TOREX

Torex...Powerfully Small!

HiSAT-COT® control

1.0A/1.5A Synchronous Step-down DC/DC converters

XC9285/XC9286 Series

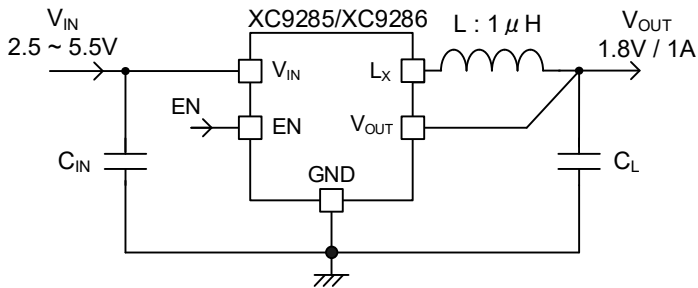# XC9287/XC9288/XC9289 Series

Feb. 2024

Torex Semiconductor Ltd.

Rev. 1.0

XC9285/XC9286 : HiSAT-COT® 1.0A Step-down DC/DC converter

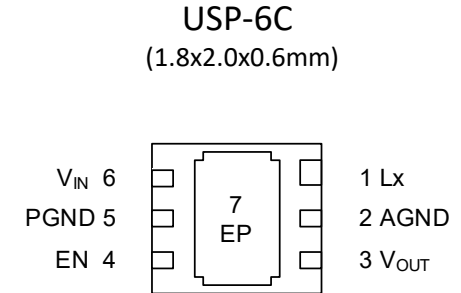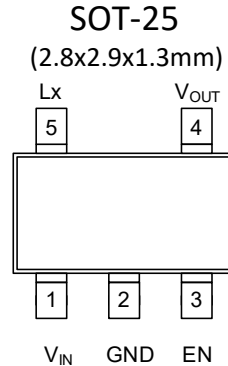## High Speed Transient Response / Small Package

■ Features

Input Voltage	: 2.5V ~ 5.5V (Absolute max.: 6.2V)
Output Voltage Range	: 0.8V ~ 3.6V (±2.0%)
Output Current	: 1.0A
Oscillation Frequency	: 1.2MHz
Control Method	: HiSAT-COT
	F-PWM (XC9285)
	PWM/PFM (XC9286)
Efficiency	: 92% (V_{IN}=5.0V, V_{OUT}=1.8V, I_{OUT}=300mA)
Functions	: Soft-start, UVLO
	C_L Discharge (Type B)
Protections	: Short Protection (Type B)
	Current Limit
	Thermal Shutdown
Packages	: SOT-25, USP-6C
Operating Ambient Temp.	: -40℃ ~ 105℃

■ Packages

SOT-25
(2.8x2.9x1.3mm)

Lx 5 — V_{OUT} 4

1 — 2 — 3

V_{IN} GND   EN

USP-6C
(1.8x2.0x0.6mm)

V_{IN} 6   1 Lx
PGND 5   7 EP   2 AGND
EN 4   3 V_{OUT}

■ Small Size

■ Typical Application Circuit

V_{IN} 2.5 ~ 5.5V — XC9285/XC9286 — V_{IN}, EN, L_X, V_{OUT}, GND — L : 1 μH — V_{OUT} 1.8V / 1A

C_{IN} C_L

## High Speed Transient Response / Small Package

### ■ Features

Input Voltage	: 2.5V ~ 5.5V (Absolute max.: 6.2V)
Output Voltage Range	: 0.8V ~ 3.6V (±2.0%)
Output Current	: 1.5A
Oscillation Frequency	: 1.2MHz, 3.0MHz
Control Method	: HiSAT-COT
	F-PWM (XC9287)
	PWM/PFM (XC9288)
	F-PWM or PWM/PFM by MODE (XC9289)
Efficiency	: 90% (V_{IN}=3.7V, V_{OUT}=1.8V, I_{OUT}=200mA)
Functions	: Soft-start, UVLO
	C_L Discharge (Type B)
Protections	: Short Protection (Type B)
	Current Limit
	Thermal Shutdown
Packages	: SOT-89-5 (XC9287/XC9288)
	USP-6C (XC9287/XC9288)
	LGA-8B01 (XC9289)
Operating Ambient Temp.	: -40°C ~ 105°C

