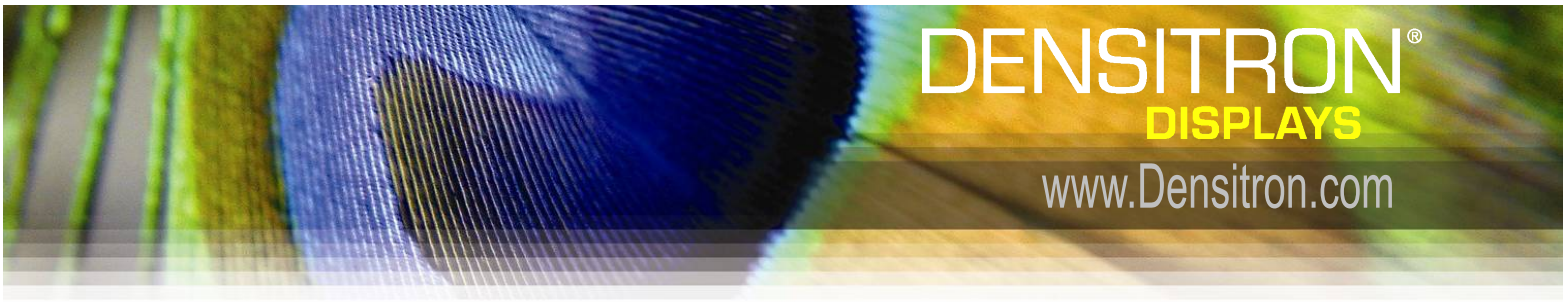
DENSITRON®
DISPLAYS

Guide to Customised LCD Solutions

The World On Display



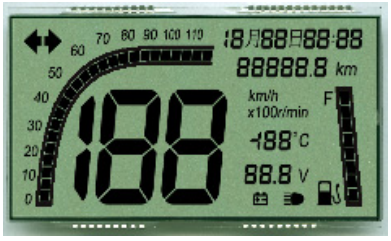
General LCD Usage

Currently LCD's are used in a wide range of applications from watches, calculators and games to industrial and medical instrumentation to laptop computers.

One of the main advantages of LCD's over other display technologies is the relative ease in which the display content can be customised to satisfy the specific requirements of an application. In this way, the custom LCD panel can present specific user-interface information which will enhance the performance and value of a product.

Custom LCD panels can display a combination of numeric and alphanumeric digits, on/off indicators, messages, annunciators, graphic icons and symbols, bar graphs, pie charts, etc. The content of a custom LCD panel is limited only by the imagination of the product designer and by the design guidelines explained in this brochure.

LCD Glass Design Criteria



Several factors must be considered in the design of a custom LCD panel. As with most product designs, there will be cost/performance trade-offs which the customer must judge. The information presented below is intended to assist the customer in making these decisions. Because many of these design trade-offs are somewhat subtle and may affect cost, the customer should identify those factors which are critical as well as those which are flexible.

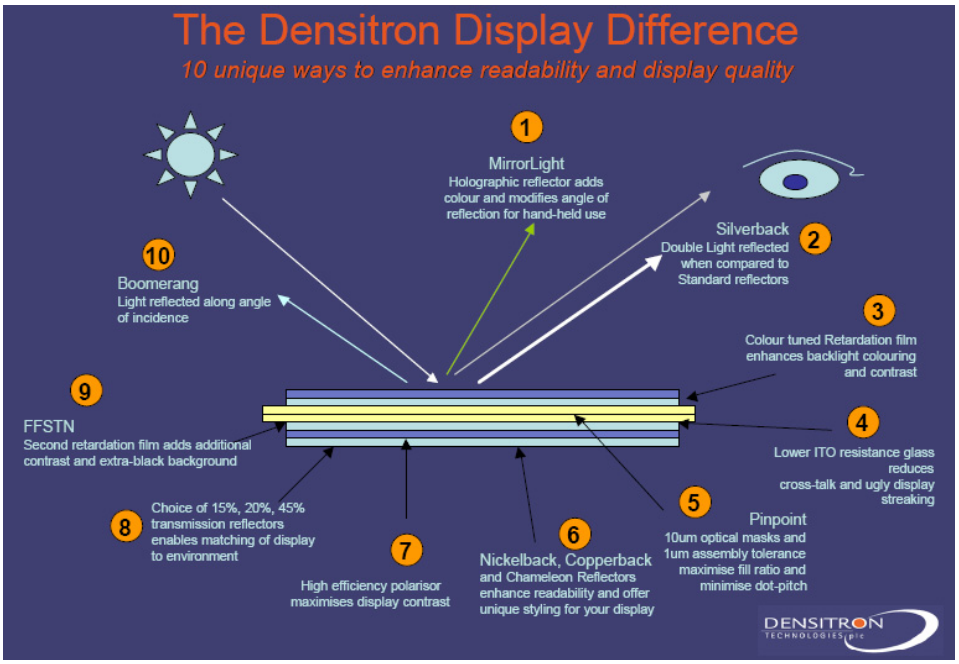
The following design information is needed by Densitron in order to prepare a quotation for a custom LCD panel:

1.LCD Technology
2.Polarisers & Display modes
3.Viewing Mode
4.Operating Environment
5.Backlight Requirement
6.Connection Method
7.Drive Method
8.Keypad Requirement (if applicable)

