## Driving LED backlights in LCD applications

All LCD (liquid crystal displays) panels require backlighting to render the display visible.
The most common types of backlighting are:

1. Transflective that reflects and transmits light (transflective = transmissive + reflective) under bright illumination (e.g. when exposed to daylight) the display acts mainly as a reflective display with the contrast being constant with luminance.
2. CCFL – Currently the most common uses cold cathode fluorescent lamps coupled with reflectors to illuminate the LCD
3. LED (light emitting diodes) are used in strings or arrays to backlight the display also with reflectors

Although the market has been dominated by CCFL backlights the emergence of LED's with longer life, higher efficiency and the prospect of more competitive pricing have lead to adoption initially in applications like notebook computers.

The characteristics of CCFL's and LED's are quite different:

LED's are easier to drive, use no high voltage or mercury vapour in their construction, operate at low temperatures and can be easily dimmed without any effect on life. On the down side they do have some problems with life at higher temperatures, poor chromatics and cost

CCFL's have a proven life at higher temperatures, very high colour stability and lower cost. They do not perform well at low temperature and do use mercury vapour within the lamp.

Many users are under the misconception that LED's are easy to drive whilst in fact the opposite is true. Very careful control of the LED current is required to ensure no loss of operating life and even a small overdrive of 5% whilst not visually apparent to the user will have serious effects.

TDK-Lambda, a world leader in the development and production of inverters for CCFL applications is now developing drivers specifically for the LED backlight market.

Most industrial applications use pseudo white LED's made using a blue led with yellow phosphor which requires a constant current to drive them.
The forward voltage drop of LED's is rather higher than ordinary diodes but as with all semiconductors varies considerable with temperature. As LED's are usually connected in series to form strings this effect is further amplified.
To achieve the level of require light larger panels use multiple strings and for this reason drivers need to be designed for this purpose.

Generally TDK-Lambda uses 2 circuit topologies:

1. For currents below 100mA an IC that can drive multiple strings of LED's is used. The IC circuit is relatively simple and low cost but variations in diode forward voltage drop causes lost power to generate heat. This is minimised by advanced thermal management in the LED driver.

2. For currents above 100mA a circuit using multiple constant current modules is used. This allows output current to be changed for individual strings and thus reduces loss in the control IC. This more complex circuit is larger and more costly than the low current topology.

On of the problems with LED's is the fact that colour chromatics change with forward current and for this reason TDK-Lambda drivers not only feature simple current dimming but also PWM dimming to compensate for this effect.

TDK-Lambda products fall into two categories.

1. LED drivers that are in PCB format incorporating all functions and suitable connectors for connection to the LCD panel backlight
2. Second generation LED drivers that are designed to be installed within the customers own mother board. These products feature multiple independent drivers for up to six strings of LED's and are very versatile

## TDK-Lambda ALD605012PJ131 development kit

This development kit is designed to allow the user to drive many kinds of LED backlight units and to easily connect by means of PCB mounted screw terminal connectors. For production purposes the driver would normally be incorporated onto the users mother board.

The TDK-Lambda ALD605012PJ131 features six independent drivers with each capable of driving up to 10 LED's (38 volts) at 50mA.

The compact package measures just 22.86 x 21.1 x 8.5 mm and is available in conventional or surface mount format.
Outputs can be paralled in any combination to allow LED current of up to 300mA when driving a single string.
Maximum LED current can be set using either an external 10k potentiometer (RBR) or an external DC voltage (VBR).
Additionally and an external PWM signal of circa 220 Hz can provide wide range dimming up to the maximum level set by (RBR) or (VBR).
Using PWM dimming ensures that during the "ON" period LED current remains at the maximum set level and thus limits the effect of colour chromatic changes.
The product has remote on off control as well as an alarm output (TTL compatible voltage level shift) in the event of LED failure. Unused drivers can be left open and multiple units can be used for larger panels.

Three key parameters need to be defined to ensure correct operation and that the ALD606012PJ131 is suitable as a driver:

- The LED current that is specified by the LCD maker for continuous operation. NB in many cases this is significantly below the maximum value to improve life

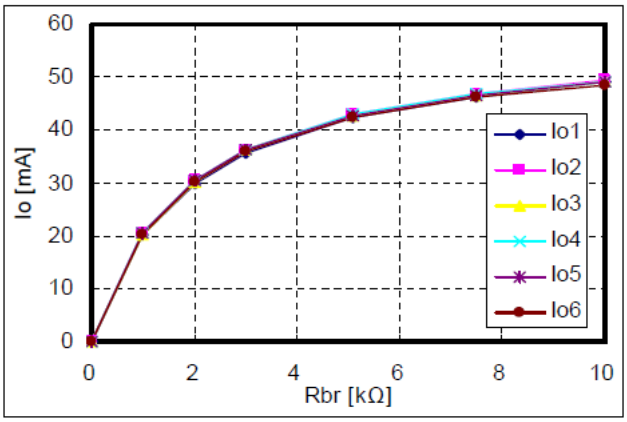
- The number of LED strings to be driven (depends on LCD size and brightness specification) The ALD has six independent drive circuits and more can be added by using multiple circuits

- The maximum forward voltage drop of each diode and string. The ALD can drive up to 38 volts at full rated current but is subject to temperature derating dependant on actual output volts. The total output power is a function of the string voltage and the LED current.

The ALD requires a supply voltage of 12 volts +/- 10% on pin 1.
The development board provides an input fuse.

