

*Torex...Powerfully Small!*

**HiSAT-COT<sup>®</sup> control**  
**600mA Synchronous Step-down DC/DC converters**  
**XC9290/XC9291 Series**

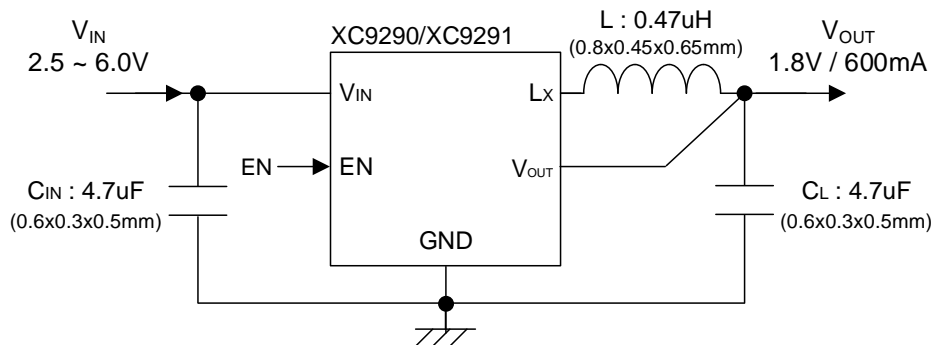
Nov. 2023  
TOREX Semiconductor Ltd.  
Rev. 1.1

## World's smallest solution area / Low consumption

### ■ Features

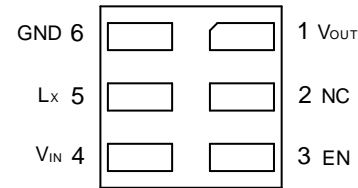
Input Voltage	: 2.5V ~ 6.0V (Absolute Max.: 7.0V)
Output Voltage	: 0.7V ~ 3.6V (Accuracy: ±2.0%)
Output Current	: 600mA
Oscillation Frequency	: 4.0MHz, 6.0MHz
Efficiency	: 90% ( $V_{IN}=3.7V, V_{OUT}=1.8V, I_{OUT}=200mA$ )
Control Method	: HiSAT-COT F-PWM (XC9290) PWM/PFM (XC9291)
Functions	: Soft-Start UVLO $C_L$ Discharge (Type B)
Protection	: Current Limit
Packages	: LGA-6B01, WLP-5-08
Operating Ambient Temp.	: -40°C ~ 105°C

### ■ Typical Application Circuit

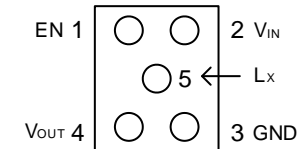


### ■ Packages

**LGA-6B01**  
(1.2x1.2x0.3mm)



**WLP-5-08**  
(0.96x0.88x0.3mm)




### ■ Ultra Small Size

- World's smallest solution 3.15mm<sup>2</sup>
- 0.6 x 0.3mm Ceramic Capacitors
- 0.8 x 0.45mm Inductor



- World's smallest solution area with fast transient response / Low noise / High efficiency

