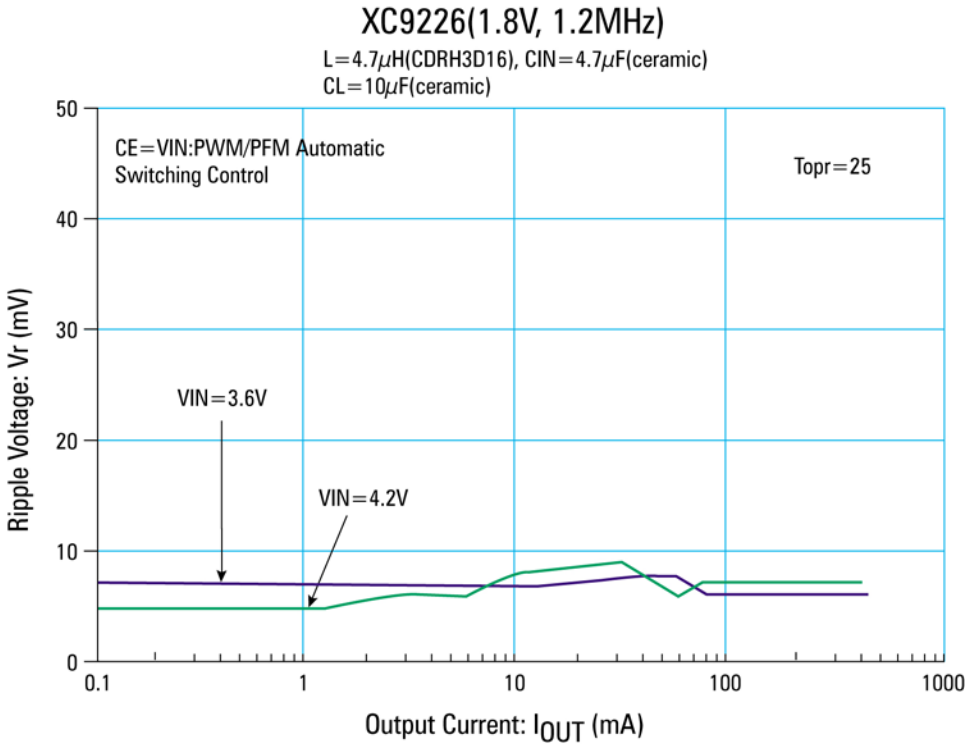
Lowering Power Consumption in Next-Generation Portable Devices

Power consumption is an issue that is attracting growing attention. Battery life can be a deciding factor in consumer selection of portable devices, and can also determine the extent of the functionality of the application itself. For home applications, energy use is also becoming increasingly important. The Blue Angel standard, for example, requires that compatible products draw 1/20th of their operating current, or less, when in standby mode. At the same time the trend for smaller packaging has meant that power supplies are often external, leaving on-board power distribution to small, localised power converters. The efficiency of these devices, and the quiescent current that they draw, both contribute to the overall power consumption of the finished product.

The first major breakthrough in converter technology for low power consumption and longer battery life was the Torex XC9215/16/17 series, which was developed for use with Lithium-Ion batteries. These were high efficiency synchronous converters, with very low output ripple of less than 10mV (see Figure 1). With such a low output ripple no filters or regulator circuits were needed to make the output stable enough for today's RF chipsets. The quiescent current drawn was 50-60μA, and the maximum output current was 500mA. A number of leading RF chipset vendors quickly adopted them for use in bluetooth and wireless LAN applications.

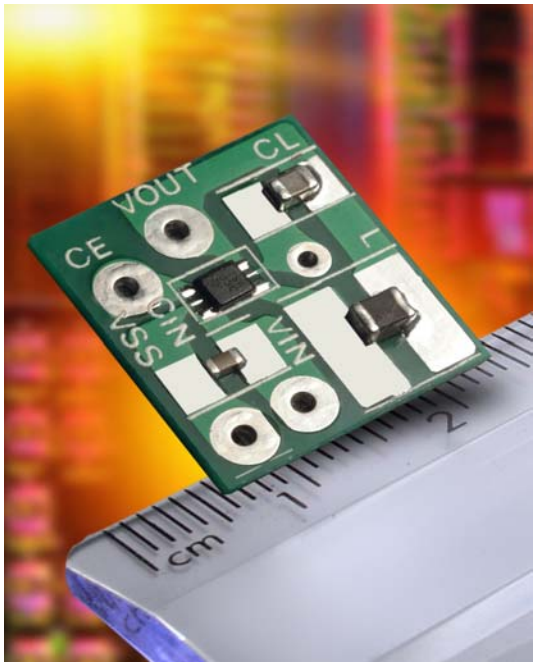


(Figure 1)

