

White Paper

Why COTS LCDs become unusable at high ambient temperatures ($>55^{\circ}\text{C}$)

What's inside?

- LCD operating principles
- Barco displays

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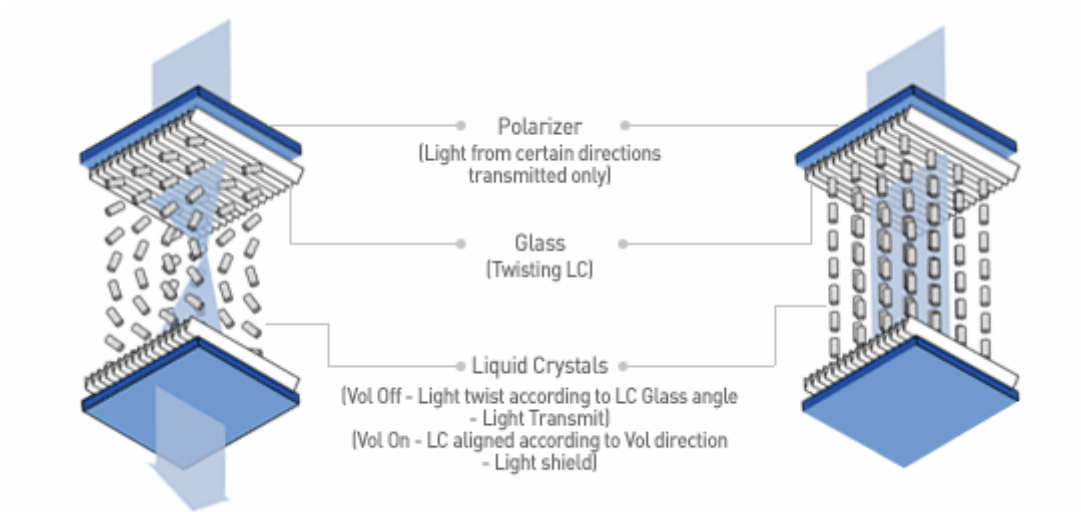
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1 INTRODUCTION

LCD displays are optically passive; they do not generate light to produce an intended image as a CRT does. Device operation depends on the ability of the Liquid Crystals (LC) to rotate polarized light relative to a pair of crossed polarizers attached to the outside of the display. Rotation of the plane of polarization is a function of the applied field (\sim driving voltage).



2 SOME PHYSICS

Nematic (“thread-like”) liquid crystals are ordered fluids whose molecules lie parallel to each other with their centers of mass randomly distributed. They are organic compounds and their molecules are rod-like in overall shape. A thread-like pattern is observed when nematics are viewed through a microscope under polarized light. The difference between nematic and ordinary fluids is illustrated in Fig. 1.

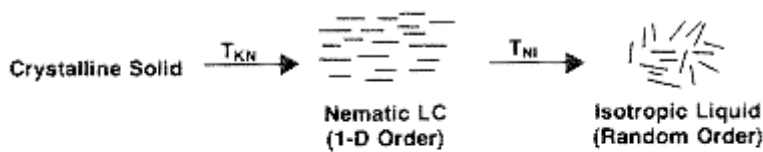


Fig. 1. Nematic liquid crystals are ordered fluids whose molecules lie parallel to each other. “Nematic” means “thread-like.”

Nematic liquid crystals are formed by melting otherwise ordinary crystalline solids. Unlike most solids, which transform into isotropic liquids upon melting (e.g. ice into water), a nematic liquid crystal passes into an ordered phase at temperature T_{KN} , which is the normal operating range. In this state, due to the inherent birefringency of the LC material, the polarization direction of the light passing through is gradually rotated with the orientation of the crystals.

Additional heating to T_{NI} the clearing temperature will cause the liquid crystal material to become unstable and fail to change orientation with a voltage applied across the cell – the orientation will become random. The temperature at which this occurs is referred to as the “clearing temperature,” and - when reached - causes the LCD to turn black, it cannot render the intended image anymore.

Cooling reverses the sequence of transformations. It will return to a natural organized state once the LC material is lowered below its isotropic or clearing point.

3 BARCO LCD DISPLAYS FOR COMMAND & CONTROL

For its LCD display range for Command & Control, Barco uses Commercial-Off-The-Shelf (COTS) LCD glass that is being ruggedized for use in extreme environmental conditions such as humidity, low temperatures, shock & vibration.

COTS components provide cost savings that originate from production quantities that are several orders of magnitude greater than the military market can absorb. The relationship between volume and cost is well known.

Since these COTS LCDs are initially made for use in benign environments (e.g. office), the LCD suppliers (Samsung, NEC, Sharp ...) use standard available LC material, with a clearing temperature of anywhere between 75°C and 100°C (depending on the supplier & the type of display). Taking an average Δt° of 20 degrees between ambient and LCD temperature, the ambient temperature must be limited to +55°C.

Bonding the LCD to the front glass filter helps conduct excessive heat away from the LCD, ensuring the highest possible operating temperature without clearing. For more information on bonding, please refer to the separate white paper on this subject.