Ultra small  
HiSAT-COT®  
600mA Step-down DC/DC  
XC9290 / XC9291



Mount Area  
1.5x2.1mm=3.15mm<sup>2</sup>

World's smallest  
2.1 x 1.5 mm  
= 3.15mm<sup>2</sup>

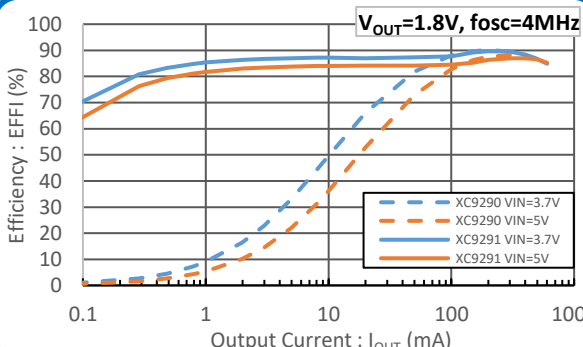
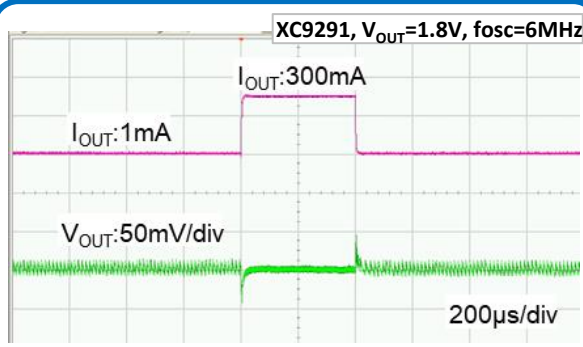
Fast transient  
Low noise

① Adapted to the smallest external components.

- ✓ 0.8x0.45mm Inductor (world-first)
- ✓ 0.6x0.3mm Ceramic Capacitor
- ✓ High efficiency despite being the world's smallest and 6MHz.

② Fast transient, Low ripple, Low EMI

- ✓ High speed transient response with HiSAT-COT control
- ✓ Low ripple voltage even with 0.6x0.3mm size low effective ceramic capacitor
- ✓ Ultra-low EMI equivalent to Built-in inductor DC/DC due to minimized layout.

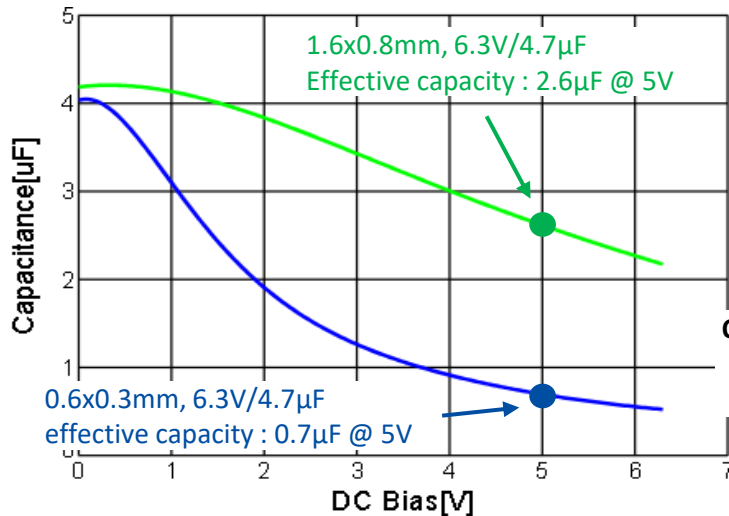



The world's smallest solution for further miniaturization of equipment/modules requiring high efficiency and low noise.

- Wearable/Hearable devices : TWS, Hearing aid, Headset, VR, Tracker, Medical monitoring
- Modules/Sensors : Camera modules, Wireless modules, SSD, Miniature sensors

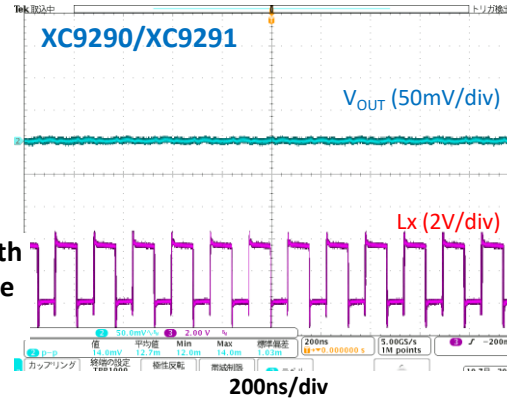
## 0.6 x 0.3mm ceramic capacitors

- Stable operation even with ultra-small ceramic capacitors with small effective capacitances.

