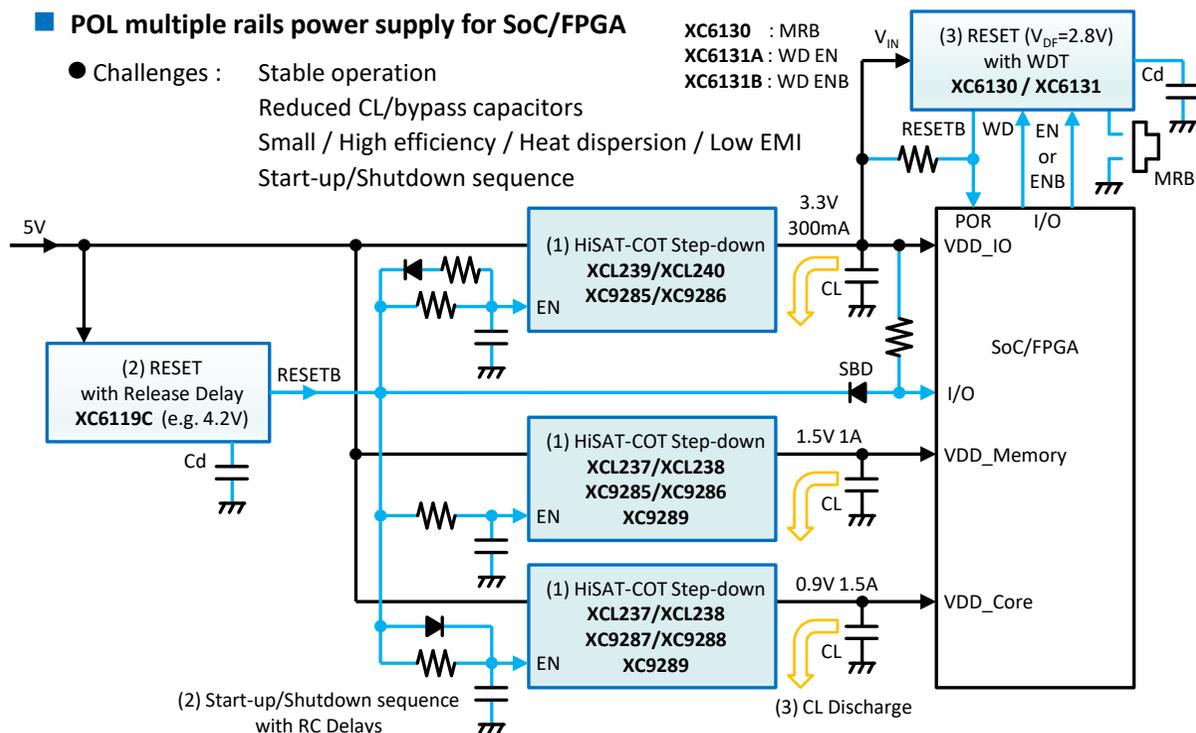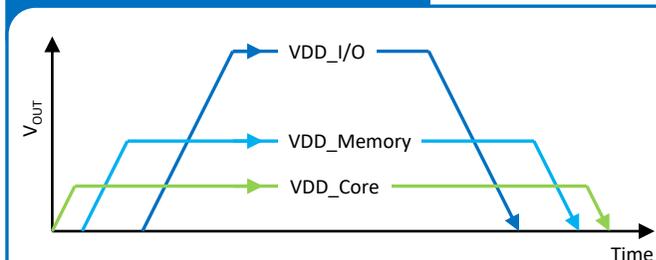# 5V : POL Solutions for Multiple Power Rails

## ■ POL multiple rails power supply for SoC/FPGA

● Challenges :  Stable operation
Reduced CL/bypass capacitors
Small / High efficiency / Heat dispersion / Low EMI
Start-up/Shutdown sequence

XC6130  : MRB
XC6131A : WD EN
XC6131B : WD ENB

(3) RESET ($V_{DF}$=2.8V)
with WDT
**XC6130 / XC6131**

**(2) Start-up/Shutdown power sequence**



(2) RESET
with Release Delay
**XC6119C**  (e.g. 4.2V)

