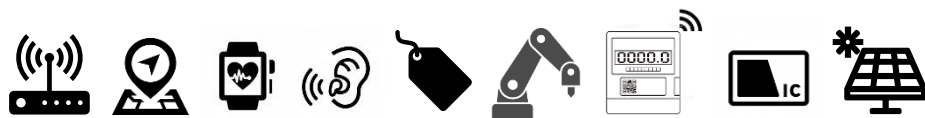


TOREX Power Management Solutions

Torex...Powerfully Small!

Reference circuits for EnerCera EC / ET batteries and Solutions for suitable applications

Small IoT devices, Trackers, Wearable/Hearable devices, RF Tags/Labels
Backup circuits, Coin battery replacement, Smartcards, and Energy harvesting.



Jan. 2024

TOREX SEMICONDUCTOR LTD.

Rev.2.0

Suitable Applications for EnerCera EC/ET Batteries

EnerCera ET/EC batteries and TOREX power management ICs provide small, easy, simple, and high-reliability solutions.

■ Suitable Applications

✓✓: very suitable, ✓: suitable

Series	Style	Suitable applications								
		Small IoT devices / modules	Location Tracker Devices	Wearable devices	Hearable devices	RFID Tags / Labels	Backup power supply	CR coin cell battery replacement	Smart Cards	Energy harvesting
EC	Pouch	✓✓ Page 7 & 8	✓✓ Page 7 & 8	✓✓ Page 7 & 8	-	✓✓ Page 7 & 8	✓✓ Page 7 & 8	-	✓✓ Page 11	✓✓ Page 8 & 12
ET	Coin	✓✓ Page 9	✓✓ Page 9	✓ Page 9	✓✓ Page 9	✓ Page 9	✓✓ Page 9 & 10	✓✓ Page 9 & 10	-	✓✓ Page 12
	Pouch	✓✓ Page 9	✓✓ Page 9	✓✓ Page 9	-	✓✓ Page 9	✓ Page 9 & 10	-	✓✓ Page 11	✓✓ Page 12

■ Power Supply Configuration Solutions with EnerCera ET/EC batteries

- [Page 7](#) EnerCera EC + **XC6808**
- [Page 8](#) EnerCera EC + **XC6810** (inc. for energy harvesting)
- [Page 9](#) EnerCera ET + **XC6240 / XC6242**
- [Page 10](#) EnerCera ET + **XC6240 / XC6242** with OR connection
- [Page 11](#) EnerCera EC/ET + thin power supply solutions for smart cards
- [Page 12](#) Various energy harvesting circuits with **EnerCera EC/ET**



EnerCera EC/ET Pouch type
38 x 27 x 0.45 mm



EnerCera ET Coin type
Φ20x 2.05 mm
Φ12.5 x 1.3 mm

EnerCera EC/ET Battery features vs. Applications

■ Characteristics and suitability of each application vs EnerCera EC/ET batteries

✓✓: very suitable, ✓: suitable

Applications		EC	ET		Features and suitability
		Pouch	Coin	Pouch	
Small IoT devices / modules	Various sensors Industrial: Temperature/Humidity, Illuminance, Dust, Vibration/Fault detection Facility/Office/Home: Temperature/Humidity, Illumination, Dust Agriculture: Temperature/Humidity, Illuminance, CO ₂	✓✓ <u>Page 7 & 8</u>	✓✓ <u>Page 9</u>	✓✓ <u>Page 9</u>	ET: Long life, simple charging (incl. Energy harvesting), ideal for IoT. Always charging capable, Can feed directly to MCU. EC, ET Pouch : High output current supports circuits with high peak currents such as RF.
Location Tracker Devices	GPS/BLE/UWB : Luggage/People tracking	✓✓ <u>Page 7 & 8</u>	✓✓ <u>Page 9</u>	✓✓ <u>Page 9</u>	Same as above.
Wearable devices	Health monitor/Smartwatch: GPS, Acceleration, Gyro, HR, Blood Oxygen Medical/Caregiver/Looking over: GPS, HR, Blood oxygen, Glucose Livestock/Pet monitors	✓✓ <u>Page 7 & 8</u>	✓ <u>Page 9</u>	✓✓ <u>Page 9</u>	Same as above. EC, ET Pouch : Can be warped, Fits curved shapes
Hearable devices	Hearing aids, TWS/Wireless earphones	-	✓✓ <u>Page 9</u>	-	Same as above. Suitable shape and safety for hearables.
RFID Tags / Labels	Commodity/Luggage tags, Electronic shelf tags	✓✓ <u>Page 7 & 8</u>	✓ <u>Page 9</u>	✓✓ <u>Page 9</u>	ET: Suitable with simple charging (incl. Energy Harvesting), Can power MCUs directly. EC, ET Pouch : Thinness suitable for tags.
Backup power supply	Industrial: Various sensors, Encoders, Position sensors Backup RTC etc. for all equipment	✓ <u>Page 7 & 8</u>	✓✓ <u>Page 9 & 10</u>	✓ <u>Page 9 & 10</u>	ET Coin: Long Life, Always charging capable, Coin-shaped, ideal for back-up.
CR coin cell battery replacement	CR battery-operated compact products, Back-up CR battery replacement	-	✓✓ <u>P.9, 10</u>	-	ET Coin : Easily CR coin cell to rechargeable battery
Smart Cards	Smart cards, Security cards	✓✓ <u>Page 11</u>	-	✓✓ <u>Page 11</u>	EC, ET Pouch : Thin to fit smart cards
Energy harvesting	Solar, Vibration power, NFC and other RF	✓✓ <u>Page 8 & 12</u>	✓✓ <u>Page 12</u>	✓✓ <u>Page 12</u>	ET : Suitable for low-current always charging, Fast voltage rise from empty by charging. EC : Easy charging from NFC, piezo and others with XC6810

