

# Use an ULQ Buck Regulator for Energy-Efficient Power Products



Anthony Lang

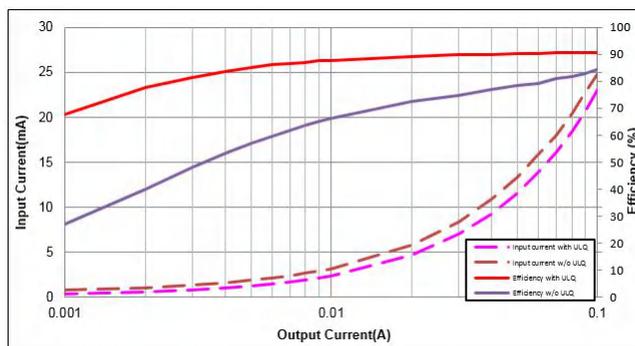


Battery life has played a more and more important role in portable devices, contributing to the overall user experience. Longer battery life has become one of the first priorities for engineers to consider when designing a battery-powered device. Energy Star and similar standards not only require increasing the efficiency of a device during normal operation, but also lower energy consumption while in a standby state.

The power-management integrated circuit (IC) implemented in electrical designs is a bottleneck if you're trying to further conserve energy. Among the various power-management ICs, buck regulators are the most widely used solution. A single electrical design could have several channels of switching buck regulators. These power rails are in either a shutdown or standby state most of the day. The power loss of these power rails under light loads will dominate the overall energy wasted. Most buck regulators on the market use the energy-saving Eco-mode™ pulse-skipping control scheme to increase the light-load efficiency. The Eco-mode control scheme lowers the switching frequency and keeps the high- and low-side power metal-oxide semiconductor field effect transistors (MOSFETs) off for several cycles just after several switching pulses. With less switching loss, the efficiency will increase significantly compared to a non-Eco-mode control scheme device.

Even with the Eco-mode control scheme, it can be challenging to meet energy-efficiency standards. The issue is when the current consumed while both power MOSFETs are off during the Eco-mode control state. The input current in a nonswitching state is called nonswitching quiescent current ( $I_q$ ), and indicates the minimum current that keeps the internal logic blocks active. With special silicon design, it's possible to disable most noncritical blocks under a nonswitching state. The always-on blocks, monitor blocks and detection blocks use little current from the IC's internal power supply. The  $I_q$  will stay at the lowest level to save energy. This feature is called ultra-low quiescent current (ULQ). With ULQ, the light-load efficiency will be further boosted during the Eco-mode control state.

Let's compare a buck regulator with ULQ ( $I_q = 45\mu\text{A}$ ) to one without ULQ ( $I_q = 310\mu\text{A}$ ). [Figure 1](#) is a comparison graph of efficiency and input current under light-load conditions. For a 24V input voltage and a 5V output voltage with no load, the input current for the regulator without ULQ is 0.480mA, while the input current for the regulator with ULQ is only 0.116mA.

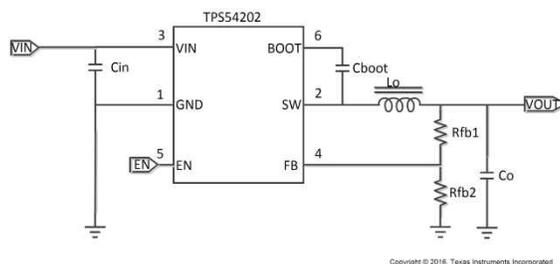


**Figure 1. ULQ and non-ULQ Buck-regulator Efficiency and Input-current Comparison**

The ULQ feature is designed to provide extremely low power consumption for battery-powered systems and energy-saving home appliances in their standby modes. Typical battery-powered systems requiring 12V and 24V power rails include portable devices like laptops, cordless mechanical tools with 12V/24V DC motors and wireless speakers. Remote-control systems like drones, car entertainment systems and many other applications also require ULQ to consume minimal current from the battery during standby. Manufacturers of indoor electrical appliances like computers, servers, white goods, heating and cooling systems, home electronics, imaging equipment, and smart home devices are likely to adhere to an energy-efficient standard like Energy Star. The ULQ feature, together with the Eco-mode control scheme, is one big step further for electrical designers attempting to meet energy-efficient standards.

### The New TPS54202/TPS54302

To meet energy-saving demands, TI has introduced the TPS54202 and TPS54302. These ULQ buck regulators are 28V, 2A/3A synchronous step-down converters with two integrated N-channel MOSFETs. They implement a fixed 400kHz switching frequency with peak current-mode control. Their 45 $\mu$ A I<sub>q</sub> is only 15% of the I<sub>q</sub> of devices without ULQ. Figure 2 is a simple TPS54202/TPS54302 schematic.



**Figure 2. Simple Schematic for the TPS54202/TPS54302**

During light-load conditions, the TPS54202/TPS54302 will enter the advanced Eco-mode control scheme state. When the inductor peak current is lower than 300/500mA, the device will prevent high-side FET turn-on and skip pulses for several cycles. During pulse skipping and with both the high- and low-side FETs off, the device only consumes the minimum nonswitching quiescent current from the input source (45 $\mu$ A) by disabling most of the internal circuit blocks. Only some always-on blocks and dynamic bias blocks that keep monitor status and fast recovery remain active. All disabled blocks will wake up once the device exits ULQ mode and the internal FETs start switching again. The ULQ feature ensures that the TPS54202/TPS54302 will have better energy-efficiency performance in standby states.

Using a ULQ buck regulator will bring benefits to the design of energy-efficient power products. For battery-powered devices with ULQ functionality, battery life will be greatly lengthened by reduced standby mode energy consumption. For the home appliances that must pass standards like Energy Star, ULQ technology will significantly improve energy efficiency. The TPS54202/TPS54302 with ULQ will contribute to a better world with low energy consumption.

**Additional resources:**

- For more information on the various energy-saving control schemes used by TI's products, download ["Practical comparisons of DC/DC control-modes to solve end equipment challenges"](#).
- As an alternative to discrete IC solutions, consider the easy-to-use TPSM84203, TPSM84205 and TPSM84212 power modules with the TPS54302 integrated.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2023, Texas Instruments Incorporated