation.

● TOREX Proposal : Dedicated ICs for OR connection

- Low consumption design to reduce battery discharge / Easy automatic switching of power supply path without control / Low VF to minimize power loss.

➤ OR connection with Ideal Diode Load Switch : XC8110 / XC8111 (1ch) XC8112 / XC8113 (2ch)

- Low VF: 20mV
- 0μA leakage current from output at reverse bias.
- Various built-in protection functions.
IEC 62368-1:2023 certified.
- Low loss requires no heat dissipation and contributes to miniaturization.

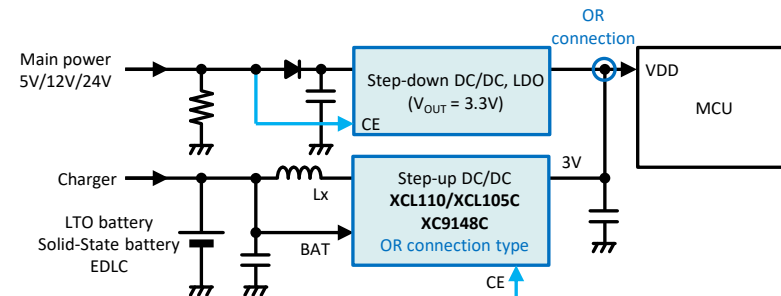


■ Load Switch with Ideal Diode function

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

➤ Step-up DC/DC for OR connection : XCL105C, XC9148C, XC9142C/F

- Switching without control when main power is input or disconnected.
- When main power is lost, immediately starts boosting to supply power.
- Low Iq 0.12μA minimizes battery discharge when main power supply.



■ Step-up DC/DC for OR connection

Product	Features	V _{IN} (V)	V _{OUT} (V)	I _{OUT} (mA) @3.3V→5V	Package
XCL110C 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)
XCL105C	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)
XC9148C	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)

HiSAT-COT® Control for Fast Transient Response

TOREX original COT control : HiSAT-COT®

● Technical trend and challenges

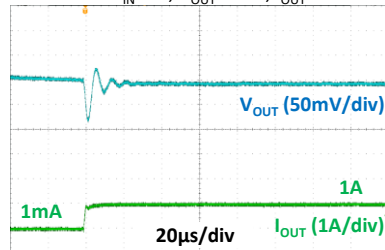
- Stable power supply including transient response to MCU/SoC/FPGA, etc.
- Miniaturization of circuits including peripheral components, and low EMI.

● TOREX Proposal : HiSAT-COT® controlled Step-down DC/DC converter

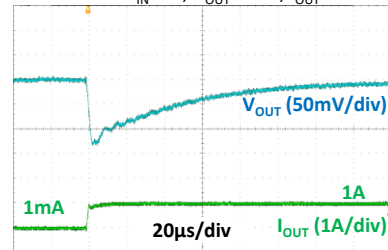
➢ Significantly faster transient response

- Compared to conventional PWM and PWM/PFM control, it achieves **overwhelmingly fast response** and thus **good voltage stability**.

HiSAT-COT® $V_{IN}=5V$, $V_{OUT}=1.8V$, $I_{OUT}=1mA \rightarrow 1A$



Conventional $V_{IN}=5V$, $V_{OUT}=1.8V$, $I_{OUT}=1mA \rightarrow 1A$



➢ Miniaturization including peripheral components

- High-speed transient response enables **significant reduction of large capacitance** required due to lack of response of conventional PWM.
- Unlike conventional PWM phase compensation, load capacitance CL can be reduced. Also **supports a significant reduction in effective capacitance due to the bias effect of ultra-small Ceramic capacitors**.

HiSAT-COT®



Conventional



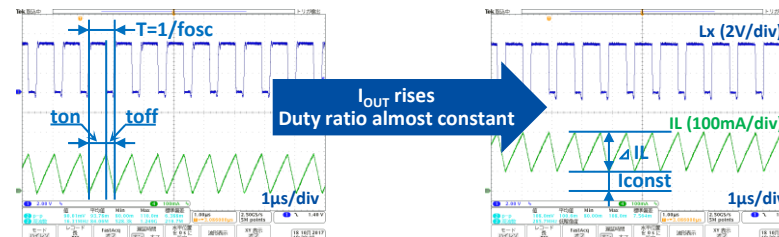
➢ Ideal for FPGA/SoC **POL power supplies** due to its compact size and high-speed response

Overview of COT control and HiSAT-COT®

What is COT (Constant on time) control?