If the LCD requires has between 1 and six strings and LED current of 50 mA the driver can be used with no adjustments.

If the LED current needs to less than 50 mA it is necessary to set this using the RBR (pin 6). The development board provides for a fixed resistor (RBR) or a potentiometer (VR1)




| Rbr [kΩ] | Io1 [mA] | Io2 [mA] | Io3 [mA] | Io4 [mA] | Io5 [mA] | Io6 [mA] |
|---|---|---|---|---|---|---|
| 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.0 | 20.08 | 20.58 | 20.28 | 20.55 | 20.43 | 20.24 |
| 2.0 | 29.99 | 30.59 | 30.30 | 30.53 | 30.37 | 30.13 |
| 3.0 | 35.76 | 36.40 | 36.14 | 36.34 | 36.16 | 35.87 |
| 5.1 | 42.22 | 42.96 | 42.70 | 42.88 | 42.66 | 42.31 |
| 7.5 | 46.14 | 46.91 | 46.66 | 46.83 | 46.59 | 46.24 |
| 10.0 | 49.01 | 49.26 | 49.05 | 49.19 | 48.95 | 48.56 |
| Open | 56.87 | 57.70 | 57.58 | 57.67 | 57.40 | 56.93 |

The actual current should be checked by measurement
Having set the maximum current the output can then be dimmed using the PWM input (pin 7) or by reducing the value of the selected dimming resistor (RBR)

If the LED current needs to be more than 50 mA two or more outputs will need to be used in parallel

The following table shows how to parallel outputs:

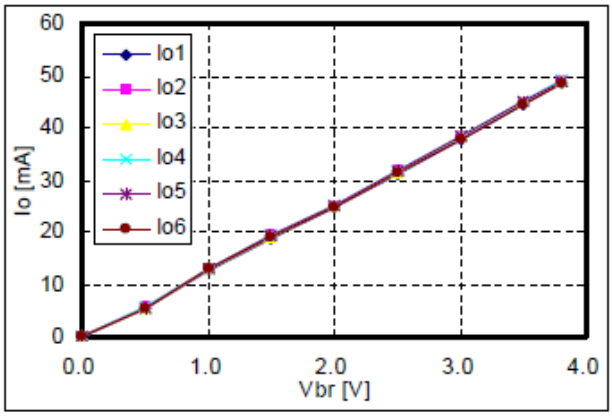
| Pin | Maximum Output | Pin | Maximum Output | Pin | Maximum Output | Pin | Maximum Output |
|---|---|---|---|---|---|---|---|
| Driver 1 8 → | 50 mA | 8 Driver 1<br>9 Driver 2 → | 100 mA | 8 Driver 1<br>9 Driver 2 → | 150 mA | 8 Driver 1<br>9 Driver 2<br>10 Driver 3 → | 300 mA |
| Driver 2 9 → | 50 mA | | | 10 Driver 3 | | 12 Driver 4<br>13 Driver 5<br>14 Driver 6 | |
| Driver 3 10 → | 50 mA | 10 Driver 3<br>12 Driver 4 → | 100 mA | 12 Driver 4<br>13 Driver 5 → | 150 mA | | |
| Driver 4 12 → | 50 mA | | | 14 Driver 6 | | | |
| Driver 5 13 → | 50 mA | 13 Driver 5<br>14 Driver 6 → | 100 mA | | | | |
| Driver 6 14 → | 50 mA | | | | | | |

In the unlikely event that the string uses more than 300 mA or more common more strings are used at higher current ALD605012PJ131 can be configured in cascade. When used in cascade the remote on/off pins can be connected together.

In all cases the common pin (LED anode) is pin 11
The development PCB provides positions for jumpers (J1 to J5) for use when outputs are used in parallel

When the output current is reduced using resistor or potentiometer the parallel operating current is also reduced. E.G. if the output is dimmed to 30 ma the outputs in parallel will produce 90 ma.
Analogue voltage dimming

It is possible to set the current level using an analogue voltage applied to pin 5 of the driver.




| Vbr [V] | Io1 [mA] | Io2 [mA] | Io3 [mA] | Io4 [mA] | Io5 [mA] | Io6 [mA] |
|---|---|---|---|---|---|---|
| 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.5 | 5.26 | 5.70 | 5.28 | 5.62 | 5.54 | 5.48 |
| 1.0 | 12.65 | 13.15 | 12.89 | 13.06 | 13.09 | 12.99 |
| 1.5 | 18.86 | 19.36 | 19.08 | 19.31 | 19.22 | 18.98 |
| 2.0 | 24.64 | 25.19 | 24.93 | 25.13 | 25.03 | 24.75 |
| 2.5 | 31.21 | 31.84 | 31.56 | 31.77 | 31.64 | 31.33 |
| 3.0 | 37.81 | 38.50 | 38.30 | 38.45 | 38.30 | 37.92 |
| 3.5 | 44.40 | 45.14 | 45.00 | 45.13 | 44.94 | 44.52 |
| 3.8 | 48.60 | 49.20 | 49.01 | 49.20 | 49.00 | 48.55 |
| Open | 56.87 | 57.70 | 57.58 | 57.67 | 57.40 | 56.93 |

The actual current should be checked by measurement

Further details are provided in the enclosed note “Dimming Characteristics” CTR-4084-X

Additional assistance with design issues can be obtained by contacting your local TDK-EPC sales office

Tim Roe
October 2010