LCD Technologies

Technology	Features
 **TN** (Twisted Nematic)	A type of liquid crystal whereas the alignment surface and therefore the LC molecules are oriented 90° from each surface of glass. TN is the simplest LCD technology. Common applications include calculators, heating controllers and utility meters. Ideal solution for "digit" or "icon" images, with little or no need for multiplexing. The TN technology comes in a single colouration, it is Black characters on a grey background. It is the least expensive, but has the lowest visual quality, primarily in viewing angle - Low cost solution recommended for general uses
 **HTN** (High Twisted Nematic)	HTN displays are based on a higher molecular twist (usually 110°) than TN (90°) and therefore offer wider viewing angles and improved contrast. In fact, these HTN products offer viewing characteristics close to those of STN technology. As low operating voltage as 2.5V and marginal extra cost over TN means that the products are well suited to hand-held applications.
 **STN** (Super Twisted Nematic)	Viewing range 180°. Most common LCD type. An STN display has improved viewing angles and contrast at high multiplex rates. Commonly available as very dark blue on yellow/green or grey background. - Good choice for many applications.
 **FSTN** (Fim Super Twisted Nematic)	STN Technology with the addition of a retardation film to the display that compensates for the color added by the birefringence effect. The FSTN technology comes in a single coloration, Black characters on a White / Grey background. Out of the LCD technology listed above, it is the most expensive, but it has better viewing angles and provides higher contrast.
 **DSTN** (Double Super Twisted Nematic	DSTN displays consist of two LC cells; one active and one passive bonded together. The direction of LC twist of one cell has an equivalent opposite LC twist of the other. This results in a very black background with virtually no bleed through of backlight when used in negative mode. It also offers a very wide viewing angle from all directions when compared to FSTN. Its response time is also significantly enhanced. Since its polariser mode is negative, DSTN LCD's need backlighting, which are provided by either LED or CCFL only. The operating temperature range can be -40 to +85 deg C, which make this type of display fully compatible with the requirements of the automotive industry. DSTN provides better contrast than STN and FSTN, and offers automatic contrast compensation with temperature. The main drawbacks are cost, thickness and weight.

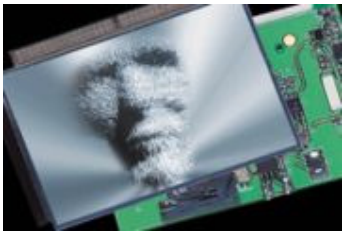
Densitron Core Technologies



Silverback

Customers who have appreciated our DV5520 will be delighted to know that Densitron has added the renowned **Siverback** enhancement feature. With a contrast ratio of 15:1, this device is probably the highest contrast monochrome display available on the market. This polariser increase the reflectance mostly and get the best contrast that you never seen...
Just see it !

Nickelback



The product is being developed to offer different coloured backgrounds and trials are underway to produce a similar display incorporating background colours for hi-duty FSTN like palm computer displays,".

Called Nickelback, the new display complements Densitron's highly successful Silverback display and gives manufacturers the opportunity to keep up with the latest design trends by incorporating stylish nickel as a background colour to their handheld device screens.

The product is incredibly versatile and can be tailored to fit any screen size. The display offers more than 50% increase in reflection through a high contrast, super-reflective film that improves readability in both natural and artificial ambient light conditions. A cleaner, smoother appearance is created in the display view area through the use of high-grade adhesives that do not increase the thickness of the screen.

Printback

Not really an innovation but this high qualityprocess will bring you a very high contrast, nice background, at very low cost... it's look like a colour display....

Just ***put colour in your displays***

Mirrorback

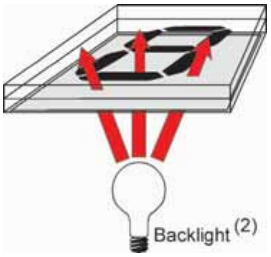
The Densitron Mirrorback technology will bring you an incredible viewing aspect and look to your final product.

This product will also give you a fantastic marketing edge over for our customers who want to be marketing leader in their approach.

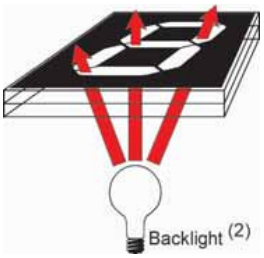
Display Modes

Display modes are available in two options:

mode (dark characters on light Positive background)

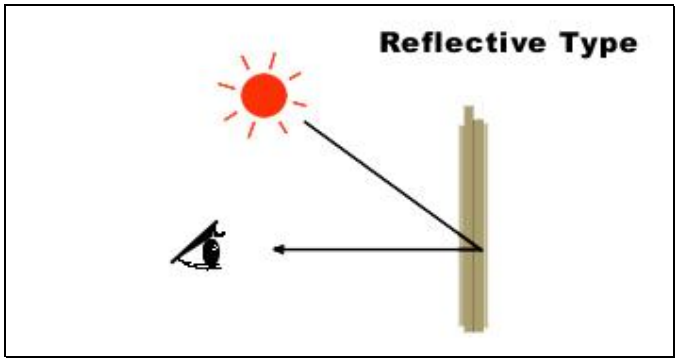


Negative mode (light characters on dark background)

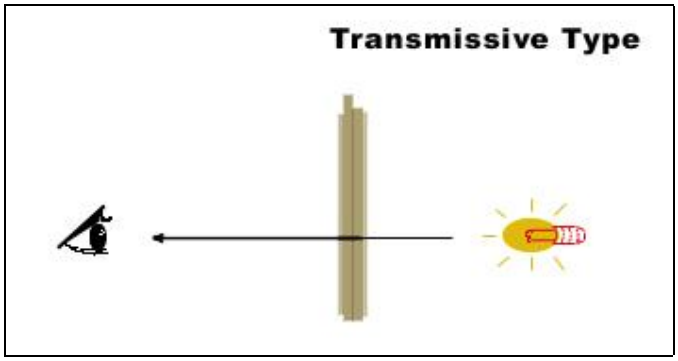


Polarisers

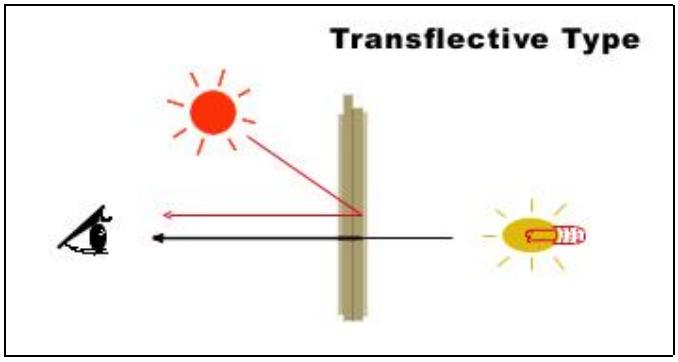
Densitron custom LCD panels can be designed to operate in a variety of viewing modes to allow operation in any lighting condition, from direct sunlight to total darkness.



