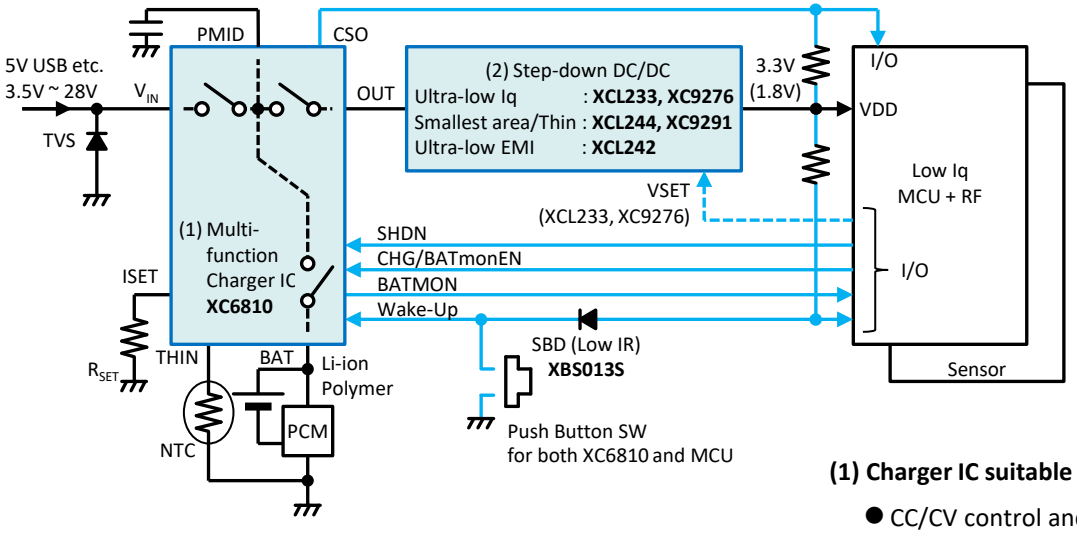
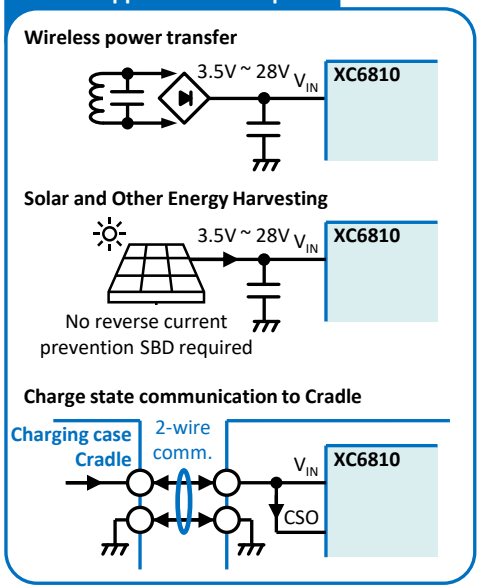
Li Rechargeable Battery : Ultra-Small and Multi-Function Solutions

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 / Charge status & Battery voltage monitoring
Two-wire communication to Cradle / Supports various types of energy harvesting



XC6810 Application Examples



	Product	Features
(1) Li Charger IC	**XC6810** FEATURED	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
(2) Step-down DC/DC	**XCL244** NEW	Built-in inductor, HiSAT-COT, Small area/Thin, PWM/PFM 3MHz, 700mA
	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

(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**.
  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**

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

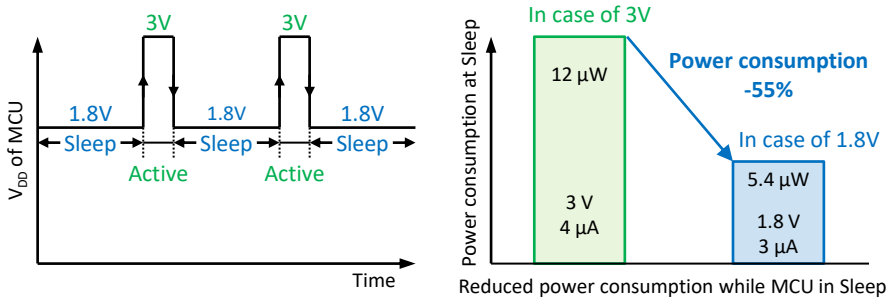
Technical trend and challenges

- 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

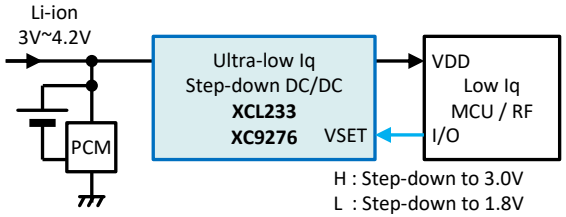
- Dynamically changing output voltage according to MCU/SoC operation, greatly reducing power consumption in standby state.

Change supply voltage according to MCU operation



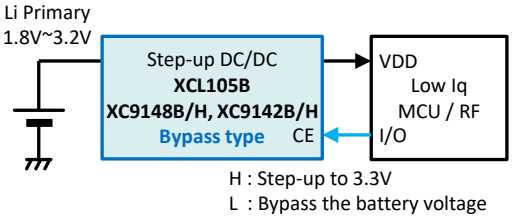
➢ Ultra-low Iq Step-down DC/DC with VSET function : XCL233, XC9276

- 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)

HiSAT-COT® Control for Fast Transient Response

TOREX original COT control : HiSAT-COT®

Technical trend and challenges

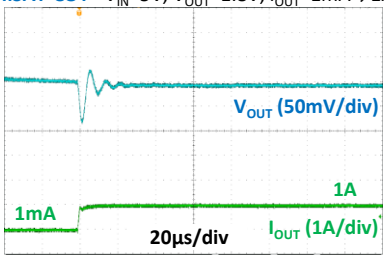
- Stable power supply including transient response to MCU/SoC/FPGA, etc.
- Miniaturization of circuits including peripheral components, and low EMI.

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

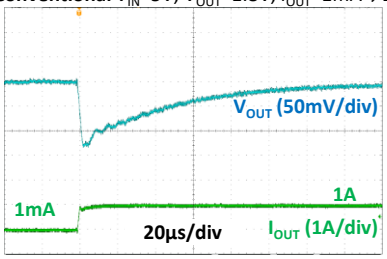
➢Significantly faster transient response

- 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→1A



Conventional V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=1mA→1A

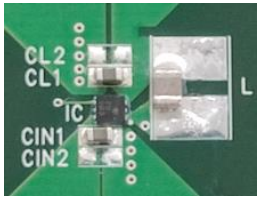


➢Miniaturization including peripheral components

- 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



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 (fosc).
  High-speed PFM comparator enables fast transient response.
- Generate **"ton"** in CCM of the targeted fosc 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 ton of step-down DC/DC at CCM PWM operation are
  ton = (1/fosc) x Duty = (1/fosc) x (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 ton of COT control to be the ton of ideal PWM control.
- Continuous mode operation with this ton operates with the same duty as PWM control at the oscillation frequency fosc.

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.