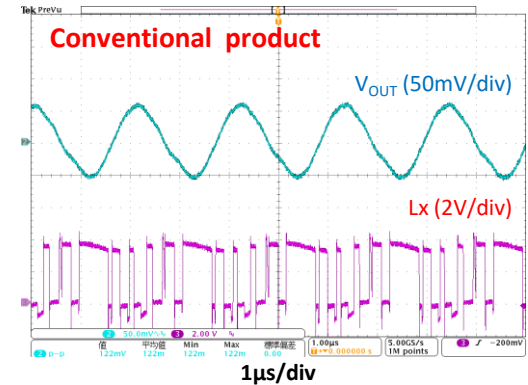


Operates with low effective capacity

### DC/DC output voltage with 0.6x0.3mm ceramic capacitors



stable operation



abnormal oscillation

## World's smallest 0.8 x 0.45mm Inductor

- Stable operation with low inductance, so it can be used with ultra-small inductors.

\* **0.8 x 0.45mm Inductor** : TDK, PLE856CBAR47M-1PT (06/2024 Mass production scheduled)

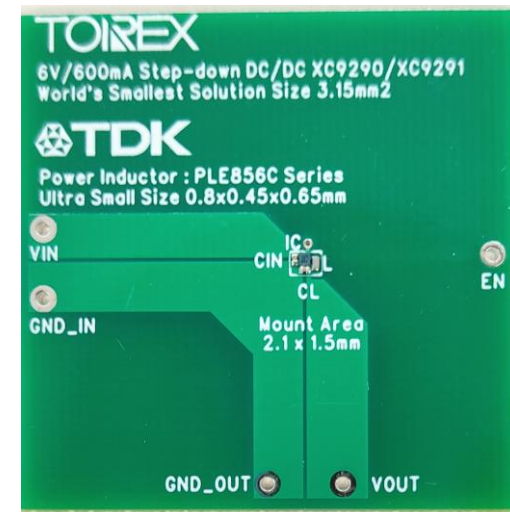
For the sample, please contact Sho.Uchida@tdk.com

Sho Uchida

TDK Corporation

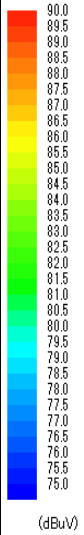
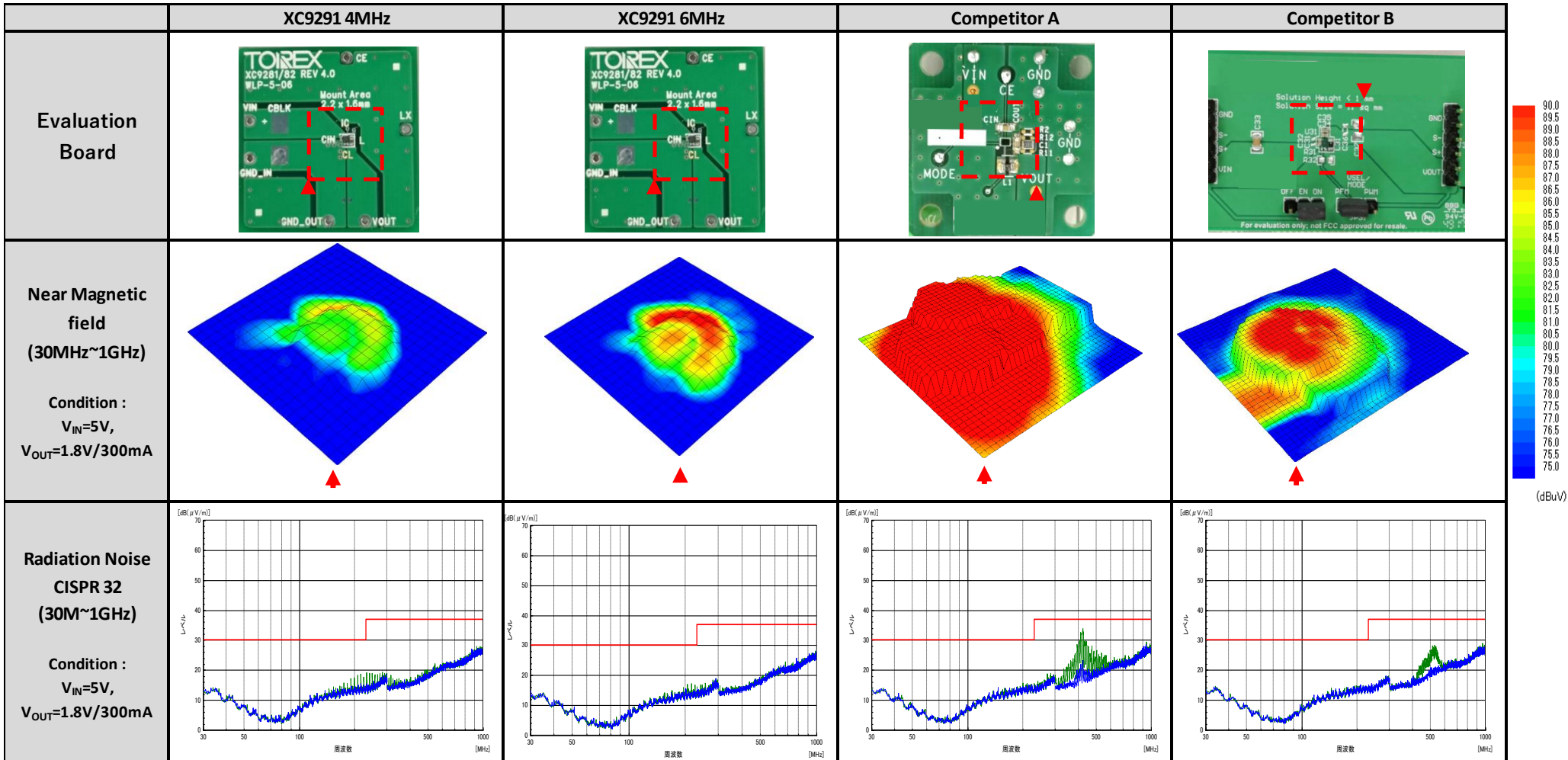
IC Collaboration Dept. Marketing Strategy Group.