- PFM control with the "ton" determined by V_{IN} and V_{OUT} voltages, resulting that appears to be PWM control with constant frequency (f_{osc}).
High-speed PFM comparator enables fast transient response.
- Generate "ton" in CCM of the targeted f_{osc} from the V_{IN} and V_{OUT} set voltages so that it appears to be a constant frequency PWM control.

● CCM (Continuous Conduction Mode) operation



- Ideal Duty ratio and t_{on} of step-down DC/DC at CCM PWM operation are
$$t_{on} = (1/f_{osc}) \times \text{Duty} = (1/f_{osc}) \times (V_{OUT} / V_{IN})$$

If there is no loss, **Duty ratio is constant** even if I_{OUT} rises.

● How to determine the oscillation frequency of COT control

- Generate the t_{on} of COT control to be the t_{on} of ideal PWM control.
- Continuous mode operation with this t_{on} operates with the same duty as PWM control at the oscillation frequency f_{osc} .

● COT issues and HiSAT-COT®

HiSAT-COT improves the issues of COT control with its own circuits.

- Improved issue of increased oscillation frequency due to output current.
- Improved the deterioration of load stability with an original circuit with an additional amplifier.

TOREX Built-In Inductor Micro DC/DC for Achieving Small / Low EMI

TOREX original Built-in inductor Micro DC/DC XCL Series

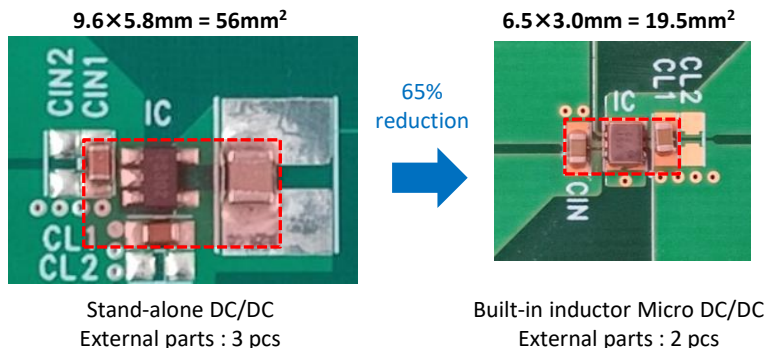
● Technical trend and challenges

- For stable operation of devices, it is important to place power supply ICs close to MCUs and FPGAs. Especially in cases where multiple power supplies are required, selecting power supply ICs suitable for POL (Point of Load) is a challenge.
- Miniaturization of power circuits including ICs and low EMI are essential.

● TOREX Proposal : Built-in inductor Micro DC/DC

➢ Significant miniaturization of power supply circuit

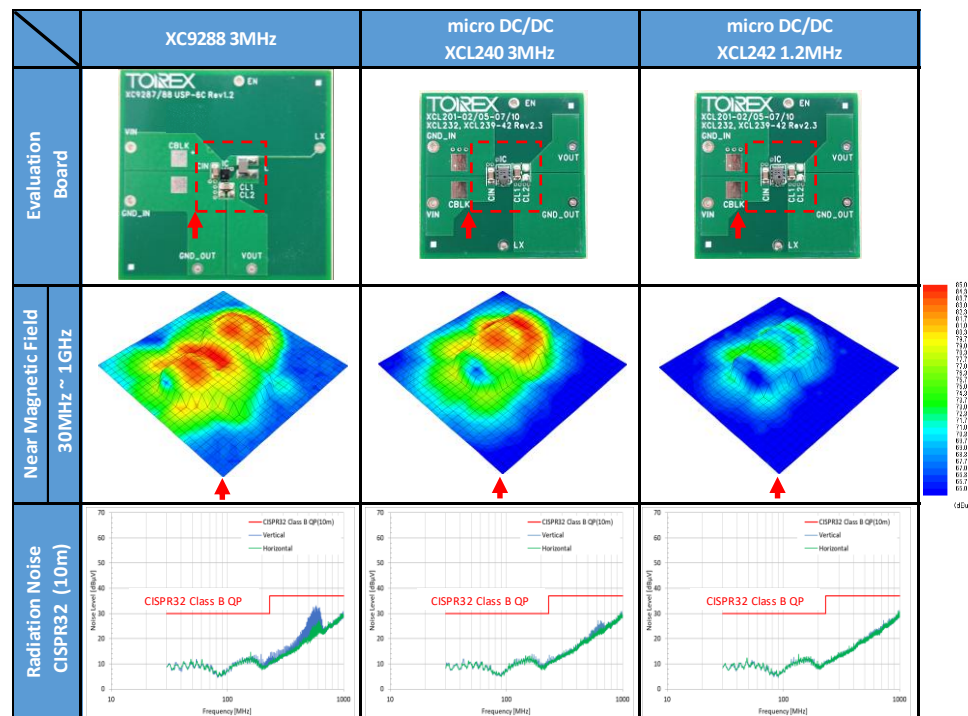
- Achieves a significant reduction in mounting area and providing smallest class of power supply solution.
- Unique package structure / Optimum inductor for the internal IC.
- Efficient heat dissipation performance with structures that connect IC/coil and substrate with low thermal resistance.