Reflective displays have an opaque rear polarizer that includes a diffuse reflector, such as brushed aluminum. This layer reflects polarized ambient light that has entered the front of the display back through the LCD cell. Reflective displays require ambient light to be seen. They exhibit high brightness, excellent contrast, and wide viewing angles. They are particularly suitable for use in battery operated equipment where an adequate level of light is always available. Reflective LCD's cannot be backlit, however they can be front lighted in some applications.



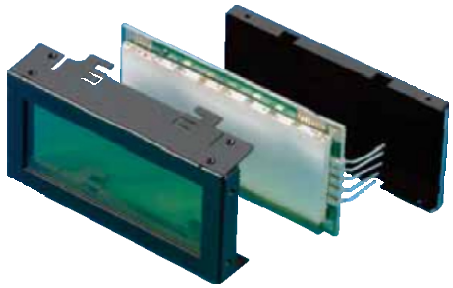
Transmissive displays have a clear polarizer on the front and the back. The display therefore depends on light coming through from the back of the display toward the observer in order to be seen. Most, but not all transmissive displays are negative image, and we sometimes add colored filters to different areas of the display to highlight different annunciators. Another example of a transmissive polarizer display would be a transparent window where you could see the segments superimposed over your line of vision through the display window (this assumes a sufficient ambient light source exists on either side of the window).



Transflective displays have a rear polarizer which includes a translucent material which reflects part of the ambient light, and also transmits backlighting. As the name implies, it is a compromise between the transmissive and reflective viewing mode. Used in reflection, it is not as bright and has lower contrast than the reflective type LCD, but it can be backlit for use in low light conditions. This polarizer is the best selection for a display that can be used in all lighting conditions with a backlight.

Module Technologies

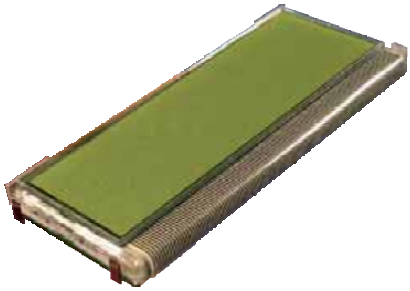
Bezel with Zebra and PCB



Advantages

- Large viewing area
- Easy to integrate via PCB holes
- Additional circuitry such as LED's, buttons…etc can be added on to the PCB.

FPC (Flexible Printed Circuit)

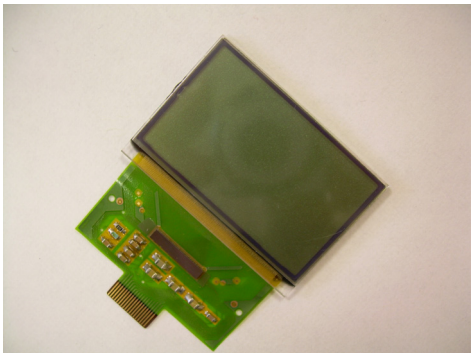


FPC is a circuit substrate of patterning Cu electrode with Polyimide film as a base. Usually offers more flexibility than Flexible Flat Cables.

Advantages

- Compact layout possible
- Variable distance from LCD to customer's hardware

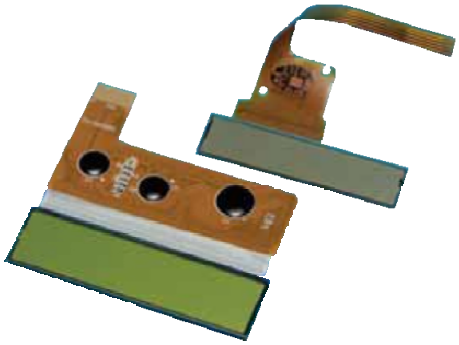
COF (chip On Film)



The IC's in their bare die form as well as other discrete components are bonded to a flex. One end of which is bonded to the LCD glass, and the other is either inserted in to a suitable ZIF connector or bonded to a PCB.

Advantages

- Very compact solution
- Variable distance from LCD to customer's hardware



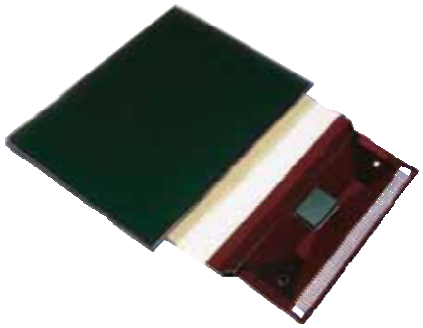
COB (Chip On Board)

COB is a popular IC mounting method that provides wire bonding as the direct attachment of bare die to laminated printed circuit boards. The LCD driver is formatted into an area on the PCB. Electrical connections are made by micro diameter gold wires. The entire area is then covered with epoxy. Most of our LCD modules use COB mounting method.

Advantages

- Very compact
- Space savings over SMT assembly.
- Cost savvy compared with SMT, since there is no plastic package

TAB (Tape Automated Bonding) / TCP (Tape Carrier Package)



TAB - The LCD driver / controller is encapsulated in a bubble on a flex circuit. The flex is attached directly to the glass or a PCB.

