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Application Note [AN-007]

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LCD Backlighting Technologies and Configurations

Introduction

Liquid Crystal Displays (LCDs) are not emissive i.e. they do not generate their own light. Transmissive and transflective displays require some form of backlighting to see the image on the display clearly. The choice of backlighting is therefore an important consideration in LCD design and construction. This application note gives information on the most common LCD backlighting technologies and configurations.

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1 Backlighting Technologies

1.1 Cold Cathode Fluorescent Lamp (CCFL)

Cold **C**athode **F**luorescent **L**amps **(CCFL), (**other abbreviations include **CFL** (**C**old **F**lorescent **L**amp) and **CCFT (C**old **C**athode **F**luorescent **T**ube)) are the most commonly used form of LCD backlighting at present. This is due to exceptional brightness and full spectral output. A CCFL is a thin (outer diameters as small as 1.6mm) glass tube with an internal vacuum. A pressurized Neon/Argon mix sealed within the fluorescent tube is excited by a high AC voltage with a striking voltage > 1000 V and a sustained voltage of 100 ~ 300 VAC (please check individual data sheets as appropriate). A DC/AC inverter is required to generate these high alternating voltages. The electrons within the gas become highly energized and when they strike the fluorescent material coated on the inner surface of the tube cause the fluorescent material to fluoresce and emit white light. The CCFL is normally used with a light-guide to illuminate a surface area (*Figure 1*).

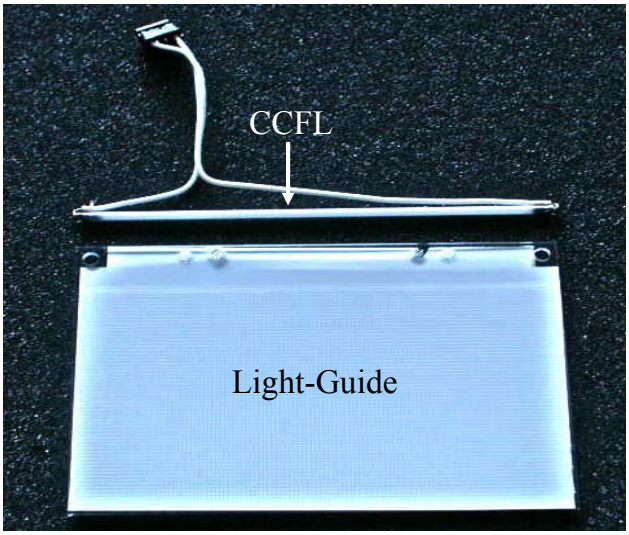

Figure 1: Cold Cathode Fluorescent Lamp (CCFL) with Light-Guide

One potential issue with Cold Cathode Fluorescent Lamps (CCFLs) is operation in cold temperatures. When a CCFL gets very cold (below 0°C), the strike voltages become excessive and it may not turn on at all. In addition, the lifetime of the CCFL at low temperatures will be reduced.

At normal operating temperatures, CCFLs have a very long life – 50,000 hours is common for new generation lamps.

The CCFL is used with two main configurations. The primary configuration used in LCD backlighting is line source with a light-guide (sometimes called side lighting) (*Figure 8*). The other configuration which increases the brightness at the expense of the power requirements uses several CCFLs directly behind the LCD without the use of a light-guide (*Figure 7*).

1.2 Light Emitting Diodes (LED)

Light **E**mitting **D**iode **(LED)** backlighting is a popular backlighting method for small and medium LCDs. The advantages of LED backlighting are low cost (at least for small area

displays), long life, immunity to vibration, low operational voltage, and precise control over its intensity. LED backlights come in a variety of colours, with white becoming a cost effective and very popular option. LED backlights offer a long operating life of 15,000 hours minimum for white and can be much longer for other colours. Being a solid state device, they are configured to operate typically with +5VDC power, so no inverter is required. The LED backlighting is also used in conjunction with a light-guide (*Figure 2*).

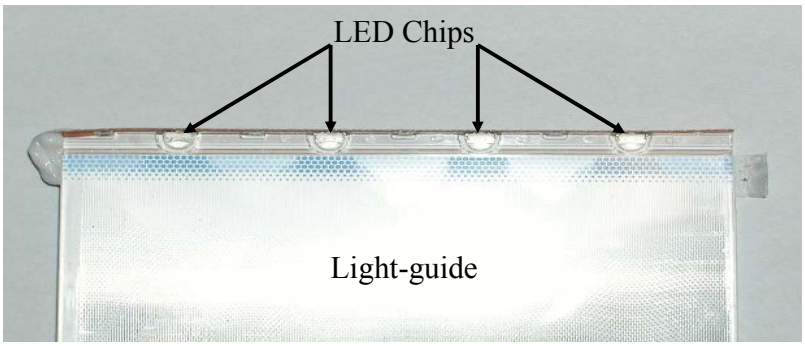

Figure 2: Light Emitting Diode (LED) with Light-Guide

LED backlights have two basic configurations. In the Array lit configuration there are many LEDs mounted uniformly behind the display offering a very bright illumination but with high power consumption (*Figure 5*). In the Edge lit configuration, the LEDs are mounted on the edge of a plastic light guide (*Figure 2*) and the light is focused into the light-guide (*Figure 6*). The edge lit configuration offers a thinner package with lower power consumption and is the most widely used system in the industry.