Electronic Components Business Company



## Low EMI & Low noise

- Low magnetic field leakage to the surroundings and minimal influence on peripheral devices during high-density mounting.



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

### ● Technical trend and challenges

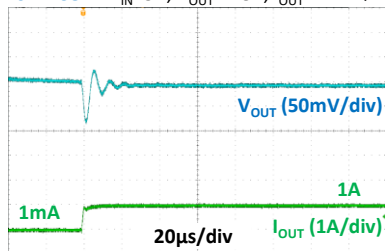
- Stable power supply including transient response to MCU/SoC/FPGA, etc.
- Miniaturization of circuits including peripheral components, and low EMI.

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

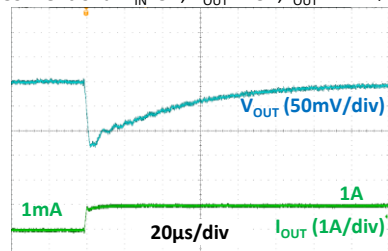
#### ➤ Significantly faster transient response

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



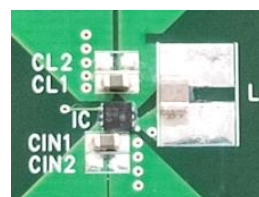
#### ➤ Miniaturization including peripheral components

- 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

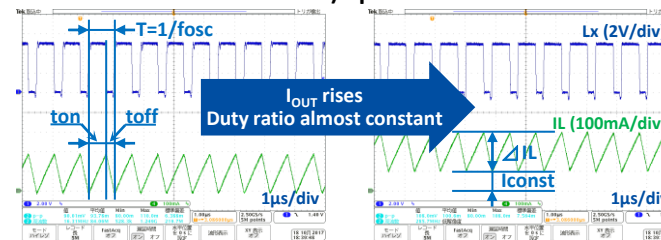


## Overview of COT control and HiSAT-COT®

### What is the 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



- Duty ratio of step-down DC/DC PWM operation above a certain  $I_{OUT}$  is **Duty ratio =  $V_{OUT}/V_{IN}$ ,  $ton = 1/f_{osc} \times \text{Duty ratio}$ .** 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  $f_{osc}$ .

### ● 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.

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