Advantages

- Offers compactness (IC and its interfacing circuitry can be bent behind the LCD glass panel).
- Some times more cost-effective than COG, if a designer has to integrate a keypad or indicator around the display.
- The active area is centered (differently from COG).
- Can provide interfacing at very fine pitches.
- Long term availability in low volume

Disadvantages

- The bonding area is weak. Less reliable than COG.
- More expensive than COG. Even though TAB LCD modules use the same type of IC as COG, tape automated bonding requires a package.

COG (Chip On Glass)

COG is one of the high-tech mounting methods that uses gold bump or flip chip ICs, and implemented in most compact applications. COG integrated circuits were first introduced by Epson. In flip-chip mounting, the IC chip is not packaged but is mounted directly onto the PCB as a bare chip. As there is no package, the mounted footprint of the IC can be minimized, along with the required size of the PCB. This technology reduces the mounting area and is better suited to handling high-speed or high-frequency signals

Advantages

- Very space economical. COG LCD modules can be as thin as 2 mm.
- Cost effective over COB, especially in graphic LCD modules, because much less IC's are required.
- More reliable than TAB, because of the weakness in the bond area of TAB.

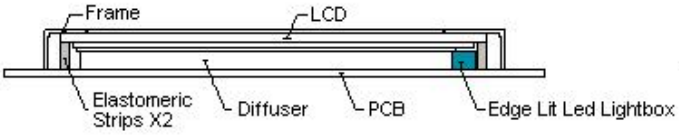
Disadvantages

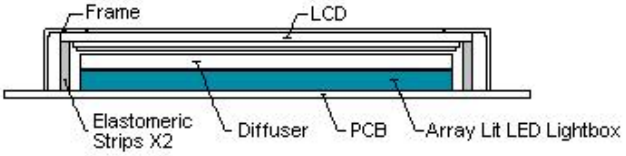
- COG can only be used at a certain resolution level where the lines are not too fine. At very fine pitches COG becomes difficult to test, and TAB is the preferred approach.
- It may be more cost-effective to use TAB or COB, if a designer has to integrate a keypad or indicator around the display.
  The active area is not centered within the outline but offset, because of the area where the circuits are
- Hi volume is required to keep long term availability

LCD Backlight

LED Backlighting

Light Emitting Diode, or LED, backlight is the most popular backlighting for small and medium LCDs. The advantages of LED backlighting are its low cost, long life, immunity to vibration, low operational voltage, and precise control over its intensity. The main drawback is it does require more power than most of the other methods, and this is a major drawback if the LCD size is large enough. LED backlights come in a variety of colors, with yellow-green being the most common, and now white is becoming cost effective and very popular. LED backlights offer a longer operating life - 50,000 hours minimum. They are configured to operate with typically a +5VDC power (and optionally 12VDC power), so they do not require an inverter.

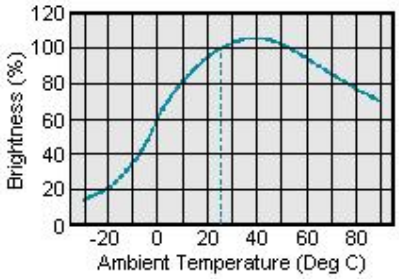


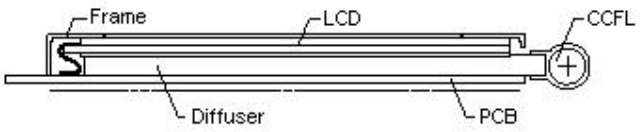


The LED backlight has two basic configurations; Array and edge lit. In both types the LEDs are the light source that are focused into a diffuser that distributes the light evenly behind the viewing area. In Array lit configuration there are many LEDs mounted uniformly behind the display, it offers more uniform and brighter lighting and consumes more power. In Edge lit configuration, the LEDs are mounted to one side (typically the top), it offers a thinner package and consumes less power.

Cold Cathode Fluorescent Lamp (CCFL) Backlighting

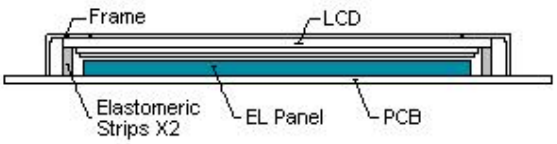
Cold Cathode Fluorescent Lamp, or CCFL, backlights offer low power consumption and a very bright white light. The primary CCFL configuration used in LCD backlighting is edge lighting. A cold cathode fluorescent lamp is the light source with a diffuser distributing the light evenly across the viewing area. CCFLs require an inverter to supply the 270 to 300 VAC @ 35KHz used by the CCFL tube. Information about these inverters can be found in the Power Supply section of our website. They are used primarily in graphic LCDs and have a longer life - 10,000 to 20,000 hours - than ELPs do. Their biggest drawbacks are: cold weather will reduce the light output by as much as 60% (see graph below), they require an inverter to generate the 350VAC (please note that the inverters do not function well at low temperatures), the light intensity cannot be varied (it is either on or off), and vibration can reduce the life expectancy of up to 50%.





Electroluminescence Panel (ELP) Backlighting

Electroluminescence Panel, or ELP, is a solid state phenomenon which uses colored phosphors, not heat, to generate light. EL backlights are very thin, lightweight and provide an even light. They are available in a variety of colors, 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. Information about these inverters can be found in the Power Supply section of our website. ELPs also have a limited life of 3,000 to 5,000 hours to half brightness. The biggest drawbacks to an EL panel is that it requires an inverter to generate the 100VAC, consistent brightness, and limited life.



