design FAQs

Constant On-Time Buck Regulator ICs

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FREQUENTLY ASKED QUESTIONS

How did the constant on-time (COT) buck regulator IC evolve?

The COT regulator is a modified version of the basic hysteretic regulator shown in Figure 1. The basic hysteretic regulator IC consists of a comparator with input hysteresis that compares the output feedback voltage with a reference voltage.

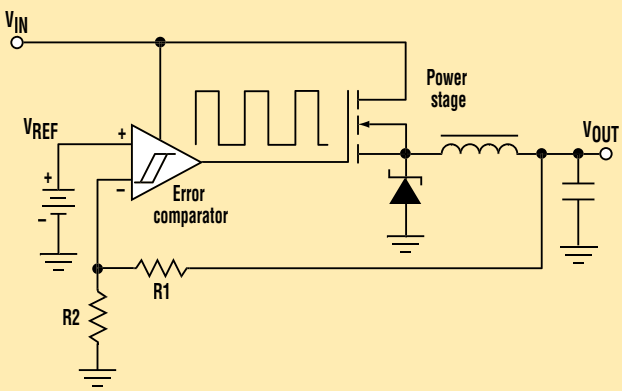
When the feedback voltage exceeds the reference voltage, the comparator output goes low, turning off the buck switch MOSFET. The switch remains off until the feedback voltage falls below the reference hysteresis voltage. Then, the comparator output goes high, turning on the switch and allowing the output voltage to rise again.

What are the characteristics of the basic hysteretic buck regulator IC?

It reacts extremely quickly to load and line transients due to its wide bandwidth control loop. Unlike a pulse-width modulation (PWM) regulator, this loop does not require an error amplifier or frequency compensation.

What is the main drawback of the hysteretic buck regulator IC?

As line and load conditions change, the hysteretic regulator operates over a wide frequency range that depends on the input/output voltages, the output filter inductance, the hysteresis window, and the output capacitor's equivalent series resistance (ESR).

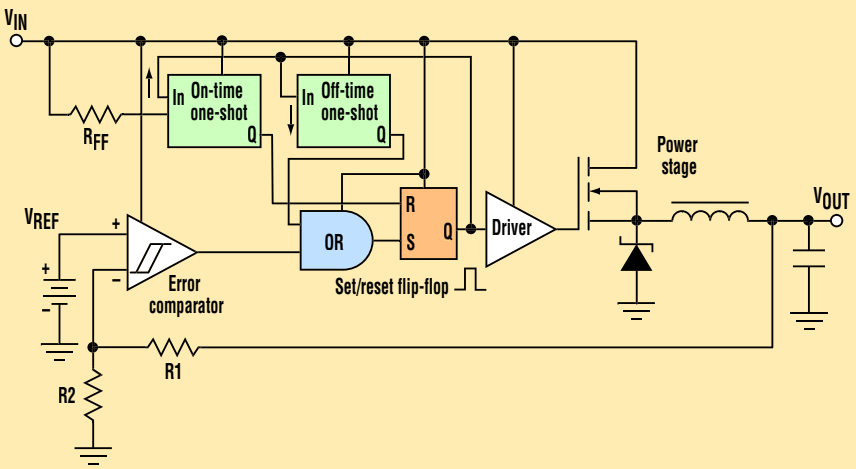


1. The basic hysteretic regulator IC operates with a varying switching frequency that makes it difficult to optimize filtering components.

What hysteretic regulator modifications create the COT regulator IC?

The COT architecture IC is a modification of hysteretic control that operates at a relatively fixed frequency without a clock. It employs a high-side MOSFET switch whose on-time varies inversely with the input voltage *(Fig. 2)*. Regulator control involves a comparator and one-shot on-timer, with the output voltage feedback compared with an internal reference.

In normal operation, the IC initiates an on-time period when the feedback voltage falls below the reference volt-



2. The constant on-time regulator IC employs on-time and off-time one-shots that cause the switching frequency to be nearly constant. This enables optimized filtering and results in lower output ripple voltage than the basic hysteretic regulator.

age. The buck switch stays on for the programmed on-time, causing the feedback voltage to rise above the reference. After the on-time period, the buck switch remains off until the feedback voltage falls below the reference. The off-time one-shot ensures a minimum off-time during startup. The addition of input feed-forward helps to maintain a constant frequency independent of the input voltage.

How does the COT regulator IC respond to load conditions?

This regulator IC operates in discontinuous conduction mode at light load currents and in continuous conduction mode with heavy load current. In the discontinuous conduction mode, current through the output inductor starts at zero and ramps up to a peak during the on-time. It then ramps back to zero before the end of the off-time.

The next on-time period starts when the feedback voltage falls below the internal reference. Until then, the inductor current remains zero, and the output capacitor supplies the entire load. In this mode, the operating frequency is lower than it is in continuous conduction mode, and it varies with load current. Unlike hysteretic regulators, the switching frequency during continuous conduction mode is independent of the inductor and capacitor size.

Why does the COT regulator IC provide better performance?

The COT regulator IC operates in a fixed-frequency mode without an oscillator, which eliminates loop compensation and stabilization. This provides fast transient response unlimited by feedback-network lag time or stability issues.

What protection features can be implemented in a COT regulator IC?

Protection features can include undervoltage lockout (UVLO), overcurrent protection, thermal shutdown, and overvoltage protection.

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