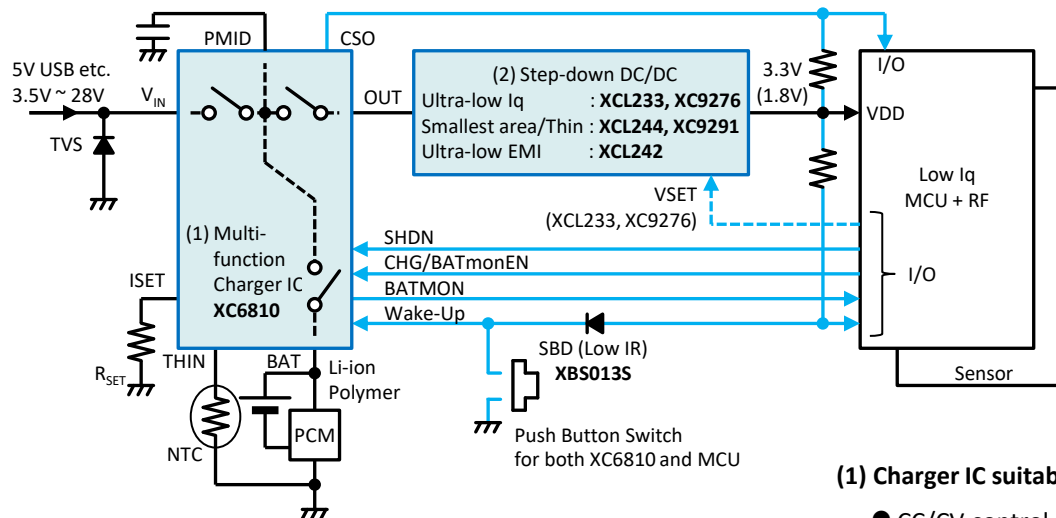


Li Rechargeable Battery : Ultra-Small and Multi-Function Solutions

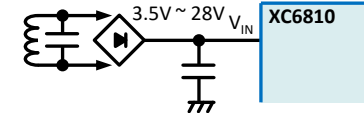
■ Ultra-small products using Li-ion/Polymer Rechargeable battery : Hearables/Wearables/IoT Sensor etc.

- Challenges : Various controls and protections suitable for small Li-ion/Polymer
Prevention of discharge after shipment(Ship) / Charge status & Battery voltage monitoring
Two-wire communication to Cradle / Supports various types of energy harvesting

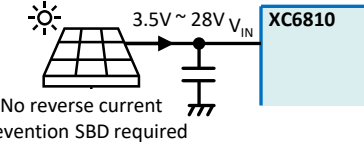


XC6810 Application Examples

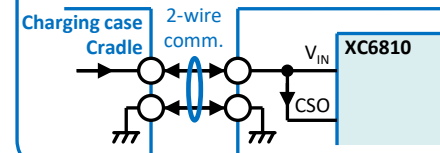
Wireless power transfer



Solar and Other Energy Harvesting



Charge state communication to Cradle



(1) Charger IC suitable for small and small-capacity Li batteries : XC6810

- CC/CV control and protection suitable for Li batteries up to 50mAh.
- Battery voltage monitor, **BATMON**, for monitoring by A/D of MCU.
- Two types of the charger status monitor, **CSO**, are available.
LED drive type and frequency notification type based on charge level which can be used for **two-wire communication with the charger case or cradle**.
- Shutdown by **SHDN** signal to prevent discharge of Li battery after shipment(Ship).
Start-up by inputting "L" to **Wake-up** with Push Button SW or by applying V_{IN} .
- Input range up to **28V** to support various types of Energy harvesting.