Overview of different LCD Styles

Yellow/Green mode reflective

FSTN positive mode with blue backlight

Yellow/Green mode with Yellow/Green backlight

FSTN positive mode with White backlight

Silver mode reflective

Silver mode with Yellow/Green backlight

Silver mode with White backlight

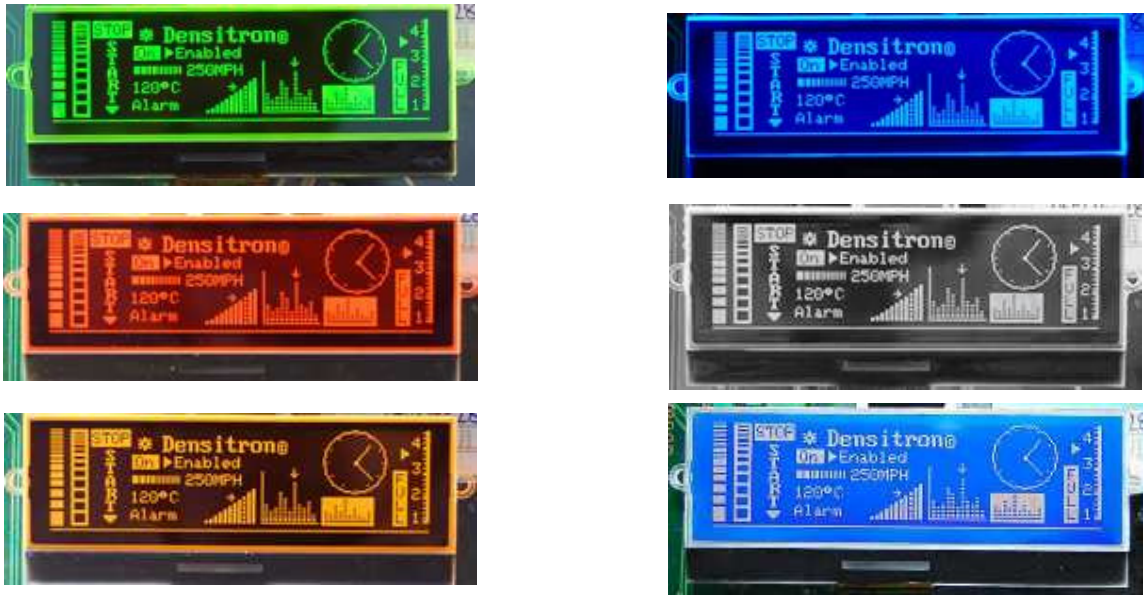
FSTN positive mode reflective

FSTN positive mode with Yellow/Green Backlight

FSTN positive mode with Amber backlight

Exemples of Negative Mode LCD's

These LCDs utilize premium materials and excellent cell gap control to accommodate the high graphic content of a 240 x 64 display packed into a module that is only 34mm tall. The stunning photos demonstrate virtually no cross talk common to some standard displays. Most standard FSTN displays appear washed out due to their dark gray background and dim backlight. The Densitron LM5428 series offer stunning contrast due to their combination of dark black (or dark blue) background and ultra bright LED design.

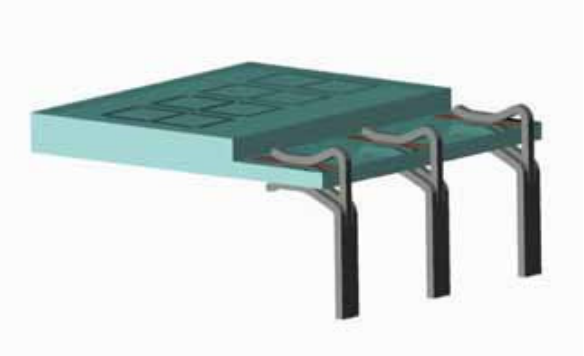


Available in • Jade Green • Arctic White • Warm Amber • Midnight Blue • Tangerine Orange • Ocean Blue

LCD Connection Type

Elastomers (Zebra Strips)

Elastomers are silicon strips of alternating conductors and insulators. These materials are generally soft and compliant and can be easily compressed between the Liquid Crystal Display and circuit board. Elastomers require a bezel to squeeze the display and circuit board together. This method will yield a higher conductor interconnection than pins, potentially less costly than pins, but requires a specialized compression bezel.

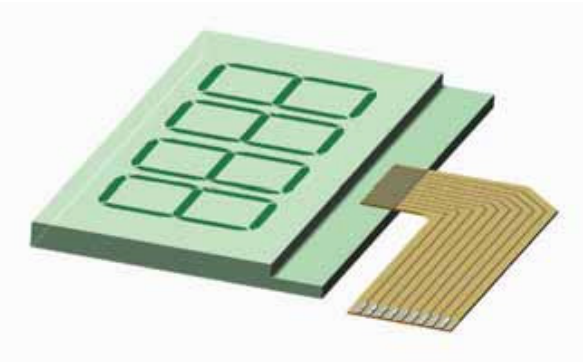


Pins

Pins are attached to the display to allow the user to either mount the display in a socket or solder it directly into a circuit board. From an end user standpoint, pins are the easiest to use since there is no requirement for a compression bezel or expensive heat seal bonding equipment.

The pins are attached to the glass with a structural epoxy on the back. On the top, we apply an electrically conductive epoxy with an RTV overcoating. Pins are the most reliable connection method, they are also the easiest to deal with for prototyping and smaller production runs. However, of all three methods, they have the lowest number of interconnects per inch.