(1) HiSAT-COT Step-down
**XCL239/XCL240**
**XC9285/XC9286**
EN

3.3V
300mA
CL

POR        I/O
VDD_IO

SoC/FPGA

SBD

I/O

(1) HiSAT-COT Step-down
**XCL237/XCL238**
**XC9285/XC9286**
**XC9289**
EN

1.5V 1A
CL

VDD_Memory

(1) HiSAT-COT Step-down
**XCL237/XCL238**
**XC9287/XC9288**
**XC9289**
EN

0.9V 1.5A
CL

VDD_Core

(2) Start-up/Shutdown sequence
with RC Delays

(3) CL Discharge

**Sequence control** of both rising and falling is realized with **Reset IC XC6119C** and **RC delay** to EN of each DC/DC. The CL discharge function is used for the falling.

● The delay for each DC/DC to start turning ON/OFF is,
$$t_{delay( ON)} = R \times C \times ( -\ln(( V_{IN} - V_{EN} ) / V_{IN} ))$$
$$t_{delay( OFF)} = R \times C \times ( -\ln( V_{EN} / V_{IN} ))$$
* $V_{EN}$ is the threshold voltage of EN

● Set RC delays considering the soft-start time of each DC/DC and the discharge time by CL discharge.

| Block | Product | Features |
|---|---|---|
| (1) Step-down DC/DC | **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, MODE selectable 1.2MHz/3MHz, 1.5A |
| (2) RESET IC | **XC6119** | Low Iq, External Cd Release Delay |
| (3) WDT | **XC6130 / XC6131** | WDT/Release delay adjustable by an external Cd MR (XC6130) or WD ON/OFF control (XC6131) |

**(1) Step-down DC/DC for FPGA/SoC (POL converter)**

High-speed transient response **HiSAT-COT** controlled DC/DC arranged as **POL**. Built-in inductor Micro DC/DC realizes miniaturization and low EMI.

**(XCL239/XCL240, XCL237/XCL238)**

**(3) Freeze countermeasure with Watchdog timer : XC6130/XC6131**

Monitoring of 3.3V line voltage and detection of freezing by the WD function. In case of abnormality, SoC/FPGA is automatically restarted. Manual reset function is also available **(XC6130)**

# HiSAT-COT® Control for Fast Transient Response

TOREX

■ **TOREX original COT control : HiSAT-COT®**

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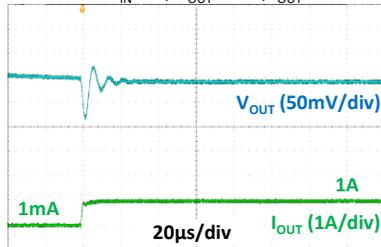
- Stable power supply including transient response to MCU/SoC/FPGA, etc.
- Miniaturization of circuits including peripheral components, and low EMI.

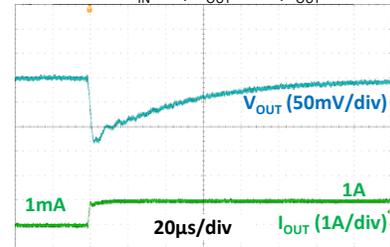● **TOREX Proposal : HiSAT-COT® controlled Step-down DC/DC converter**

➤ **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



$V_{OUT}$ (50mV/div)   $V_{OUT}$ (50mV/div)

1A   1A

1mA   1mA

20µs/div   $I_{OUT}$ (1A/div)   20µs/div   $I_{OUT}$ (1A/div)

➤ **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.**
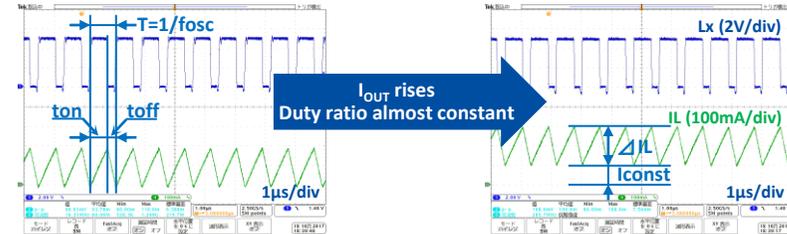
HiSAT-COT®       Conventional



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**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**



T=1/fosc   Lx (2V/div)

ton   toff   $I_{OUT}$ rises
Duty ratio almost constant   IL (100mA/div)

1µs/div   ⊿IL   Iconst   1µs/div

- 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.