■ Packages

SOT-89-5
(4.5x4.35x1.6mm)

USP-6C
(1.8x2.0x0.6mm)

LGA-8B01
(1.2x1.4x0.3mm)
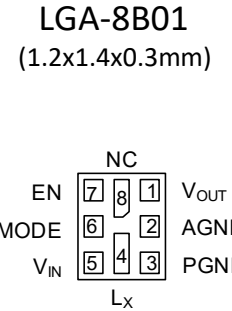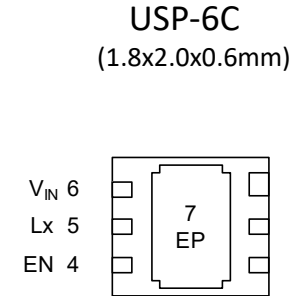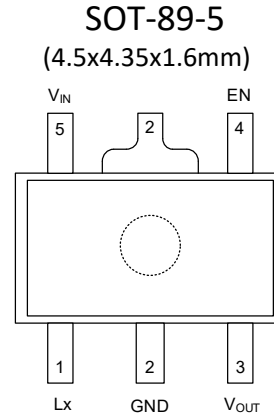
■ Typical Application Circuit
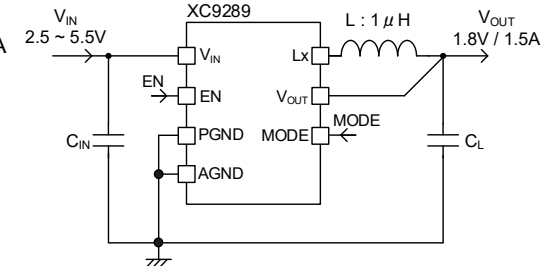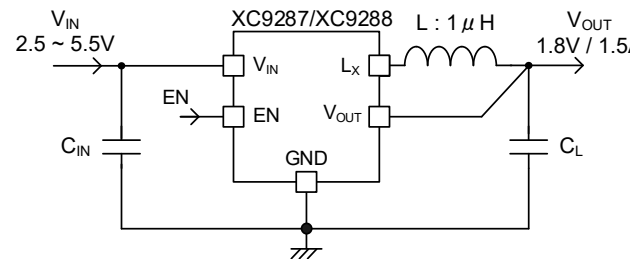
XC9285/XC9286, XC9287/XC9288/XC9289
: HiSAT-COT® 1.0A/1.5A Step-down DC/DC converters

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■ HiSAT-COT® for area saving, fast transient / low noise / high efficiency

HiSAT-COT®
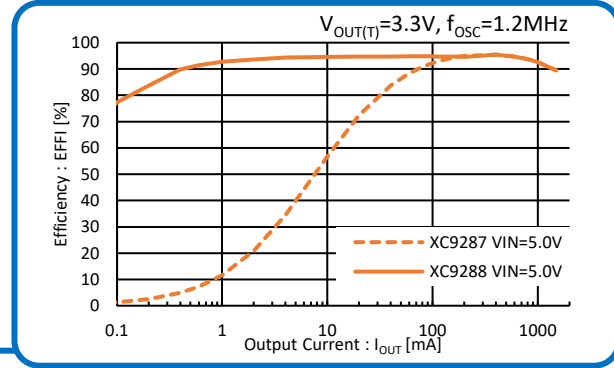1A/1.5A Step-down DC/DC
XC9285/86 (1A)
XC9287/88/89 (1.5A)

