MECHANICAL DESIGN CONSIDERATIONS FOR INTEGRATING LIQUID CRYSTAL DISPLAYS INTO NOTEBOOK & PEN BASED COMPUTERS

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ABSTRACT

In portable computers, there is a need to reduce overall size and weight of the units. The following guidelines focus on several problems facing the designer. Discussions include the maintenance of flatness and rigidity, thermal management, placement of the inverter, heat sinking the CCFT, and protecting the face of the display.

INTRODUCTION

As more companies begin the manufacturing of their next generation of computers, there is a need to reduce the overall size and weight of the units to improve their portability. This has sparked the need for more compact designs where the various components are placed in closer proximity, thus making them more susceptible to interaction from signal noise and heat dissipation. The following is a series of guidelines for the placement of the display components, and a summary of suggestions for overcoming difficult design constraints associated with component placement.

In notebook computers, the thickness of the display housing is important. The design usually requires the display to be in a pivotal structure so that the package may be folded down over the keyboard for transportation. Also the outline dimensions must be minimal so that the overall package will remain as compact as possible. These two constraints drive the display housing design and placement of the various components. The following is the result of actual experiences with design problems, and promotes practical solutions for the designer.

The problems facing the pen based computer designer will be similar to those realized in designing notebooks. In addition, however, pen based designs will require the implementation of protection for the face of the display. In pen based applications, as the pen moves across the surface of the display, the pen could scratch the soft plastic that the front polarizer is made of. For this reason, the front of the display must be protected. We will discuss various methods for protecting the face of the display while minimizing the effects of the cover material on the optical properties of the display image.

Within this application note, we will also discuss the need to specify the flatness of the bezel. Suggestions will be presented concerning acceptable construction techniques to accomplish a sound design. Further, we will identify the display components likely to cause problems due to heat buildup, while discussing the methods used to minimize the effects of the heat on the display.

Even though this paper is intended to assist the designer in considering the problems associated with the development of a display system for notebook and pen based computers, the ideas expressed here are not to be construed as being the only solutions to the various problems, and have not been assessed as to whether they may infringe on any patents issued or applied for.

FLATNESS AND RIGIDITY OF THE BEZEL

In the notebook computer, the bezel has several distinct functions. It houses the display, the inverter for the backlight, and in some instances, the controls for contrast and brightness of the display. The bezel is usually designed to tilt in order to compensate for the optimum viewing angle of the display and its relationship to the person operating the computer.

It is important to understand that the bezel must provide a mechanism to keep the display flat, particularly at the mounting holes, in that even subtle changes in flatness will place uneven stress on the glass which can cause variations in contrast across the display. Slight changes in pressure may cause significant variation in the apparent contrast of the display. Also, at the extremes, significantly uneven pressures can cause the display glass to fail.

Because the bezel must be functional in maintaining the flatness of the display, consideration must be made for the strength of the bezel. Care must be taken to provide structural members, while minimizing the weight of the unit.

This may be executed using a parallel grid, (Figure 1a) normal to the edges of the bezel, or angled about 45° off of the edges of the bezel (Figure 1b). The angled structure may be more desirable in that it will

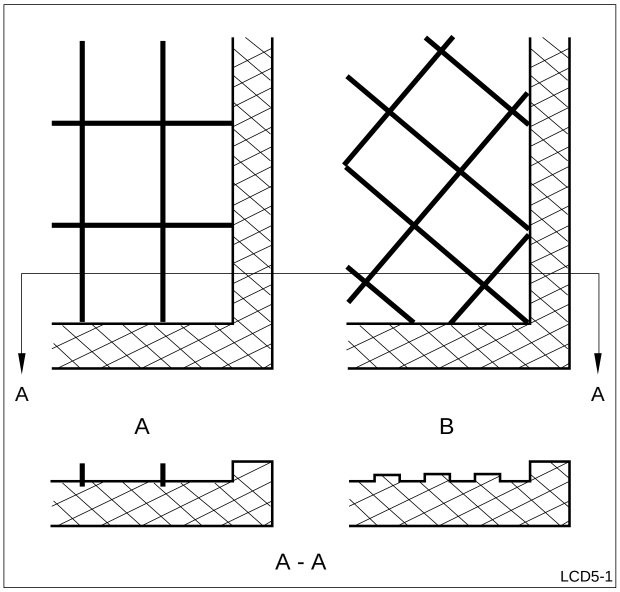

Fig. 1a,b. Parallel and Angled Bezel Grids

provide resistance to torquing the unit while lifting the cover with one hand. Again, the display is sensitive to the stresses due to uneven pressure on the display housing.

Another structure that will provide excellent rigidity, but adds more weight to the computer would be a "honeycomb" structure (Figure 2). This "honeycomb" structure resists torquing from all directions and tends to provide the best protection for the display.