1.3 Electroluminescent Panel (ELP)

Electro **L**uminescent **(EL)** backlights use a solid state phenomenon based on coloured phosphors to generate light when an AC voltage is applied to the EL panel. EL backlights are very thin, lightweight and provide an even distribution of light, without the need of a light-guide (*Figure 3*).

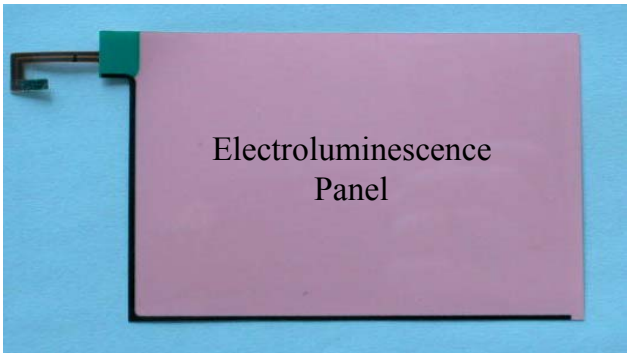

Figure 3: Electroluminescent Panel (ELP)

They are available in a variety of colours, with white being the most popular for use with LCDs. While their power consumption is fairly low, they require voltages of 100 VAC @ 400Hz. This is supplied by an inverter that converts a 5, 12 or 24 VDC input to the AC output. EL backlights also have a limited life of 3,000 to 5,000 hours to half brightness (half-life). The limited

brightness and lifetime of EL panels has made them unpopular and they are rarely used to backlight graphical LCDs. EL has only one configuration, broad area emitter (*Figure 4*).

1.4 Other Backlighting Technologies

CCFL, LED and EL are by far the most commonly used forms of backlighting, although there are other types of backlighting available but very seldom used.

They include

- Hot Cathode Fluorescent Lamp (HCFL) (similar to CCFL);
- Organic Light Emitting Diode (OLED) (broad area emitter)
- Halogen Light (can be used in conjunction with woven fibre optics)
- Filament Lamp (can be used in conjunction with woven fibre optics)

These technologies could be used for specialised applications or in the case of Organic Light Emitting Diode (OLED) is still in early development.

2 Backlight Configurations

In the previous section *Backlighting Technologies*, the main backlighting technologies were introduced. However, without an appropriate configuration of these technologies it is not possible to get a uniform distribution of the light in the LCD's active area. The section below describes configurations used to achieve an even distribution of the light.

2.1 Broad Area Emitters

A broad emitting backlight (*Figure 4*) emits its light evenly over the entire surface of the backlight. As it illuminates behind the whole of the LCD cell, no light-guide is required.

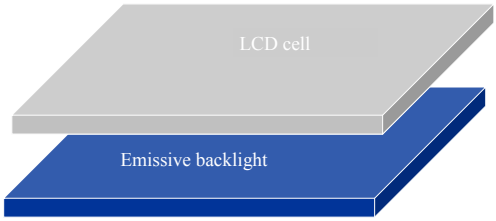

Figure 4: Broad Area Emitter

The technology most used with this type of backlight is Electroluminescent Tiles, (*Backlighting Technologies*). However, in the longer term, Organic LED (OLED) backlight may provide improvements over ELP, in terms of brightness and life time issues which currently prevent the wide use of EL backlighting in LCDs.

2.2 Point Source Array of Direct Emitters

A point source direct emitter uses a number of light sources to illuminate the LCD (*Figure 5*). Illumination of the LC display can either be high brightness or low brightness depending on the number of light sources used - i.e. a high number of point sources results in a high brightness and a low number of point sources results in a low brightness.