Features and Benefits of EnerCera EC/ET Batteries

■ Features of EnerCera batteries

● EnerCera EC

Type	Pouch	
Model Number	EC382704P-T	EC382704P-Hr
Dimension	38 x 27 mm	38 x 27 mm
Height (with terminals)	0.45 mm	0.45 mm
Nominal Capacity	27 mAh (CV=4.3V) 24 mAh (CV=4.2V)	20 mAh
Nominal Voltage	3.8 V	
Charging Control	<u>CC/CV</u> XC6808, XC6810 (See page 5)	
Peak Discharge Current	560 mA	130 mA
Operation Temp.	Discharge -20°C ~ 45°C Charge 0°C ~ 45°C	Discharge -20°C ~ 60°C Charge 0°C ~ 60°C
Features	High peak output current	Hot lamination for smart cards



EnerCera EC/ET Pouch type

● EnerCera ET

Type	Coin		Pouch
Model Number	ET2016C-R	ET1210C-H	ET382704P-H
Dimension	Φ20 mm	Φ12.5 mm	38 x 27 mm
Height (with terminals)	2.05 mm	1.3 mm	0.45 mm
Nominal Capacity (2.7V charge)	25 mAh	4 mAh	20 mAh
Nominal Voltage	2.3 V		
Charging Control	<u>CV by simple LDO</u> XC6240, XC6242 (See page 6)		
Peak Discharge Current	60 mA	20 mA	300 mA
Operation Temp.	-40°C ~ 70°C	-20°C ~ 105°C	-20°C ~ 70°C
Features	Suitable for Coin battery replacement	High temp operation, Reflow soldering	Fast charging, High peak output current



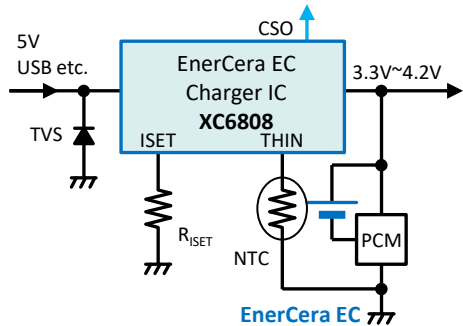
EnerCera ET Coin type

■ Benefits

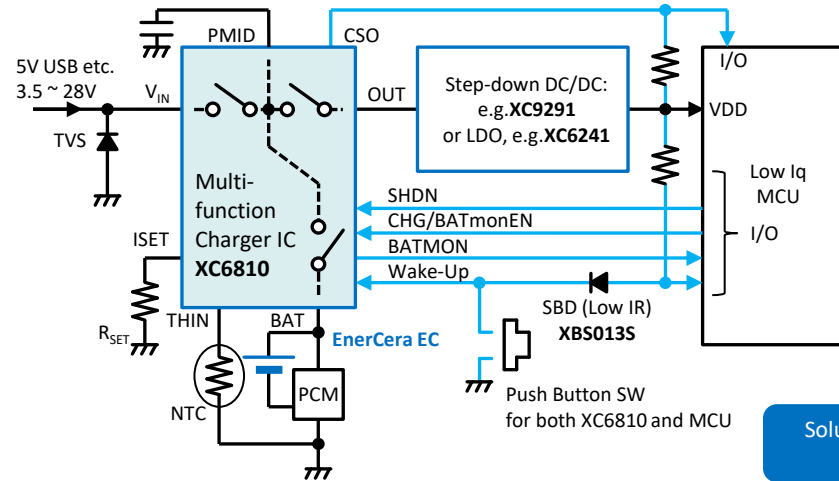
Series	Style	Size	Easy charging	Easy supply for subsequent circuits	High peak current supply	High temperature operation	Safety & High reliability	Long life	Reflow soldering
EC	Pouch	Thin	(CV/CC)	LDO (or Step-down)	Up to 560 mA	Up to 60 °C	✓	✓✓	-
ET	Coin	Small	Very Easy by LDO	Direct supply (or Step-up)	Up to 60 mA	Up to 105 °C	✓✓	✓✓	✓✓
	Pouch	Thin			Up to 300 mA	Up to 70 °C	✓	✓✓	-

Reference circuits for EnerCera EC Batteries

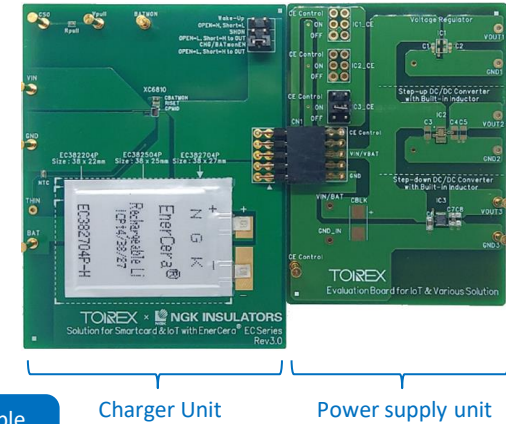
■ **XC6808** for simple charging



■ **XC6810** for ultra-compact, multi-function solutions



■ Evaluation Boards : Please consult us.