Saving area
5.3 x 4.5 mm
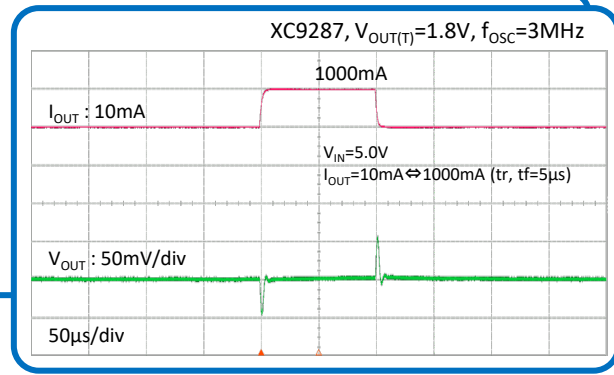
5.3 x 4.5mm
CL
L
CIN
IC

Fast transient
Low noise

①

① **Small components, saving area and high efficiency**

✓ Small components save area

✓ High efficiency

✓ Application-specific packages
- Ultra small   LGA-8B01 (XC9289)
- Small leadless   USP-6C (XC9285-88)
- With lead   SOT-25 (XC9285/XC9286)

$V_{OUT(T)}$=3.3V, f_{OSC}=1.2MHz

Efficiency : EFFI [%]

XC9287 VIN=5.0V
XC9288 VIN=5.0V

Output Current : I_{OUT} [mA]

②

② **Fast transient, Low ripple, Low EMI**

✓ High speed transient response with HiSAT-COT control

✓ Low ripple voltage and Low EMI

✓ Ideal for POL power supplies

XC9287, $V_{OUT(T)}$=1.8V, f_{OSC}=3MHz

1000mA
I_{OUT} : 10mA

V_{IN}=5.0V
I_{OUT}=10mA⇔1000mA (tr, tf=5μs)

V_{OUT} : 50mV/div

50μs/div

Suitable for all types of equipment/modules requiring **Fast transient response, High efficiency, Low noise**

➢ Industrial Applications/Control Systems   : POL power supplies for SoC/FPGA

➢ Modules/Sensors   : Camera modules, Wireless modules, SSD, Sensors

HiSAT-COT® for fast transient response and Miniaturization

■ TOREX original COT control : HiSAT-COT®

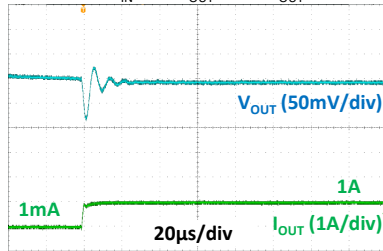**● Technical trend and challenges**

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

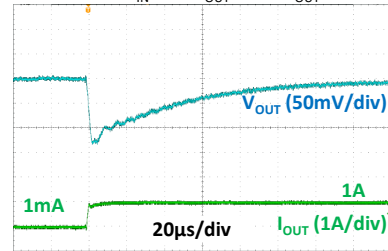**● TOREX Proposal : HiSAT-COT® controlled Step-down DC/DC converter**

➤ 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 I_{OUT} (1A/div)   1mA I_{OUT} (1A/div)
20μs/div   20μs/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.**
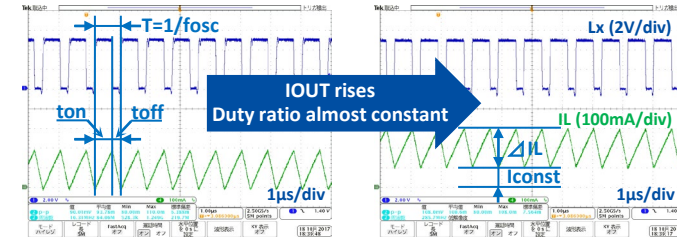
HiSAT-COT®   Conventional
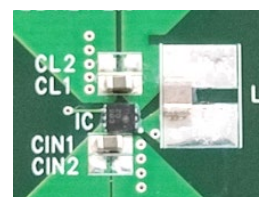
Overview of COT control and HiSAT-COT®

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 (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   **IOUT rises / Duty ratio almost constant**   IL (100mA/div)
ΔIL
Iconst
1μs/div   1μs/div

- Duty ratio of step-down DC/DC PWM operation above a certain IOUT is
  Duty ratio = V_{OUT}/V_{IN},   ton = 1/fosc x Duty ratio.
  If there is no loss, **Duty ratio is constant** even if IOUT 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.