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

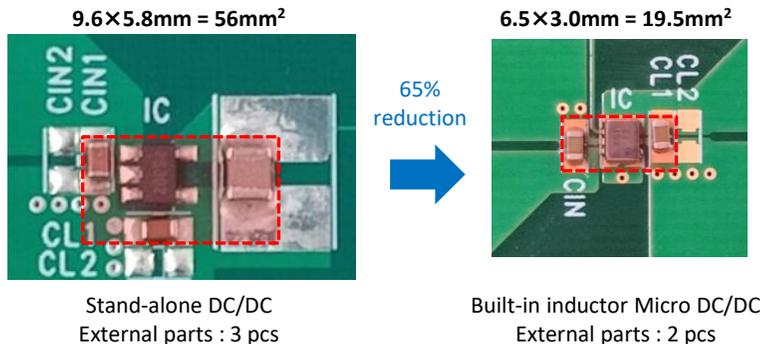■ **TOREX original Built-in inductor Micro DC/DC XCL Series**

● **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**

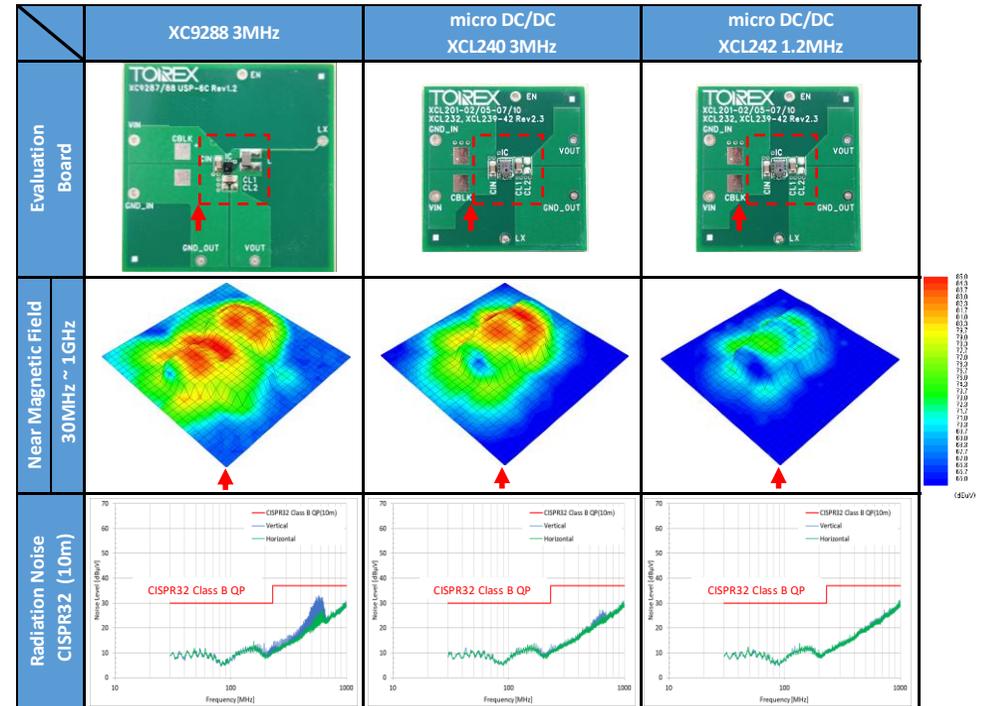➤ **Significant miniaturization of power supply circuit**

- 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.

**9.6×5.8mm = 56mm²**



65% reduction

**6.5×3.0mm = 19.5mm²**



Stand-alone DC/DC
External parts : 3 pcs

Built-in inductor Micro DC/DC
External parts : 2 pcs

➤ **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**

| | XC9288 3MHz | micro DC/DC XCL240 3MHz | micro DC/DC XCL242 1.2MHz |
|---|---|---|---|
| Evaluation Board |  |  |  |
| Near Magnetic Field 30MHz ~ 1GHz |  |  |  |
| Radiation Noise CISPR32 (10m) | CISPR32 Class B QP | CISPR32 Class B QP | CISPR32 Class B QP |

**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.