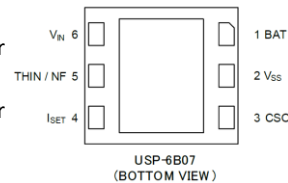


Solution example
P.8

■ **XC6808** - Compact charger IC for Li-ion batteries.

- Charging voltage : 4.20V / 4.35V / 4.40V
- With Battery Temperature Monitor function

Input Voltage	: 4.5V ~ 6.0V
Charge Voltage	: 4.20V, 4.35V, 4.40V
Charge Current	: 5mA ~ 40mA
BAT Sink Current	: 0.1µA (TYP.)
Function	: Battery Temperature Monitor UVLO
Protection	: Battery Temperature Monitor Thermal shutdown Safety timer
Package	: USP-6B07 (1.8mm x 2.0mm x 0.33mm)
Topr	: -40°C ~ 85°C



■ **XC6810** - Ultra-small Charger IC for Li-ion batteries compatible

- Optimized for small-capacity Li-Ion, with Shutdown Function for shipping
- Two-wire communication / Charging status & Battery voltage monitoring

Input Voltage	: 3.5V ~ 28.0V
Charge Voltage	: 3.80V ~ 4.40V (0.05V increments)
Charge Current	: 1mA ~ 25mA
BAT Sink Current	: 10nA (TYP. at shutdown)
Function	: Current path Shutdown/Wake-up Charging status & Battery voltage monitoring OUT line switch interlocked with UVLO (option) Battery temperature monitor Charge Enable control
Protection	: Battery Over Discharge, Output Short Thermal control, Safety timer
Package	: WLP-12-01 (1.17 x 1.57 x 0.33 mm)
Topr	: -40°C ~ 85°C

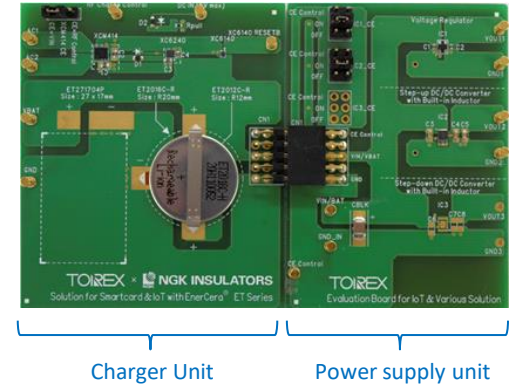
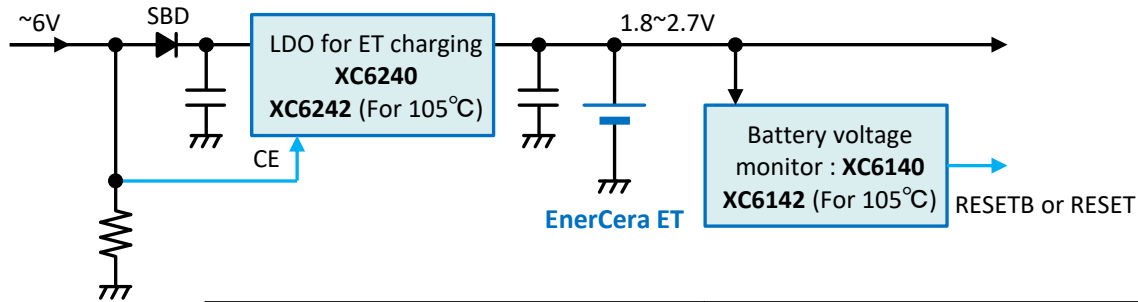


Multi-function charging IC
Achieves ultra-compact size together
with a step-down DC/DC.

Reference circuits for EnerCera ET Batteries

■ LDO : [XC6240](#) / [XC6242](#) simple charging and Battery voltage monitoring : [XC6140](#) / [XC6142](#)

Evaluation Boards : Please consult us.



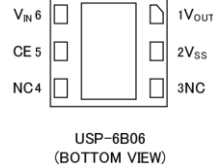
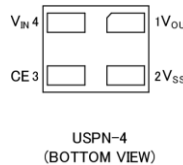
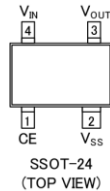
EnerCera ET		EnerCera ET1210C-H, 105°C support	
LDO for charging	XC6240	LDO for charging	XC6242
Battery voltage monitor	XC6140	Battery voltage monitor	XC6142 UNDER DEVELOPMENT

UNDER DEVELOPMENT

■ [XC6240](#) / [XC6242](#) - LDO for EnerCera ET CV charging

- Charge at max 2.70V including temperature range to match EnerCera ET
- For 105°C type (ET1210C-H), high temperature compatible [XC6242](#) available

V_{IN} : 1.6V ~ 6.0V
 V_{OUT} : 2.630V
 I_{OUT} : 150mA
 I_q : 0.8μA
 I_{SINK} : 0.24μA
 PSRR : 60dB @ 1kHz
 Topr : -40°C ~ 85°C (XC6240)
 -40°C ~ 105°C (XC6242)

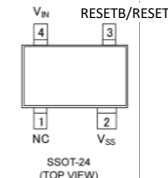
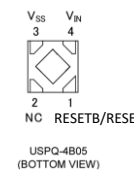