➢ EMI reduction due to unique Built-in inductor structure

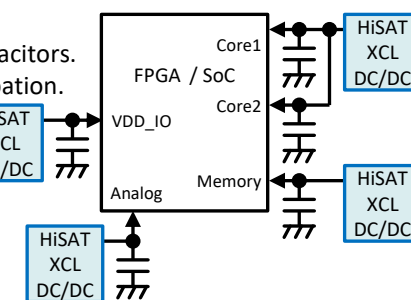
- ✓ The pocket-type structure covering the IC with a coil and the optimum placement of the IC enable a **significant reduction of radiated noise** compared to the stand-alone IC.
- ✓ Can be placed near RF ICs/Sensors, etc., contributing to miniaturization.

EMI comparison of Built-in inductor Micro DC/DC and stand-alone DC/DC



Benefits of POL (Point of Load) power supply and Micro DC/DC & HiSAT-COT®

- Shorter power supply wiring length.
In addition to stable operation, reduced capacitors. Heat source dispersion facilitates heat dissipation.
- Using **Micro DC/DC XCL Series** with built-in inductor for **POL converter** enables further miniaturization, lower EMI, and easier design.
- HiSAT-COT** provides highly stable power supply, including transient response.



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

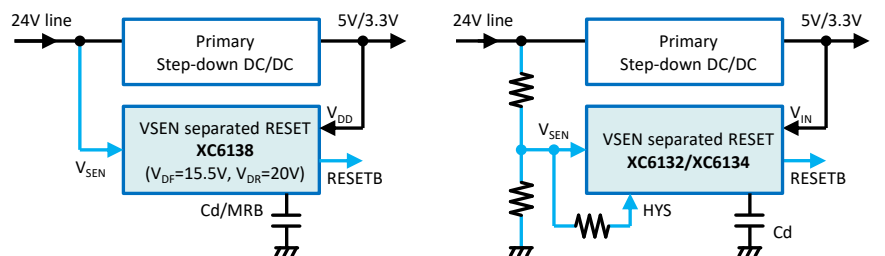
76V High voltage Sense pin

Wide hysteresis range selectable.

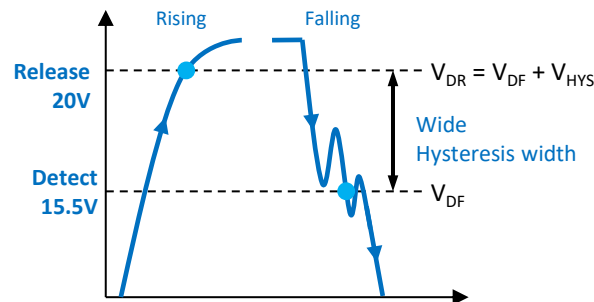
XC6132/XC6134, XD6132/XD6134

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)

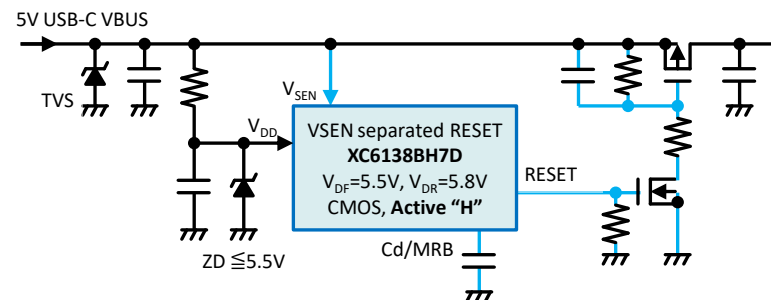
● Technical trend and challenges

- 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 Iq V_{DD} : 0.5μA, V_{SEN} : 0.15μA@12V Detect/Release Delay external adj., Selectable Hysteresis
	XC6118 XC6134	Separated Sense pin, Low Iq, Adj. Release delay, Hysteresis adj. (XC6134)