FPC / FFC / Heat Seals



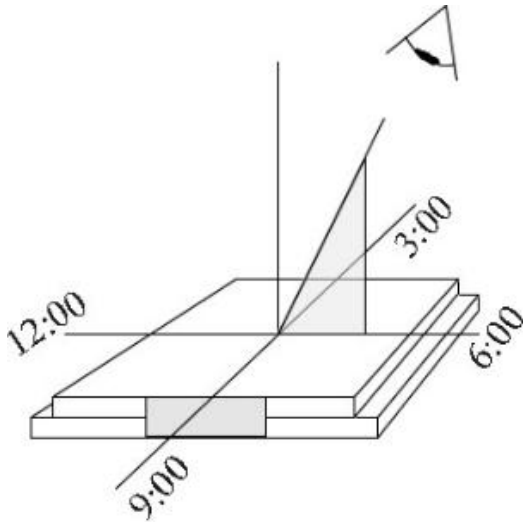
Heat seals are similar to flexible circuit boards with the difference being that the interface tabs are made of a conductive hot melt adhesive. Generally, particles such as carbon, gold, or silver are added to the adhesive to make it conductive. The pads of the heat seal are aligned with the pads of the display and a hot bar is brought down under pressure and the conductive adhesive is melted and bonded to the display. The adhesive is allowed to cool and an electrical bond is made with the display. This method is the most cost effective for the higher volume applications, but due to the expensive setup and equipment required in this process, Heat Seals are typically not used for lower volume / low interconnection density requirements.

FPC (Flexible Print Circuit) is a circuit substrate of patterning Cu electrode with Polyimide film as a base. Usually offers more flexibility than Flexible Flat Cables.

FFC (Flexible Flat Cable) is a cable with two smooth or corrugated, but essentially flat, surfaces. Attached to the PCB by soldering or plugging into a zero insertion force connector. Very reliable.

Viewing Direction & Viewing Angle

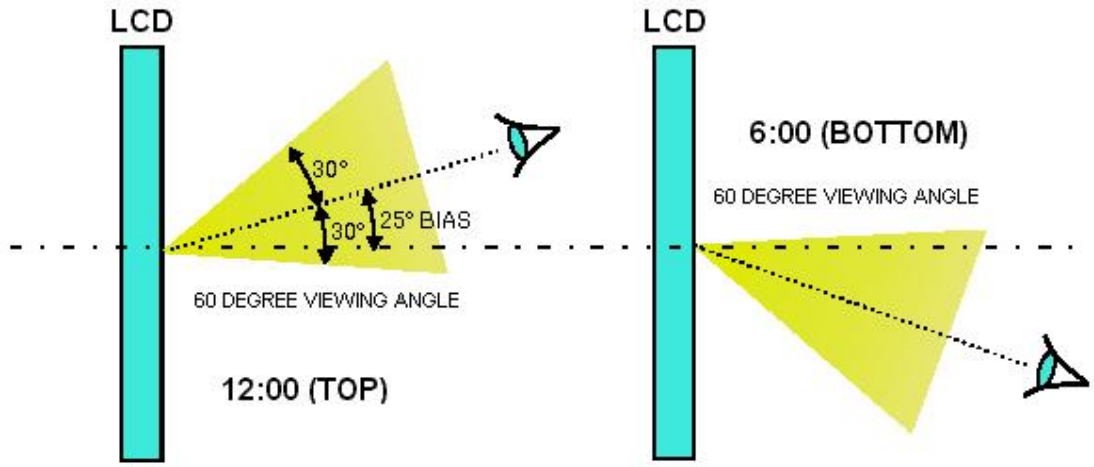
Viewing direction (or bias angle) is the direction from which the display will look the best. It is set during the manufacturing process, and cannot be changed later by rotating the polarisers. Viewing direction is specified as positions of a clock face. A twelve o'clock viewing direction means that the optimum direction is above the normal to the display, while a part with a six o'clock viewing direction is best viewed from below the normal.



When specifying the viewing direction, one needs to think about how the device is going to be used. For example, a calculator is usually sitting on a desktop or held in the palm of your hand and viewed from the six o'clock direction . Some instrumentation, like a wall thermostat, may be mounted below the viewer and needs to be viewed from the twelve o'clock direction. Other viewing directions are possible but not common. A car clock display, which is usually to the drivers right, may have a nine o'clock viewing direction, or possibly a ten-thirty one if the clock is low on the dashboard.

In a direct drive display, viewing direction is not critical because the display will look good from almost any direction. It becomes critical when the display is multiplexed. The higher the multiplex rate, the greater the problem becomes. In displays with extremely high multiplex rates, great care must be taken when designing the drive circuitry. Special films can also be applied to the front of the display glass to enhance the overall viewability. However they tend to be expensive.

The viewing angle is the angle formed on either side of the viewing direction (or bias angle), where the contrast of the display is still considered acceptable. The term "viewing angle" is often used erroneously with the term "viewing direction" or "bias angle".



Liquid Crystal Displays have a limited viewing angle. They lose contrast and become hard to read at some viewing angles and they have more contrast and are easier to read at others. The size of the viewing angle is determined by several factors, primarily the type of Liquid Crystal Display fluid and the duty cycle. Because the viewing angle tends to be smaller than most people would like, certain viewing direction (or bias angle) is designed into the module at the time it is manufactured. This means the nominal viewing angle is offset from the perpendicular by some amount. Several versions of the LCD module are then offered with this bias set to different angles or positions to accommodate as many applications as possible.

An STN character display running at a duty cycle of 1/16 has a viewing angle of ±20 degrees, and a bias angle of 25 degrees. For this example, assume the display is a 12:00 (top viewing) type. When the display is viewed from 25 degrees above the vertical, it will have its maximum contrast and best “look”. If the viewer moves his eye further above the display by an additional 30 degrees, he will see the display reduces in contrast (but still be easily readable). Moving the viewing position any further above the display will reduce its contrast to an unacceptable degree.