Package : XC6240 : SSOT-24 (2.0 x 2.1 x 1.1mm)
 USPN-4 (0.9 x 1.2 x 0.4mm)
 USP-6B06 (1.8 x 1.5 x 0.33mm)
 XC6242 : USPN-4 (0.9 x 1.2 x 0.4mm)

■ [XC6140](#) / [XC6142](#) – Battery voltage monitor for EnerCera ET

- Optimal release / detection voltage for EnerCera ET
- For 105°C type (ET1210C-H), [XC6142](#) with optimized Release voltage available

V_{IN} : 1.1V ~ 6.0V
 Detect Voltage : 1.6V ~ 2.2V (XC6140)
 1.6V ~ 2.1V (XC6142)
 Release Voltage : 2.475V (XC6140)
 2.450V (XC6142)
 I_q : 104nA
 Output : CMOS or Nch Open Drain
 Active "L" or "H"
 Topr : -40°C ~ 105°C
 Package : XC6140 : SSOT-24 (2.0 x 2.1 x 1.1mm)

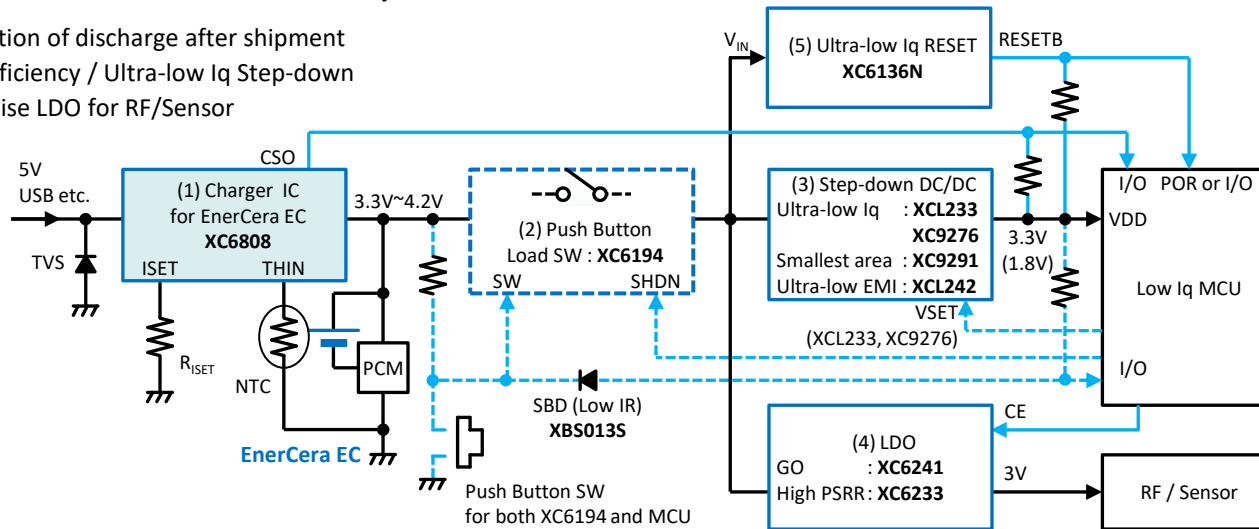


Package : XC6140 : SSOT-24 (2.0 x 2.1 x 1.1mm)
 USPQ-4B05 (1.0 x 1.0 x 0.33mm)
 XC6142 : USPQ-4B05 (1.0 x 1.0 x 0.33mm)

EnerCera EC batteries : Small and Low Power Consumption solution

Products using EnerCera EC batteries : IoT Sensor/Wearable etc.

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



Block	Product	Features
(1) Charger IC for EnerCera EC	XC6808	CC/CV Charger, CC~40mA, Battery Temperature Monitor
(2) Push button SW	XC6194	I _{STB} =1nA, Shutdown function(Ship/Main power SW) For system freeze
(3) Step-down DC/DC	XCL233	Built-in inductor, Iq=200nA, PFM, 150mA, VSET(V _{OUT} selectable)
	XCL242 UNDER DEVELOPMENT	Built-in inductor, HiSAT-COT, Ultra-low EMI, PWM/PFM, 1.2MHz, 500mA
	XC9291	HiSAT-COT, Smallest area, PWM/PFM, 4MHz/6MHz, 600mA
	XC9276	Iq=200nA, PFM, 150mA, VSET(V _{OUT} selectable)
(4) LDO	XC6241	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

(1) Simple CV/CC charger IC for EnerCera EC batteries : XC6808

(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.