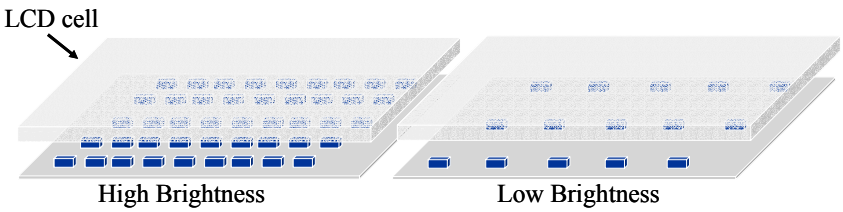

Figure 5: Point Source Array of Direct Emitters

The technology most commonly used in this configuration is LED (*Backlighting Technologies*). This configuration provides higher brightness than edge lit point source with light guide (*Figure 6*). However the increase in brightness results in higher power consumption especially as the display size increases and more point sources are needed.

As well as LED, incandescent lighting and halogen lighting could be used to illuminate the LCD. This method suffers from larger physical size of the LCD package and heating.

2.3 Edge Lit Point Source with Light-Guide

In this configuration (*Figure 6*) the point sources are placed along one or two edges of the display (one edge means low power consumption with lower brightness, two edges means higher power consumption with higher brightness). The light is then evenly distributed behind the display using a light-guide.

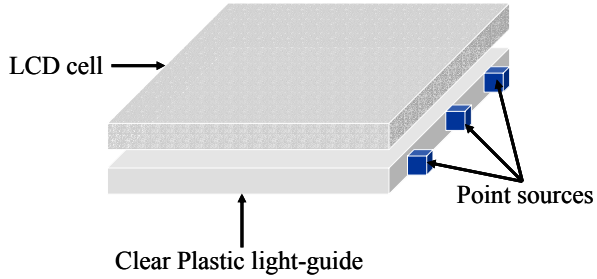

Figure 6: Edge Lit Point Source with Light-Guide

The light source is usually based on LED (*Backlighting Technologies*). This is the most common system for LED backlighting.

2.4 Line Source Array of Direct Emitters

In the line source array configuration (*Figure 7*) many direct line emitters usually CCFL are placed behind the LCD cell on top of a reflective material, to focus the light towards the LCD cell.

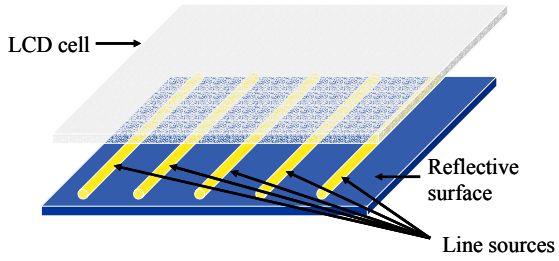

Figure 7: Line Source Array of Direct Emitters

This configuration provides a high brightness due to the large number of light source, which is dependent on screen size. However, since several lamps are placed behind the display this configuration tends to be thicker, heavier and more power hungry than an edge lit configuration.

2.5 Edge-Lit Line Source with Light-guide

In the edge lit line source configuration the lamp (usually CCFL) is used in conjunction with a light-guide to evenly distribute the light behind the LCD cell (*Figure 8*).

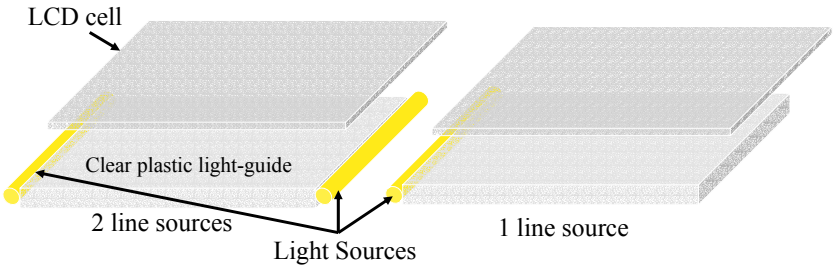

Figure 8: Edge-Lit Line Source with Light-Guide

The illumination of the light source can either be from one or two light sources and the light guide is designed to provide a uniform output of light from the front. This is the most common lighting configuration for medium and large size LCDs.

3 Summary

The following is a brief summary (*Table 1*) of which LCD backlighting technologies can be used with the main backlighting configurations.

		ARRAY		EDGE LIT	
Technology	Broad area emitters	Point source direct emission	Line source direct emission	Point source with light-guide	Line source with light-guide
	El lamp	**LED**	**CCFL**	**LED**	**CCFL**
	OLED	Halogen bulb	HCFL	Halogen bulb	HCFL
		Filament bulb		Filament bulb	

Table 1: Backlighting Summary

Although all of the above options are possible, most commercial LCD products in the market are based on the Edge Lit light guide configuration using LED's for small and medium sized products (2" to 5") and CCFL for medium and large LCD's (3" and larger). These two configurations provide the best price / performance possible for backlighting LCD panels at present.

4 Cautions

Keep safety first in your circuit designs!

- Hitachi Europe Ltd. puts the maximum effort into making display products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with display products may lead to personal injury, fire or property damage.
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