# AN EFFICIENT APPROACH TO DRIVING WHITE LEDs IN LCD BACKLIGHT APPLICATIONS

Virtually every piece of portable and handheld equipment incorporates an LCD. The growth in demand for PDAs, laptops, WAP phones, mobile video phones has thus been accompanied by a similar growth in demand for more displays, and particularly 'brighter' LCDs which can be easily read in daylight . The simplest way to produce a brighter LCD is to backlight it with white LEDs. Efficiency of the backlight circuit is crucial in the conservation of battery power and while specially designed ICs are available for this purpose, a more cost-effective solution is at hand. The XC9105 from Torex Semiconductor is a new DC-DC converter that gives designers a highly efficient solution to driving the white LEDs used to backlight colour LCDs.

In backlight applications LEDs are preferred to incandescent bulbs for a number of reasons. LEDs are more efficient at converting input energy into light. As they are more efficient, batteries last longer. A low battery will cause a bulb to dim. Not so an LED whose brightness stays constant even when the battery voltage is low. LEDs are also tougher than bulbs and are able to withstand much higher levels of shock, vibration and switching. Lifetimes of 100,000 hours are common, allowing designers to 'fit and forget' unlike bulbs which invariably at some point during the lifetime of the equipment will need replacing.
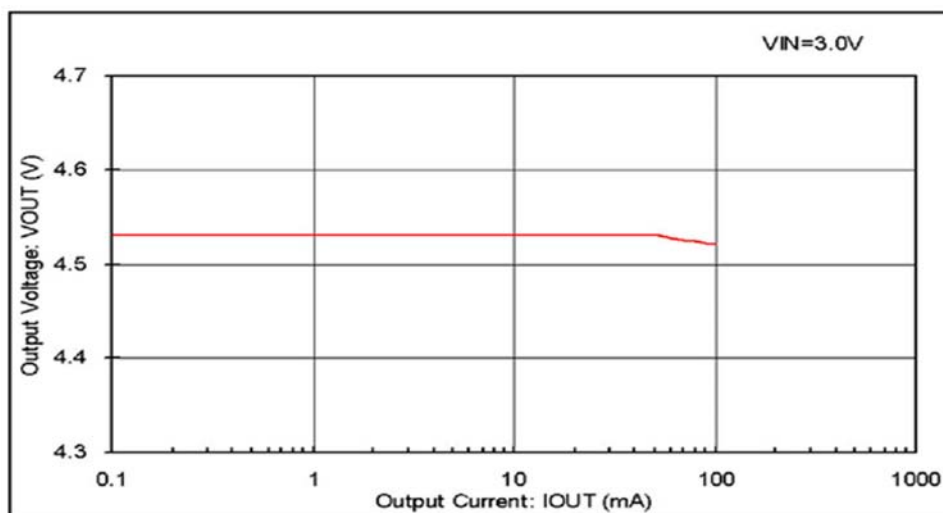
The white LEDs used in backlight circuits tend to typically require a drive voltage of 3.5V and current of around 20mA to 50mA. Torex Semiconductor's latest generation of step-up DC-DC converters, the XC9105, provides low ripple across a wide output range. As well as being an ideal solution for driving white LEDs in LCD backlights it is also particularly suited to RF wireless and MP3 applications. It employs the very latest current/voltage multiple feedback technique. This means that ceramic capacitors, rather than expensive tantalums, can be used to stabilise their output bringing significant savings in terms of both space and cost.

The XC9105 series has a PWM to pulse frequency modulation (PFM) switching facility, allowing it to operate at maximum efficiency, over a broad range of output loads. It uniquely boasts external control of PWM or PFM mode switching, thus allowing designers flexibility in tailoring the converter exactly to the needs of their application.
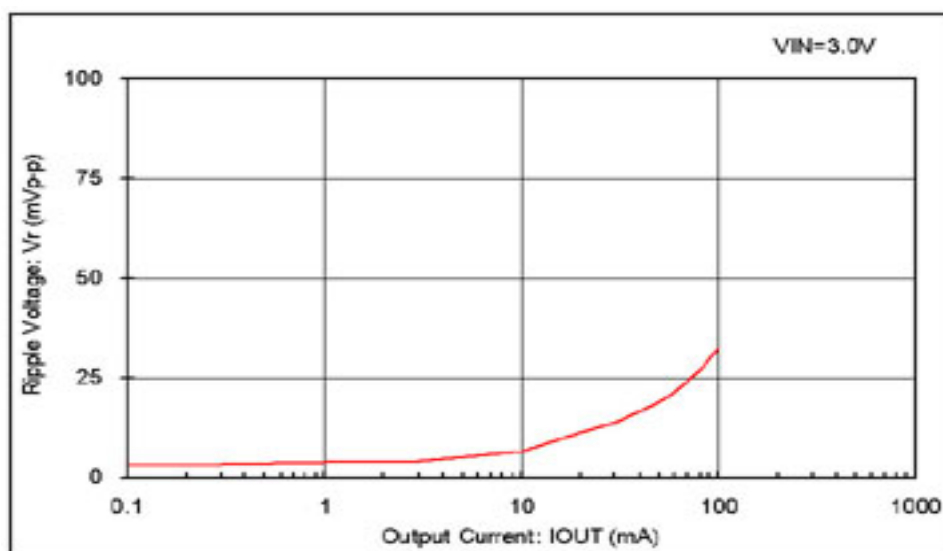
The XC9105 produces a very stable output voltage over the full range of output currents (Figure 1). Standard oscillation frequencies of 300kHz or 180kHz enable the size of external components to be reduced. The device's low ripple is shown in Figure 2. Low ripple is ensured with a built-in current limiter circuit, monitoring voltage ripple at the FB pin. If the voltage ripple exceeds 250mV the converter shuts down. Other features include a 'softstart' internally set at 10ms offering protection against inrush currents when power is switched on and voltage overshoot. Maximum