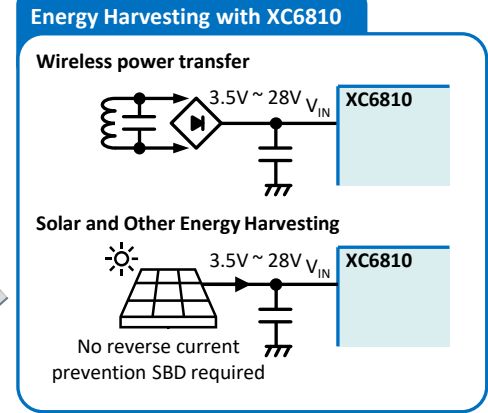
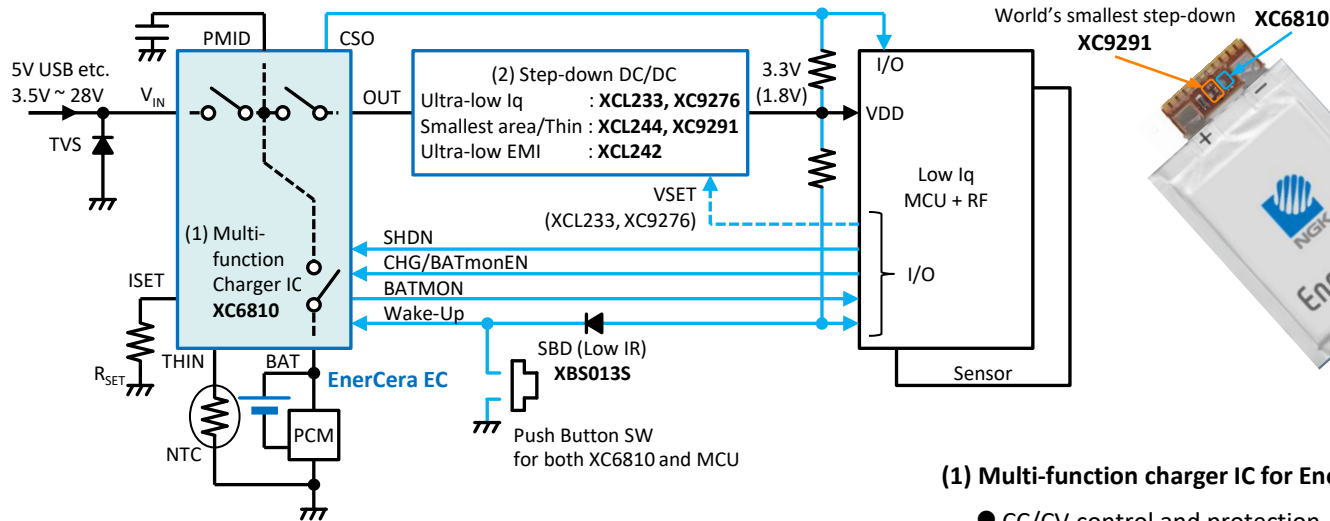
(4) LDO for RF/Sensor : XC6241

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

EnerCera EC batteries : Ultra-small and Multi-function solution

■ Ultra-small products using EnerCera EC batteries : Hearables/Wearables/IoT Sensor etc. and Energy harvesting.

- Challenges : Various controls and protections suitable for EnerCera EC battery
Prevention of discharge after shipment / Charge status & Battery voltage monitoring
Two-wire communication to Cradle / Supports various types of energy harvesting



(1) Multi-function charger IC for EnerCera EC battery : XC6810

- CC/CV control and protection.
- 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 step-down DC/DCs with ultra-small and low consumption

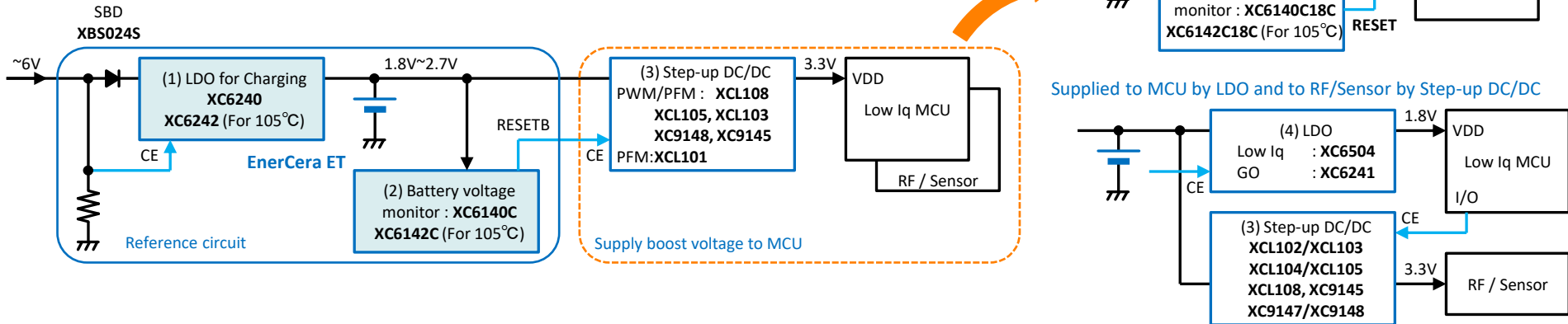
- Ultra-low consumption / VSET function, Built-in inductor : **XCL233**
- World's smallest solution with ultra low EMI : **XC9291**

Block	Product	Features
(1) Charger IC for EnerCera EC	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
(2) Step-down DC/DC	XCL244 UNDER DEVELOPMENT	Built-in inductor, HiSAT-COT , Small area/Thin, PWM/PFM 3MHz, 700mA
	XCL233	Built-in inductor, Iq=200nA, PFM, 150mA, VSET(V _{OUT} selectable)
	XCL242 UNDER DEVELOPMENT	Built-in inductor, HiSAT-COT , Ultra-low EMI, PWM/PFM, 1.2MHz, 500mA
	XC9291	HiSAT-COT , Smallest area, PWM/PFM, 4MHz/6MHz, 600mA
	XC9276	Iq=200nA, PFM, 150mA, VSET

EnerCera ET batteries : Solution for Small and Low Consumption devices

■ Products using EnerCera ET battery : IoT Sensor/Wearable etc.