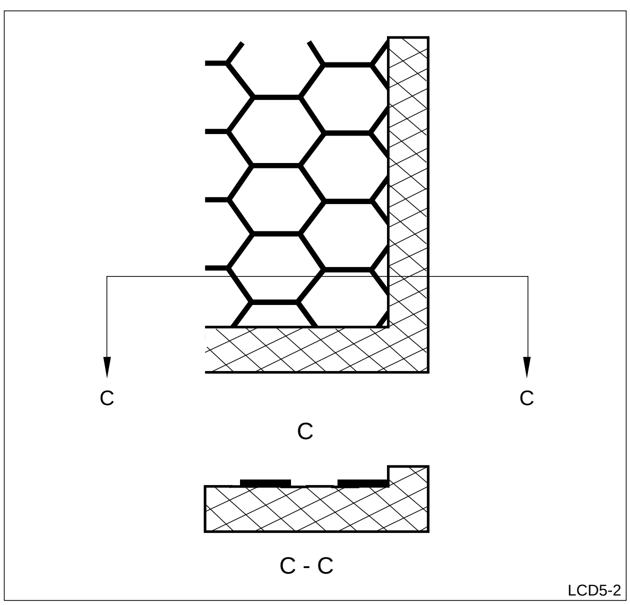

Fig. 2. Honeycomb Bezel Grid

With each of these structures, it is easy to provide mounting assemblies for the display. Threaded inserts (blind nuts) can be molded into the housing. The mounting may be done to either the front or rear of the bezel, however, attachment to the rear may provide better rigidity for the display and easier placement of the mounting hardware.

One last caution is worth noting in the development of a bezel. The bezel should be engineered to absorb most of the shock and vibration experienced in a portable computer. Even though the display has been carefully designed, the notebook computer can present extraordinary problems, related to use and abuse, for the design engineer.

AVOIDING HEAT BUILDUP IN THE DISPLAY

Several of the display components are sources for heat problems. If thermal management is not taken into account in the design of the display bezel, the display may be adversely affected evidenced by a loss of contrast uniformity. The Cold Cathode Fluorescent Tube (CCFT) itself gives off a small amount of heat relative to the amount of current dissipated in its glow discharge. Likewise, even though the inverters are designed to be extremely efficient, there is some heat generated. The build up of heat in this component will be aggravated by the typically "tight" designs currently being introduced (Figure 3). There is little ventilation designed into most display bezels. To compound the problem, the plastics used are poor thermal conductors, thus causing the heat to build up which may affect the display.

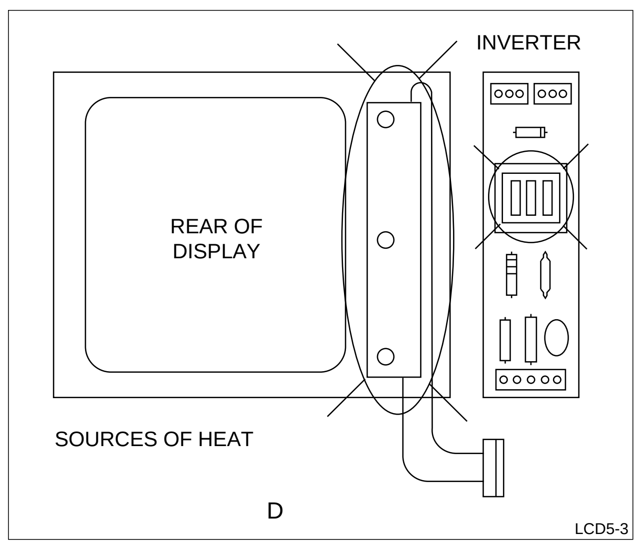

Fig. 3. Typical "Tight" Design

Some current designs suffer from poor placement of the inverter and/or poor thermal management techniques. These designs can be improved, even where redesign of the display housing, with improved thermal management, is impractical.

One of the most common mistakes in current designs is that there has been no consideration for the build up of heat from the CCFT. Typically, the displays for notebook applications have only one CCFT to minimize the power requirements for the display. This lamp is usually placed along the right edge of the display. Since the lamp is placed very close to the display glass, it can cause a temperature rise in the liquid crystal. It is important to note that variations in temperature of as little as five degrees centigrade can cause an apparent non-uniformity in the contrast of the display. Variations caused by slightly higher temperature variations will cause objectionable variations in the contrast and the appearance of the display.

To further aggravate the situation, some designs have the inverter placed in the bottom of the bezel. This has a tendency to cause the same variations in contrast, particularly when the housing does not have any heat sinking for the inverter. This problem will manifest itself as a "blooming" of the display, just above the inverter. This "blooming" looks like a washed out area where in the worst case, the characters on the display fade completely, thus making the display unreadable in that area.