Contrast Adjustment and Viewing Angle

Adjusting the contrast voltage, VO, will affect the viewing direction (bias angle) to some extent, but not the viewing angle. 12:00 display can be optimized for a 6:00 viewing position by adjusting the contrast voltage. A 12:00 display set for 6:00 viewing position will not have as great a contrast as a 6:00 display set for 6:00 viewing position, and vice versa. Designers often want a display to be optimized for straight-on viewing. Either a 12:00 or a 6:00 module can be used; and the contrast voltage can be adjusted slightly to optimize the display for that viewing position. In the example used above, the viewing angles of both the 6:00 and 12:00 modules actually overlap the perpendicular (or straight on) viewing position.

Temperature ranges

TN Temperature Ranges

The operational and storage temperature range of a Twisted Nematic (TN) Liquid Crystal Display is dependent on the driving voltage of a part. The following parameters are for general reference.

TN Standard Temperature Range
Operating Temperature: -10°C to +60°C
Storage Temperature: -20°C to +60°C

TN Wide Temperature Range
Operating Temperature: -20°C to +70°C
Storage Temperature: -30°C to +80°C

TN Extended Temperature Range (Automotive)
Operating Temperature: -30°C to +80°C
Storage Temperature: -40°C to +90°C

There are also specially designed TN LCD that operates at an especially higher temperature (-20 to 105) or lower temperature (-55 to 85).

STN/FSTN Temperature Ranges

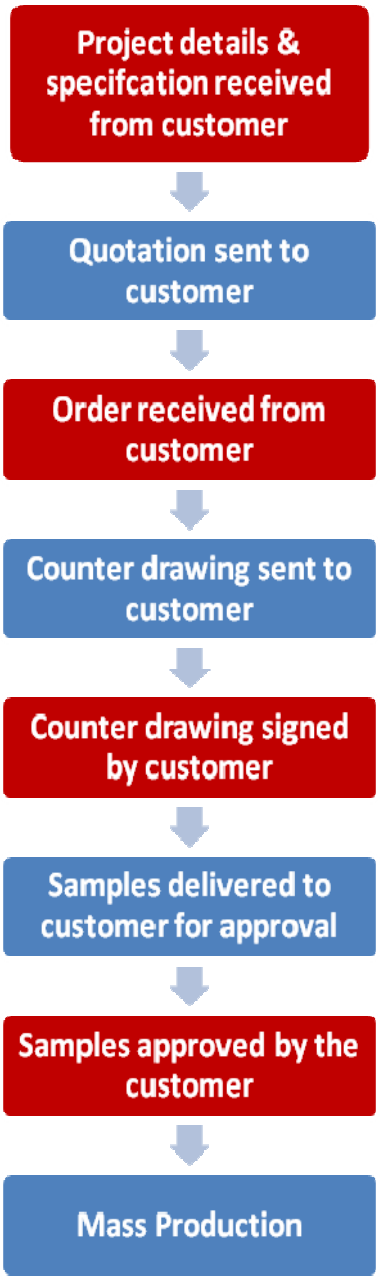
The operational and storage temperature range of a super Twisted Nematic (STN) and Film compensated STN (FSTN) LCDs are set pretty much into two ranges for standard products.

STN/FSTN Standard Temperature Range
Operating Temperature: 0°C to +50°C
Storage Temperature: -10°C to +60°C

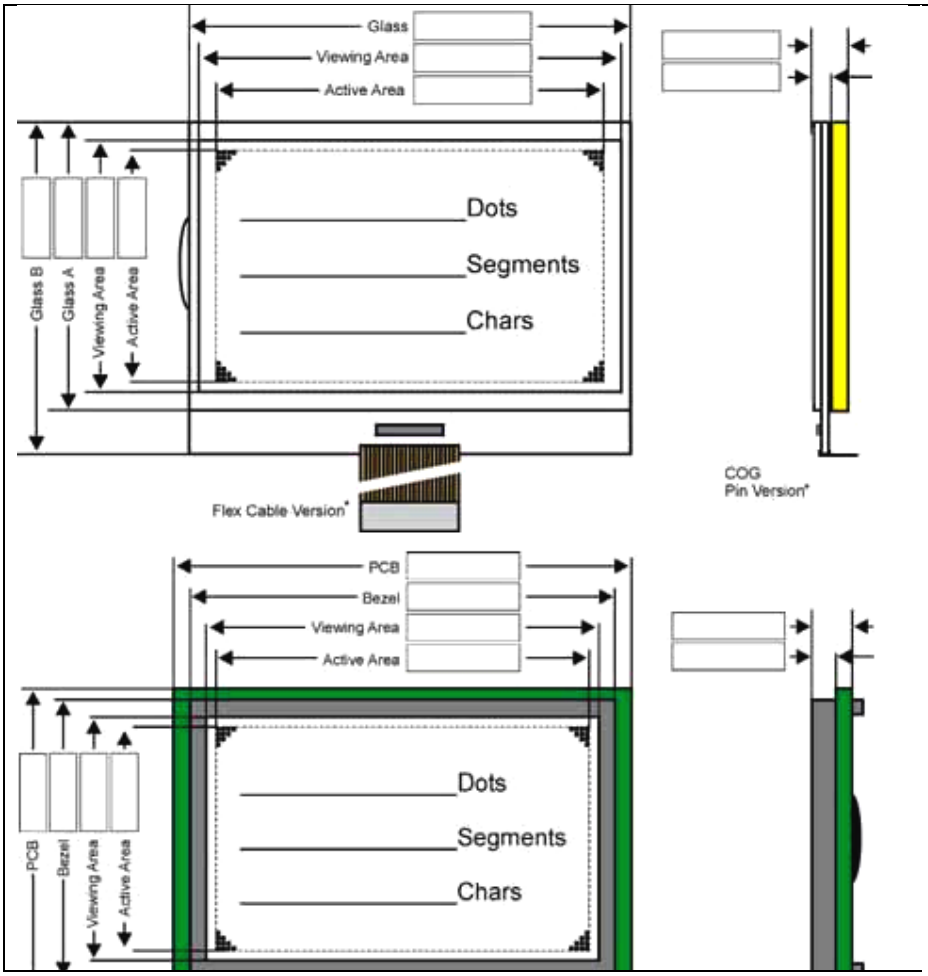
STN/FSTN Wide Temperature Range
Operating Temperature: -20°C to +70°C
Storage Temperature: -30°C to +80°C