- Challenges : Simple structure / Small / Low Iq / High efficiency
Simple main and backup power supply / Power supply to the system during charging



Block	Product	Features
(1) LDO for Charging	XC6240 / XC6242	For EnerCera ET charging, 150mA For Topr=105°C: XC6242
(2) Battery voltage monitor	XC6140 / XC6142 <small>UNER DEVELOPMENT</small>	EnerCera ET battery voltage monitoring Detect: 1.6V~2.2V, Release:2.475V/2.450V, Iq=104nA For 105°C: XC6142
(3) Step-up DC/DC	XCL102 / XCL103	Built-in inductor, F-PWM, PWM/PFM 3MHz, 450mA@3.3V→5V
	XCL104 / XCL105	Built-in inductor, F-PWM, PWM/PFM, 1.2MHz 710mA@3.3V→5V
	XCL108	Built-in inductor, Ultra-low Iq: 400nA, PWM/PFM 1.2MHz, 300mA@3.3V→5V, V _{ST} =1.6V
	XC9145	Ultra-low Iq: 400nA, PWM/PFM 1.2MHz, 430mA@3.3V→5V, V _{ST} =1.6V
	XC9147 / XC9148	F-PWM, PWM/PFM, 1.2MHz/3MHz 750mA@3.3V→5V
(4) LDO	XC6241	Iq=0.6μA, PSRR=60dB, GO, 150mA
	XC6504	Iq=0.6μA, CL less, 150mA

(1) LDO for EnerCera ET battery charging : XC6240, XC6242

Charging at max. 2.70V with low Iq LDO considering temperature range and EnerCera ET battery specifications

(2) EnerCera ET battery voltage monitor : XC6140, XC6142

Set the voltage to Release when charging starts using the LDO in accordance with the charging and discharging characteristics of the EnerCera ET battery.

Power supply for MCU and RF/Sensor

(3) Cases of Boosting voltage

Ultra-low Iq=400nA and high efficiency XCL108, XC9145.

Built-in inductor Micro DC/DC for low EMI.

PWM for low ripple requirement for RF/Sensor (XCL102, XCL104, XC9147)

(4) LDO or (5) Pch FET cases

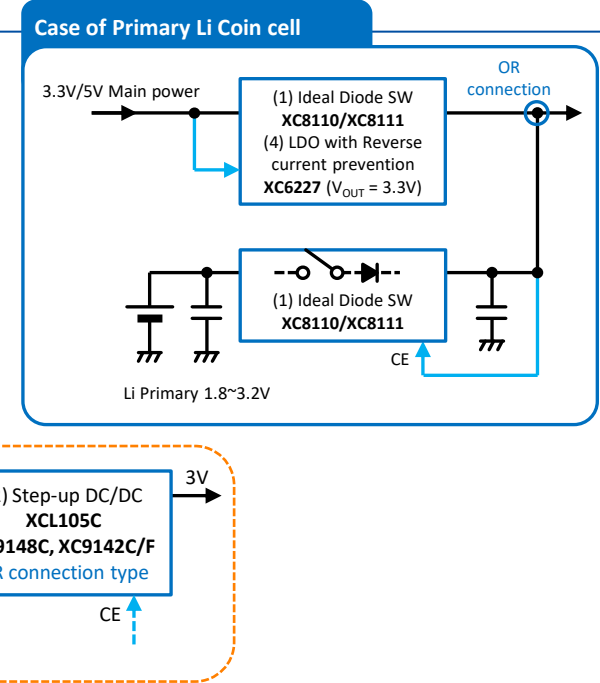
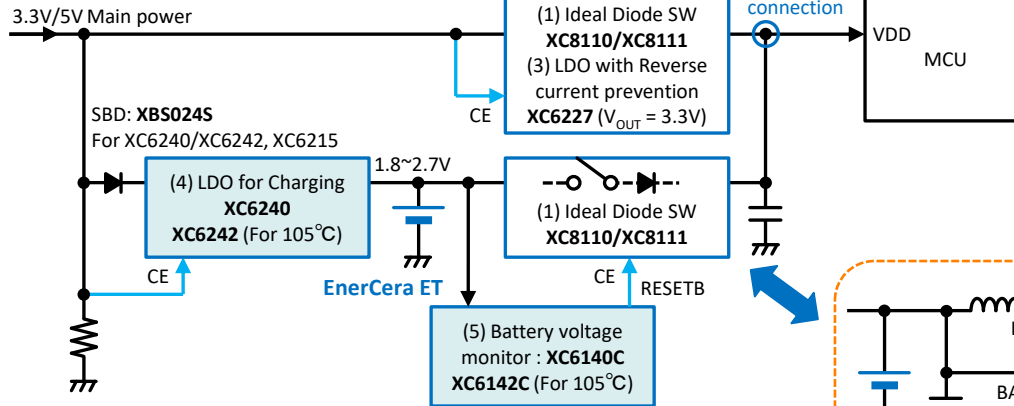
Supplied by **GO LDO XC6241** for lower consumption.

Also, **XC6140CxxC** with detection "H" output is used to drive Pch FET and supply battery voltage directly.