The following section will discuss the recommended methods for overcoming these design problems.

PLACEMENT OF DISPLAY COMPONENTS

A. The Inverter

One of the things that can be done is to design the inverter into the base of the computer with the motherboard. In some applications, however, this is impractical in that this design would require the high voltage leads to be mounted within the hinges connecting the display bezel to the main body of the computer. This causes a problem with strain relief of the high voltage leads, and thus with U.L. Certification.

One mistake, made most often, is placing the inverter at the bottom of the bezel next to the lower edge of the display. It is a fact that heat rises, yet this is one of the most overlooked problems in new notebook designs. Even though the inverters are very efficient, some energy is lost in the inverter in the form of heat. Because of the insulating properties of the plastic materials used in the bezel construction, heat will build up and affect the display contrast as previously explained.

Designs with the inverter at the bottom can be improved in one of three ways. The inverter can be relocated away from the display; heat sinking materials can be placed between the display and the inverter (Figure 5); or ventilation can be provided to remove the heat.

In mature designs, it may be impractical to do what is obvious and move the inverter up to the side of the display towards the top of the housing. In these cases, the inverter may be insulated from the display with a "heat dam". One method of accomplishing this would be to use a piece of mica insulator dye cut to fit tightly between the inverter and the display. This heat dam would divert the heat around the end of the display bezel to rise harmlessly to the top of the housing. Mica is recommended in this application because of its thermal and electrical insulating properties.

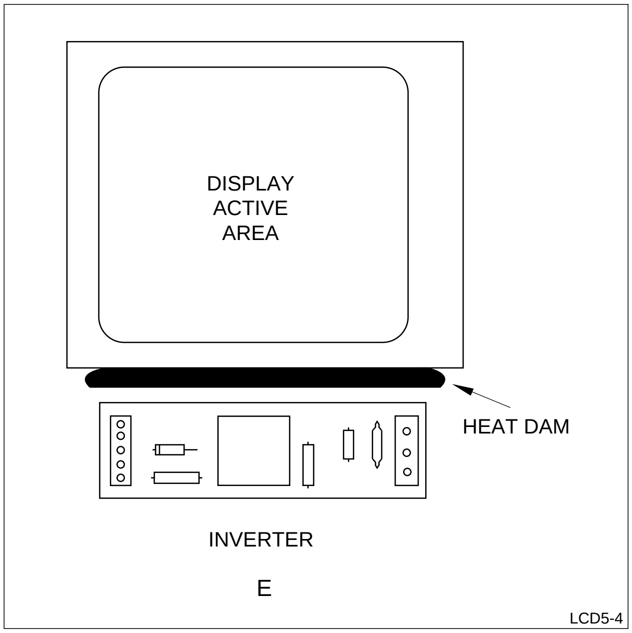

Fig. 4. Heat Dam

The last suggestion as to how to remove the heat would be to provide some ventilation to the inverter area. This would have to be done very carefully to prevent exposing the high voltage. Ventilation may not be a practical solution in that resistance to liquids and dust would be compromised.

The best solution for the designer of new hardware would be to only consider the placement of the inverter to the side of the display and at the top of the bezel. In existing designs, the effects of heat from the inverter, even in tight housings, has been minimal or nonexistent.

B. Heat Sinks For The CCFT

One problem that is aggravated by the placement of the inverter at the bottom of the bezel would be the heat dissipated by the CCFT. In designs where the inverter is placed up and to the side of the display, fading of the display contrast due to the heat from the CCFT is not a problem. However, when the inverter is placed at the bottom of the bezel, some designs have experienced a loss of contrast aggravated by the heat from the CCFT combined with the heat from the inverter.

In cases where the inverter must be left at the bottom, and the CCFT is causing a loss of contrast, the problem can be minimized by using an aluminum foil heat sink, not to remove the heat from the display (Figure 5), but to dissipate it over the entire display area, thus normalizing the display contrast. The aluminum foil is easy to install and in some present designs has successfully improved the display contrast.

Remember that the objection to the contrast variation stems more from nonuniformity than from a total loss of contrast. (Note: Contrast can be adjusted with VDE). The aluminum foil represented in Figure 3 represents a configuration that has worked well.

PROTECTING THE FACE OF THE DISPLAY

One of the last considerations in the design of notebook and more importantly, pen based computers is the protection of the face of the display. The front polarizer is made of a mylar base and thus is susceptible to scratching. The front protection for the display, along with providing scratch protection, may also provide an antiglare surface.

