

Dimming options for LCD brightness control

The environment of the application often determines an LCD inverter's dimming technique

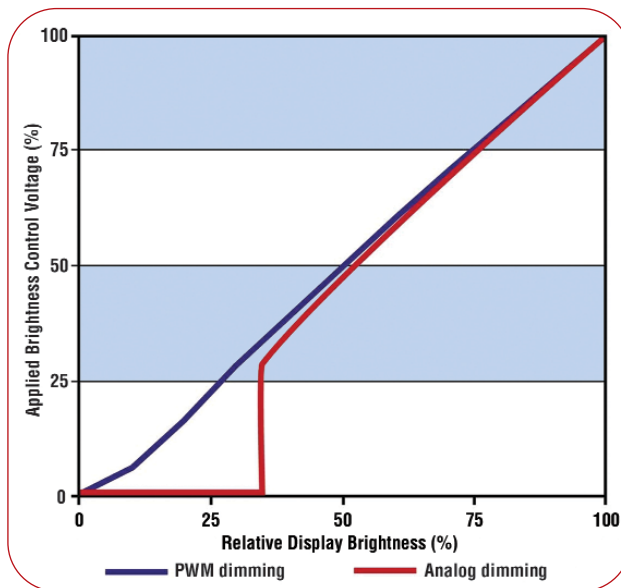
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The two most common techniques used to control the brightness of the cold-cathode fluorescent tubes (CCFLs) that backlight an LCD panel are analog dimming and digital (or PWM) dimming. In analog dimming, a dc voltage directly controls the output current of the inverter powering the CCFL, which in turn, controls the display's brightness.

The pulse width modulation (PWM) dimming technique fixes the output current of the inverter and modulates the time that the inverter is on. Each technique has its own set of advantages and limitations—important design considerations that must be taken into account during system design and integration.

Analog dimming

Analog dimming is the simplest technique to implement. An applied dc voltage directly controls the output current of the CCFL inverter. Generally, this voltage is electrically summed into the on-board voltage control loop or is used to supply drive current to the inverter's primary switches. In either case, the inverter operates continuously. In this mode, power supply requirements are reduced since there is little input ripple current and additional filtering



The difference between the dimming ratios offered by analog and digital/PWM techniques show most clearly at lower voltages.

of the power supply is not required.

However, the dimming range available when using analog dimming is quite poor, particularly for applications such as daylight- and nighttime-readable displays that require a wide dimming range. The display's minimum brightness would occur when the specified CCFL is operating at its specified minimum operating current, often 30% to 50% of the rated typical current.

Since light output is relatively linear, a dimming ratio of roughly 2:1 or 3:1 can be accomplished. This is further complicated by large displays, typically larger than 17 in., with high electrical losses in the CCFL assembly that could effectively reduce the dimming ratio to as low as 1.5:1.

The dimming ratio is the ratio between the highest achievable bright-

ness of a display and the lowest attainable brightness level. Lower dimming ratios are perfectly acceptable for many applications.

Typically, office environments—where the ambient light levels are fixed—require a relatively limited dimming range. However, if the ambient light levels change significantly, such as in the automotive or aeronautical industry, very bright backlights are needed to make the display bright and readable in direct sunlight and the display must also not blind the user at night.

PWM dimming

Digital or PWM dimming is rapidly becoming the dimming technique of choice since it is less display-sensitive and offers more flexibility in choosing brightness levels. To make PWM dimming possible, an inverter needs to be specifically designed for it.

On many generic closed-loop inverters, the control loop is often too slow for an effective dimming range. When PWM dimming is used, the time that the inverter is on is modulated and the applied duty cycle roughly equates to display brightness, with 100% being the maximum.

Since the inverter is actually being turned on and off at the PWM frequency, care should be taken in the design of the inverter's power supply to take into account the low-frequency pulses of current produced by the

inverter. Furthermore, magnetic structures may *sing* as a result of the windings compressing and expanding (magnetostriction) as the current through them changes rapidly at the PWM frequency, so acoustics are also a consideration.

One of the greatest advantages of using PWM dimming is a wide dimming range. Since the minimum tube current requirement is always met (the inverter is either fully on or fully off), the minimum brightness is a function of controllable duty cycle, which can be below 1%. With a minimum duty cycle of 1%, a dimming ratio of 100:1 is easily accomplished.

Some inverters offer on-board analog-to-PWM converters that allow for the increase in dimming range while interfacing to legacy circuits or potentiometers. However, when possible, the source of the dimming sig-

nal should be digital and at the desired PWM frequency.


If it is not, undergoing the conversion process from analog to digital or digital to analog to digital can be plagued by noise and tolerance problems. These are manifested in minimum brightness stability (flicker or brightness drift) and lack of repeatability (consistent brightness levels from assembly to assembly).

Soft starting and the signal interface

If an extreme dimming ratio is not required, the disadvantage of acoustics and power supply ripple requirements can be reduced by choosing an inverter with *soft-start* functionality. Soft start gradually increases and reduces the CCFL current at each PWM cycle, which in turn softens the edge on startup and turnoff. The performance hit in dimming ratio is-

n't a killer either, as dimming ratios of greater than 50:1 can still be accomplished, which is sufficient for applications like portable tracking stations and POS terminals.

Interfacing signals to inverters is not always a straightforward task. It is important to note that many of the interface signals on the inverter side are *not digital*. Some interface to voltage levels outside of the digital range, are not compatible with TTL-level signals or require current sourcing or sinking.

In some cases, it can be as simple as a mismatch in the PWM analog control range voltage or swapped polarity on enable or control signals. Instead of developing circuitry to accommodate the inverter, the knowledgeable inverter manufacturer will configure the inverter to accommodate the interface signals or offer interface solutions. 



The Power Behind the Display

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