EnerCera ET batteries : OR connection solution for Backup

Backup power supply with EnerCera ET battery

- Challenges : Seamless switching to backup at main power loss
Efficient charging and discharging to backup devices



Block	Product	Features
(1) Ideal diode SW	XC8110 / XC8111	True Reverse current prevention Ideal Diode Load SW VF=20mV, 500mA (XC8110), 1A (XC8111), IEC 62368-1 certified
(2) Step-up DC/DC	XCL105C	Built-in inductor, 1.2MHz, 710mA@3.3V→5V, For OR connection
	XC9148C	1.2MHz/3MHz, 750mA@3.3V→5V, For OR connection
	XC9142C/F	1.2MHz/3MHz, 450mA@3.3V→5V, For OR connection
(3) LDO with Reverse current prevention	XC6227	High-speed PSRR=65dB, 700mA True Reverse current prevention
(4) LDO for Charging	XC6240 / XC6242	For EnerCera ET charging, 150mA For Topr=105°C: XC6242
(5) Battery voltage monitor	XC6140 / XC6142 UNDER DEVELOPMENT	EnerCera ET battery voltage monitoring Detect: 1.6V~2.2V, Release:2.475V/2.450V, Iq=104nA For 105°C: XC6142

OR connection : How to connect the backup device and Main power

- Supplies battery voltage directly to MCU : XC8110/XC8111
- Supplies boosted voltage to MCU : XCL105C, XC9148C, XC9142C/F
- LDO, DC/DC for Main power side

LDO with reverse current prevention to prevent reverse current flowing into the main power supply. (XC6227)
Also, DC/DC or standard LDO with a SBD can be configured for OR connection.

(4) LDO for EnerCera ET battery charging : XC6240/XC6242.

(5) Battery voltage monitoring : XC6140/XC6142

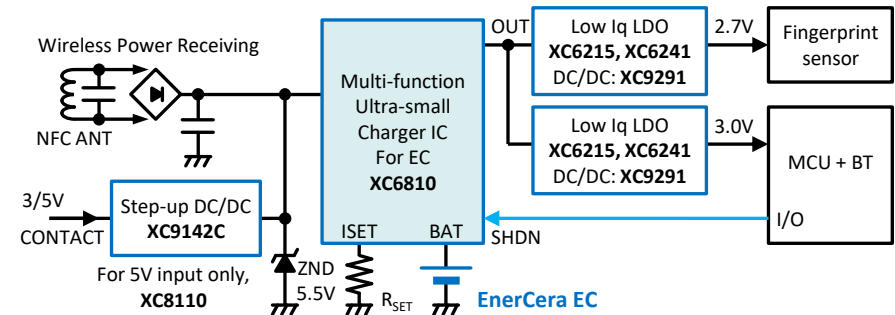
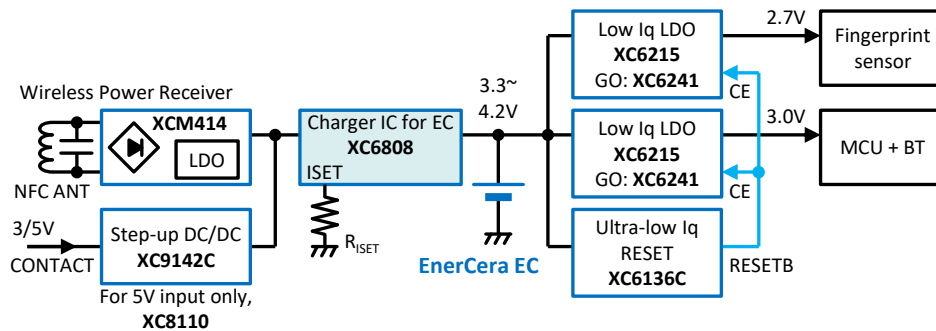
Detect/Release voltage set according to EnerCera ET battery characteristics.

EnerCera EC/ET batteries : Solutions for Smart Cards and Energy Harvesting

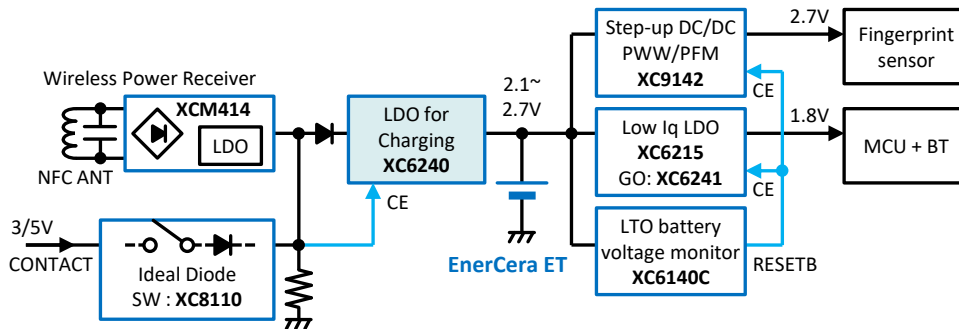
Example of thin power supply configuration with h = 0.33mm max for Smart cards

- Challenges : Support h=0.33mm max. including external components
- High efficiency charging circuit for input sources such as NFC