The latest generation power ICs have performance characteristics that far exceed these. Torex Semiconductor has continued to work on its power technology, and has now developed a series of converters that draw just 15μA in operation, or 0.1μA in standby mode. The XC9225/26/27 series are synchronous step-down DC/DC converters that have a typical efficiency of 92%, making the series one of the most energy efficient available, while still supplying a stable output current of 500mA. Torex sets the fixed output voltage by laser trimming, giving an output that is selectable in increments of 100mV in the range 0.9V to 4.0V. Minimum operating voltage is 2.0V.

These converters are also very stable, having the same exceptionally low output ripple of less than 10mV as their predecessors. A built in frequency generator oscillates at 600kHz or 1.2MHz to make available the frequency best suited to the application. The XC9225 is PWM controlled, while the XC9226 series is automatic PWM/PFM switching controlled. The XC9227 series can be manually switched between the PWM and PWM/PFM switching control modes, allowing fast response, low ripple and high efficiency over the full range of load conditions. The soft-start and current control functions of all three models are internally optimised.

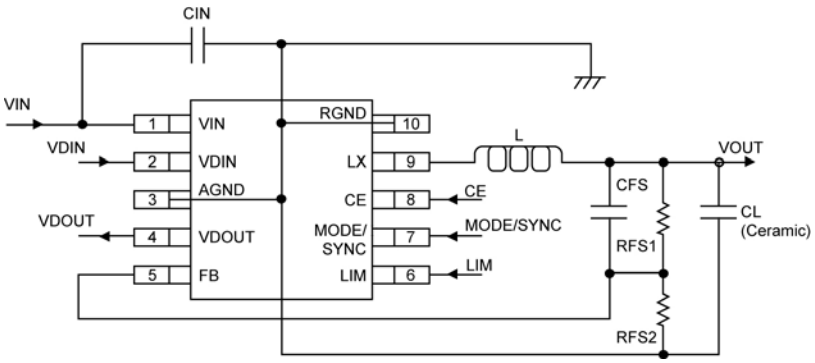
The devices can be configured using only a coil and two ceramic capacitors connected externally. The IC and companion components will fit on a board space just 6mm^2 (see Figure 2), making them ideal for applications where PCB space is at a premium.



(Figure 2)

For applications that require a higher current, Torex has introduced the XC9223/24 series that can provide output currents of up to 1.2A with output voltages down to 0.8V (see Figure 3). With switching frequencies of 1MHz or 2MHz, small inductors can be used, making the series ideally suited to applications where height and PCB area is limited. Depending on application conditions, efficiencies of up to 94% can be achieved (see Figure 4).

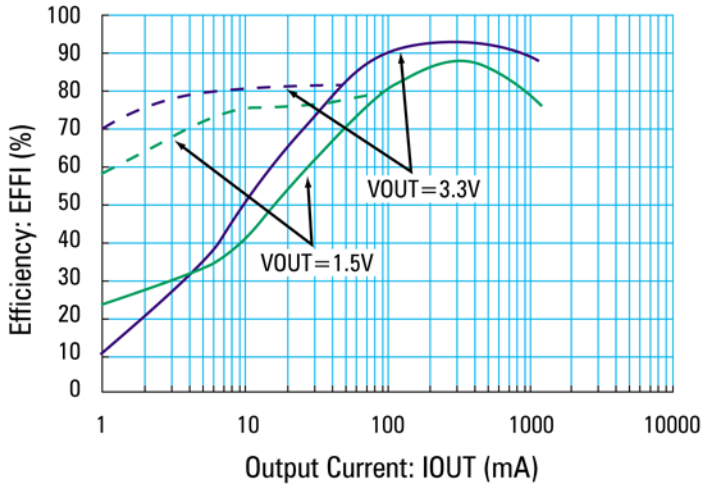
Typical Application Circuit



(Figure 3)