(2) Various ultra-small step-down DC/DCs with low consumption

- Ultra-low consumption / VSET function, Built-in inductor : **XCL233**
- World's smallest solution with ultra-low EMI : **XC9291**

	Product	Features
(1) Li Charger IC	XC6810	3.5V~28V, CV=3.80V~4.40V, CC=1mA~25mA Battery Temperature Monitor, Charge ON/OFF, Current path Charge status & Battery voltage monitoring Shutdown/Wake-up, Two-wire communication to Cradle Supports various types of energy harvesting
	XCL244	Built-in inductor, HiSAT-COT , Small area/Thin, PWM/PFM 3MHz, 700mA
(2) 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

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

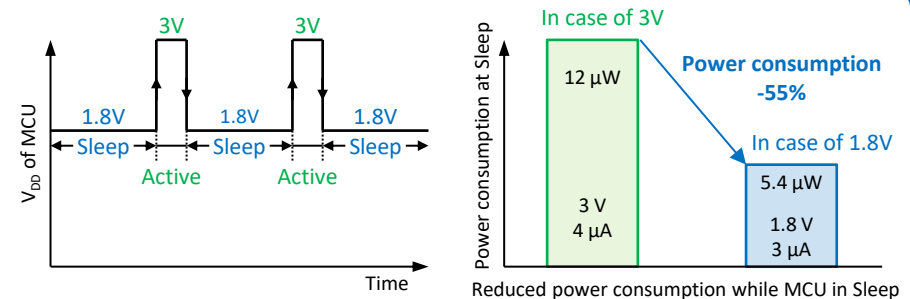
● Technical trend and challenges

- 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

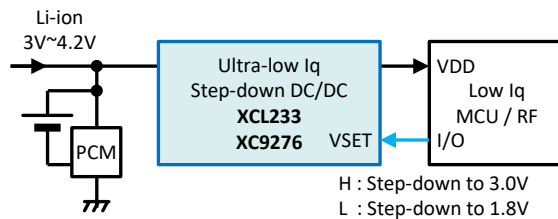
- Dynamically changing output voltage according to MCU/SoC operation, greatly reducing power consumption in standby state.

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

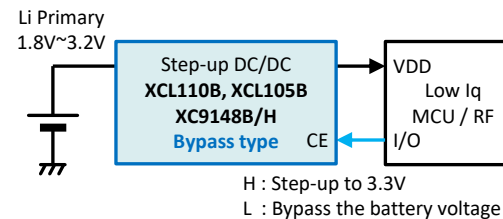


■ Ultra-low I_q VSET (V_{OUT} selectable) function Step-down DC/DC

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)

HiSAT-COT® Control for Fast Transient Response

TOREX original COT control : HiSAT-COT®

● Technical trend and challenges

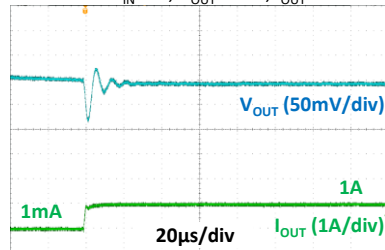
- Stable power supply including transient response to MCU/SoC/FPGA, etc.
- Miniaturization of circuits including peripheral components, and low EMI.

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

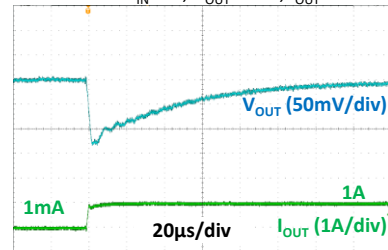
➢ Significantly faster transient response

- 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



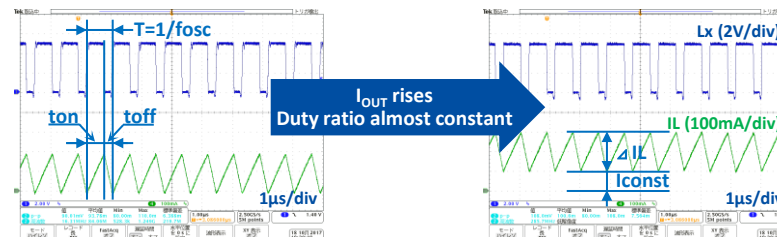
➢ Ideal for FPGA/SoC **POL power supplies** due to its compact size and high-speed response

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.