There are several ways that scratch resistance and antiglare surfaces can be incorporated. A glass or plastic cover may be placed over the display, thus providing protection. The material should be placed as close to the display as possible to minimize possible parallax problems associated with reflections off of the cover material. With antiglare materials, the further the material is from the front of the display, the more "frosting" of the antiglare material will take place causing distortion of the display image.

In pen applications, the front anti-scratch material is best placed in contact with the front glass of the display. The cover glass material normally needs to be slightly thicker to protect the display from distortion when pressure is being exerted on the front.

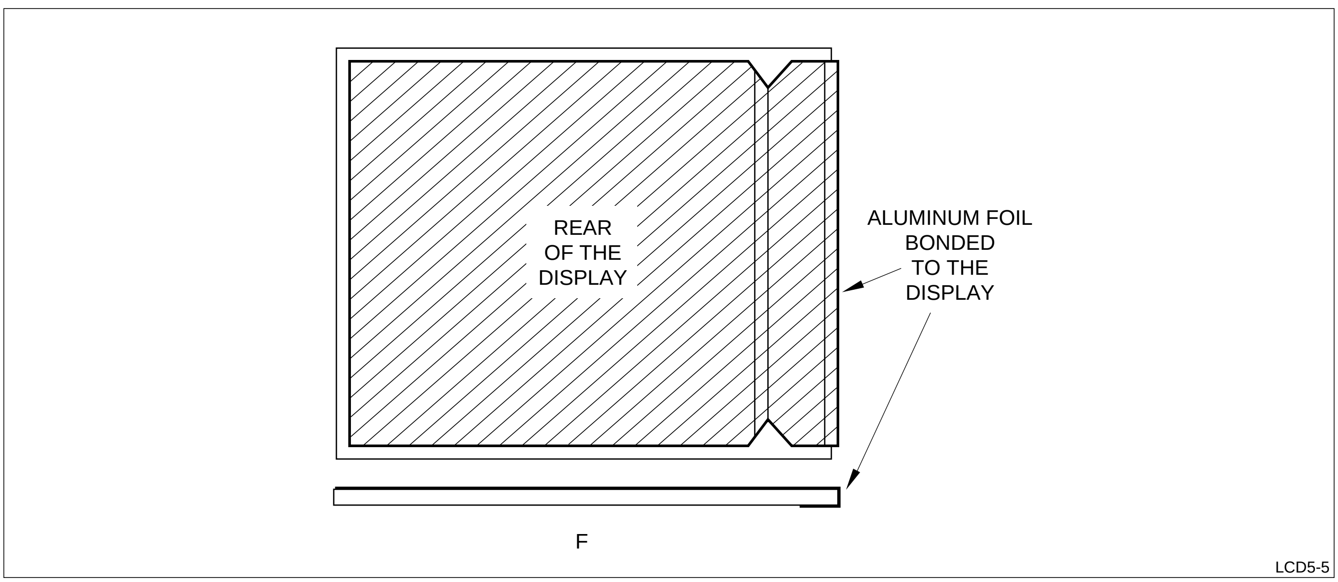

Fig. 5. Aluminum Foil Heat Sink

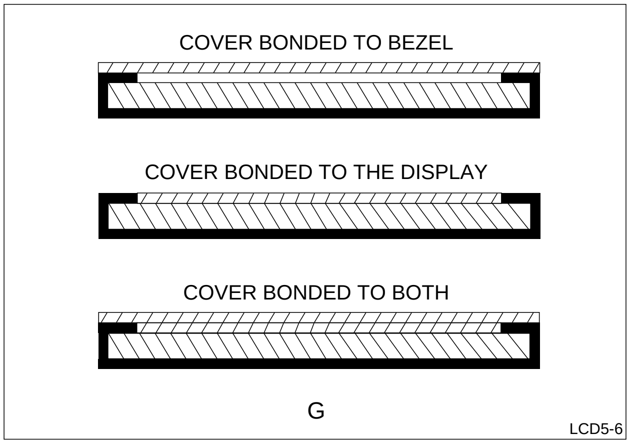

Fig. 6. Aluminum Foil Heat Sink

There are several methods for making the pen input devices. Some use the front surface of the cover glass to provide input data, and some use a field effect to a printed wiring board on the back of the display. When the pen input is on the front of the display, the input device is usually on a glass surface.

To limit specular reflection in this application, the front cover glass should be bonded to the display. Care must be taken to insure that the coefficient of thermal expansion is matched for all of the materials used in this system.

Because of the difficulties encountered with the bonding of the cover glass, and the potential to destroy the display through improper workmanship, we strongly recommend that you consult an engineer, experienced in the bonding of a cover glass to a liquid crystal display module.

CONCLUSIONS

There are several problems that are easily overcome with careful planning and design. This application note is intended to assist the designer and to minimize problems already experienced by others.

NOTES

NOTES

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