Typical Performance Characteristics
Efficiency vs. Output Current

VIN=5.0V, FOSC=2.0MHz
L=2.0μHICDRH4028CI, CIN=10μF(Ceramic), CL=10μF(Ceramic)



(Figure 4)

For applications influenced by switching noise, the XC9223/24 series can be synchronised with an external clock signal within the range of ± 25% toward an internal clock signal via the MODE/SYNC pin. The series automatically operates in PWM mode when synchronised in this way. The MODE/SYNC pin also allows the user to select fixed PWM mode or PFM/PWM auto-switching control. With PFM/PWM control, the XC9223/24 series selects the best switching mode depending on output load thus ensuring the highest efficiencies from light to heavy loads.

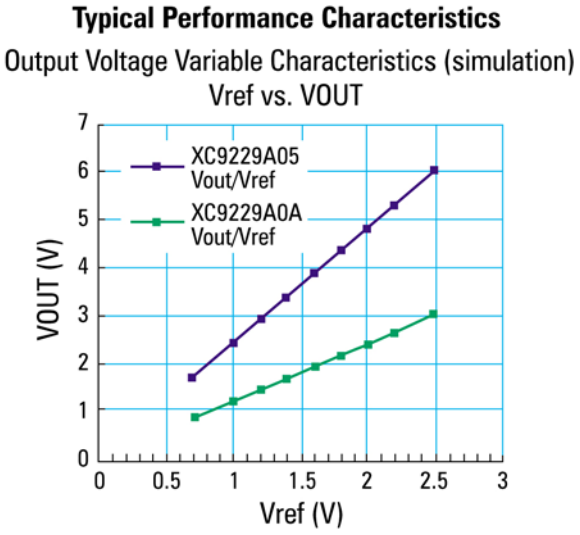
The series also has a built-in current limiter circuit that safely enables the user to fix either a 0.5A or a 1.5A threshold thereby allowing a smaller inductor to be used safely in the knowledge that it will be protected from over-current. For example, a 2.2μH inductor can be used in place of a typical 10μH inductor.

A built-in voltage comparator is incorporated, which could be configured to monitor battery output for low battery protection. Alternatively it could be used for monitoring a start-up sequence and ensuring that a particular circuit will be activated at the right step. To prevent an over-current state, the IC detects overshoot current by analysing the voltage difference between the VDD and Lx pin. After an over current state

continues for a few milliseconds, the IC's operation goes into suspension mode and the driver transistor is turned off.

The series also incorporates a thermal shutdown circuit that operates if the IC's junction temperature reaches 150ºC. When the temperature drops to 130ºC or less, the IC performs the soft start function and full operation is resumed. In addition the short-circuit protection will shut down the IC when the FB voltage decreases less than half of the setting voltage.

To satisfy increased demand from chipset vendors for dynamic voltage control, Torex has designed the XC9228/29 series of converters. These are suitable for use with next generation applications that have varying power demands, such as 3G cellular phones and PDAs. The XC9228/29 series are synchronous step-down DC/DC converters that allow the output voltage to be adjusted via an external voltage reference (Vref) input. The converters feature a comparator that gives a precise linear output selectable from Vref x 1.2 or Vref x 2.4 (see Figure 5). This dynamic output can be used, for example, with a 3G/UMTS radio where the power needed for the TX/RX depends on the distance from the handset to the base-station. The nearer the base-station, the less power is needed. One way to regulate this TX/RX power is to dynamically control the voltage of the PA in the RF chipset.



(Figure 5)

The series has a built in 0.6 Ω P-channel driver transistor and 0.7 Ω N-channel switching transistor and can provide high efficiencies (92%), a stable power supply and output currents of 500mA using only a coil and two ceramic capacitors connected externally. Quiescent current is only 18μA and during stand-by, all circuits are shutdown to reduce current consumption to 0.1μA or less. Minimum operating voltage of the series is 2.0 V.

The XC9228 series is a PWM control type, while the XC9229 series has automatic PWM/PFM switching control, allowing fast response, low ripple and high efficiency over the full range of current load. A built-in under voltage lock out (UVLO) function, current limiter and latch-protection circuit protects the device.

Electronic devices will undoubtedly continue to develop, continuing the trend of packing more and more features into an ever-smaller space. The challenge for power solutions providers is to continue to develop supplies that will provide the required power whilst drawing minimal current themselves.