STN/FSTN Extended Temperature Range (Automotive)
Operating Temperature: -30°C to +80°C
Storage Temperature: -40°C to +90°C

Flow Chart for Custom LCD Products



Customers Checklist



LCD Technology **Duty Ratio**
☐ TN 1/____
☐ HTN
☐ STN
☐ FSTN
☐ DSTN

Display modes & Polarisers
☐ Positive ☐ Negative
☐ Reflective
☐ Transmissive
☐ Transflective

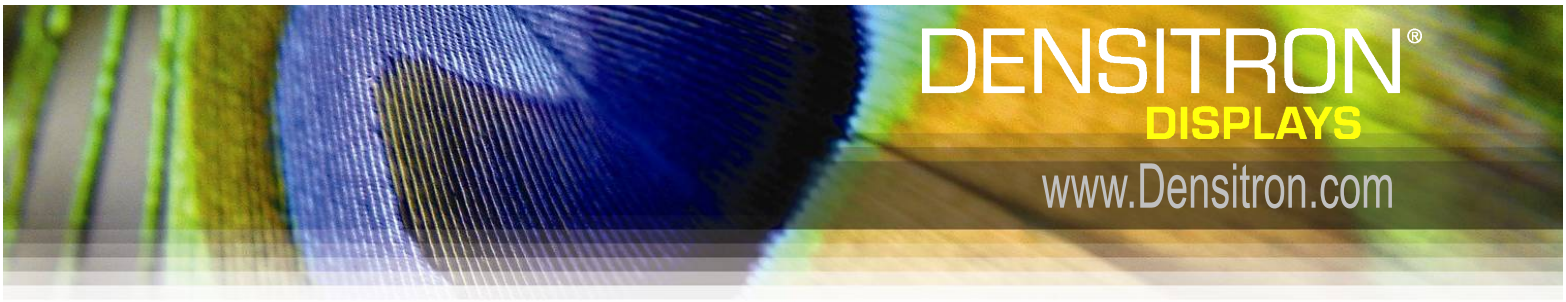
Backlight types & Colour
☐ LED
☐ CCFL
☐ EL
Colour_____

Connector types
☐ Pins
☐ ZIF
☐ FFC /FPC
☐ Elastomer

Interface
☐ Serial
☐ Parallel

Supply Voltage (controller/LCD)____V
Operating Temp_____°C to _____°C
Storage Temp _____°C to _____°C

Viewing Angle
☐ 6 o'clock ☐ 12 o'clock
☐ 3 o'clock ☐ 9 o'clock



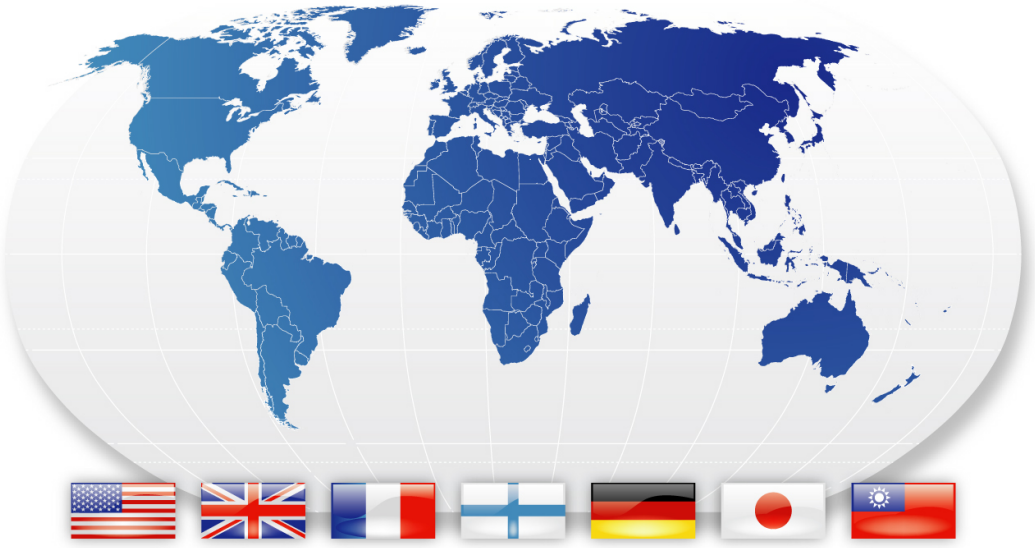
Customer details
Company_____
Contact Name_____
Tel_____
Email_____
Address_____
_____
_____
Application_____
_____
Timescales and Volume
Samples - _____pcs Q__ /_____
Mass Production
_____pcs Q__ /_____

Densitron Displays is the largest division of Densitron Technologies plc. Densitron is a public company listed on AIM. For over 30 years, Densitron plc has been a leading global company in the information technology sector.

Densitron Display Solutions is an experienced manufacturer and supplier of standard and customised display modules utilising OLED, TFT, CSTN, Monochrome and Touch Screen technology. It has over thirty years of experience in providing comprehensive solutions to global organizations.

Densitron continues to adapt its product and service offerings to accommodate the rapidly changing requirements of industry worldwide and its dedicated project management team is on hand to assist customers with the design and production of value added display solutions. To enhance the product development process, Densitron has a local office in Taiwan to manage its relationships with factories in the Far East.

Whether it is a display module, pre-configured display kit, single board computer or an interface cable, every product in the Densitron range is covered by the Company's first-class technical support services.



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