power consumption is only 1.0μA on stand-by and quiescent current is a low 20μA (typ.).
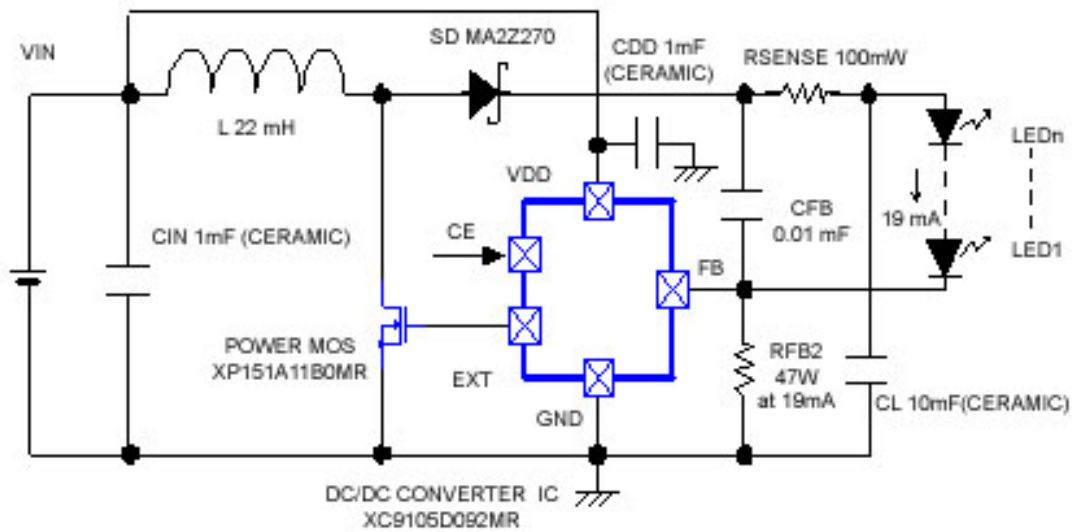

Figure 3 shows the optimum configuration for driving white LEDs using the XC9105. Although the XC9105 can be used to drive LEDs in series or parallel, tests show that higher efficiencies and thus longer battery life is achieved by driving the LEDs in series (see Table 2 below).

By configuring the LEDs in series, they are operated by a constant current requiring only one series resistor, regardless of the number of LEDs in the circuit. The resulting reduction in components enables a decrease in power consumption. Additionally, the dispersion of the LEDs' forward voltage does not effect the current, while their current is adjusted by changing only one resistor. Almost no change is necessary when changing the number of LEDs in the circuit, say from two to four, while use of a ceramic capacitor ensures low ripple, suppresses unwanted emissions and gives a long service life.

For the XC9105 input voltage can be set from 0.9V to 10V. Using the externally connected components in the backlight circuit, output voltage can be set freely from 1.5V to 30V. Setting the XC9105 is very straightforward.

The current required to drive the white LEDs is calculated as follows:

Voltage at the FB pin (0.9V in this case) divided by the value of the resistor RFB.

The output voltage of the DC-DC converter is the sum of the forward voltage of the LED (or the forward voltage multiplied by the number of LEDs if more than one is used) and the FB terminal voltage (0.9V).

Thus the required VOUT setting on the XC9105 for each combination of LEDs is shown in Table 1:

Number of LEDs	VOUT
1	4.4V (0.9 + 3.5)
2	7.9V (0.9 +3.5 x 2)
3	11.4V (0.9 + 3.5 x 3)
4	14.9V (0.9 + 3.5 x 4)

Table 1:

The components used in this circuit allow a maximum of four white LEDs to be used when VIN is 3.0V.   Five or more LEDs can be driven by the circuit by increasing VIN or choosing a coil and FET with higher current ratings and by using components with smaller direct current resistance. When the number of white LEDs is two or less, the capacitor to ground CDD can be eliminated and CE and VDD can be taken from VOUT. If three or more LEDs are used VOUT exceeds 10V, and VDD should be taken from VIN.

Efficiency of the configuration is very important, playing a significant role in determining battery life. Efficiency is calculated as follows:

$$\text{EFFI \%} = \frac{\text{applied voltage to LEDs x current at LEDs x 100}}{\text{Input voltage x input current}}$$

Comparing the efficiencies offered by the series circuit with those of the optimum parallel connected solution (Table 2), clearly it can be seen that the series connection of white LEDs conserves battery life far better than when connected in parallel.

| | Efficiency (EFFI %) | |
Number of LEDs	in series	in parallel
1	71.48	65.14
2	79.96	65.93
3	82.48	66.30
4	82.92	67.23

Table 2:

Thus the new XC9105 step-up DC-DC converter from Torex Semiconductor allows designers to achieve a very efficient solution for the backlighting of colour LCDs using white LEDs. Through the XC9105, power consumption is kept to a minimum, effectively extending battery life, and component count is reduced enabling both significant cost and space savings to be made.