EnerCera EC battery



EnerCera ET battery



List of low-profile power supply ICs with h ≤ 0.33mm or 0.40mm

	Product	Features	Package	Size
LDO	XC6215	Iq=0.8μA	USP-6B06	1.8 x 1.5 x h 0.33mm
	XC6241	High-speed, Iq=0.6μA, GO	USPQ-4B05	1.0 x 1.0 x h 0.33mm
LDO + Bridge Diode	XCM414	For wireless power receiving LDO with internal bridge diode	USP-8B10	2.6 x 2.9 x h 0.33mm
Step-up DC/DC	XC9142	PWM/PFM Step-up DC/DC	WLP-6-01	1.08 x 1.28 x h 0.40mm
Step-down DC/DC	XC9291	HISAT-COT, PWM/PFM, 6MHz	LGA-6B01	1.2 x 1.2 x h 0.3mm
Battery voltage monitor	XC6140	Voltage monitoring for EnerCera ET Detect: 1.6V~2.2V, Release:2.475V	USPQ-4B05	1.0 x 1.0 x h 0.33mm
	XC6136	Iq=88nA		
Charger IC	XC6810	For 1 cell Li-ion, multi-function Charger IC	WLP-12-01	1.17 x 1.57 x h 0.33mm
	XC6808	Charger IC for EnerCera EC	USP-6B07	1.8 x 2.0 x h 0.33mm
	XC6240	LDO for charging EnerCera ET	USP-6B06	1.8 x 1.5 x h 0.33mm
Load SW	XC8110	Ideal Diode SW	USP-6B06	1.8 x 1.5 x h 0.33mm

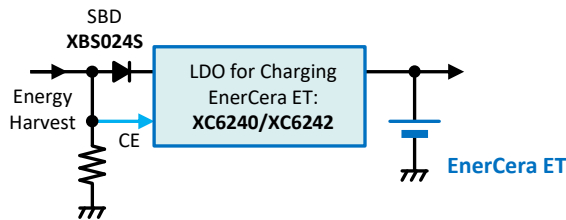
EnerCera ET batteries : Solutions for Energy Harvesting

Examples of charging from Energy Harvesting to EnerCera ET battery

- Challenges : Supporting various Energy Harvesting : Wireless power transfer (WPT), NFC, solar panels, piezo, etc.
Charge EnerCera ET battery from unstable/micropower sources

Example of 3V~6V input + EnerCera ET

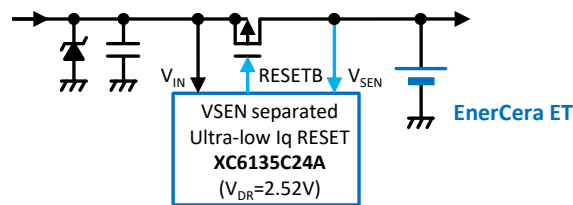
Supported by EnerCera ET charging reference circuit



At micro power source

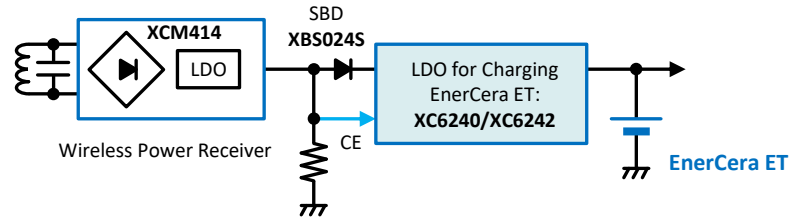
Example of 3V~6V Rectenna and other micro power (a few μW) + EnerCera ET battery

ON-OFF control of Pch FET with Ultra-low Iq Voltage Detector

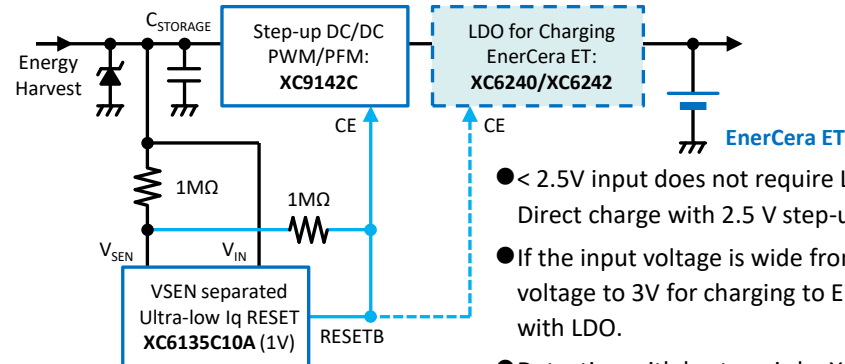


Example of Wireless power transfer + EnerCera ET battery

Charging with wireless power receiving IC + LDO



Example of 0.9V~2.7V / 0.9V~6V input + EnerCera ET battery



- < 2.5V input does not require LDO for charging. Direct charge with 2.5 V step-up output.
- If the input voltage is wide from 0.9 to 6V, boost the voltage to 3V for charging to EnerCera ET battery with LDO.
- Detection with hysteresis by XC6135 and resistors. When C_{STORAGE} is charged to 2.1V, the step-up is started to charge, and stopped when it drops to 1V.

- Depending on the voltage characteristics and power of Energy Harvesting, the optimal charging circuit and control voltage varies.

TOREX offers optimal power supply configurations to match the characteristics of your energy harvesting.

Please contact : <https://product.torexsemi.com/en/contact-us/technical-inquiry>

Torex...Powerfully Small!

We have introduced a **variety of power supply configuration and circuit solutions** along with our products to support our customers. We hope this information will be one of the references for you.

The following document is provided as a reference guide for various power supply configurations as well.

"Power Management Solutions" <https://product.torexsemi.com/en/selection-guide/catalog>

TOREX Semiconductor

Product Site <https://product.torexsemi.com/en>

Technical Information <https://product.torexsemi.com/en/technical-support>

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