

Engineered Solutions To Help Prevent LCD Failures

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ENGINEERED SOLUTIONS TO HELP PREVENT LCD FAILURES

A liquid crystal display (LCD) utilizes two sheets of polarizing material with a thin layer of liquid crystal solution between them. The use of LCDs has increased substantially over the past decades, and today they can be found in devices such as notebook- and tablet-sized personal computers (PCs), personal digital assistants (PDAs), cell phones, digital clocks, calculators and watches, microwave ovens, CD players and many other electronic devices. LCDs offer some real advantages over other display technologies. They are thinner, lighter and draw less power than cathode ray tubes (CRTs), for example.

Mobile, hand-carried equipment such as cellular telephones, PDAs and PCs are often susceptible to accidental drops. The part of the PC, PDA or cell phone most likely to get damaged during an accidental drop is the protective front glass (touch panel in the case of a PDA) and the LCD behind it.

Generally, the cost of replacing the front glass is nominal, though the LCD cost is substantial. In most applications, the glass (touch panel) is permanently glued/attached to the LCD. This makes replacing the glass alone impossible. There is hence a considerable need to protect the LCD assembly from damage in mobile equipment, like cell phones, PDAs, and notebook computers.

Shock and vibration solutions

Space constraints in electronic equipment limit the amount of protection that elastomeric mounts or foam pads can provide against shock and vibration. Usually, the most effective isolation is provided by highly damped materials.

Critical performance requirements and tight space constraints in today's portable electronic devices are forcing product

designers to re-evaluate traditional shock. Accordingly, a new generation of portable electronic products has evolved, destined for new applications that require new levels of ruggedness and reliability.

Many of the new applications involve exposure to high levels of shock and vibration, either of which can induce premature fatigue or initiate failure in components. Shock—often described as an impact of short duration and large acceleration amplitude—occurs when electronic packages are inadvertently dropped or bumped against a hard surface. In contrast, vibration usually consists of continuous harmonic or random motion of relatively small acceleration amplitude. Neither of these conditions will damage equipment, however, if the components are properly protected. And highly damped elastomeric materials often provide the best choice for adequate protection in these applications.

Conventional shock-mounting systems must provide considerable freedom of movement to protect electronic components effectively. This also means that isolated electronic assemblies need to incorporate "sway space," which often is not available or is severely limited because of today's smaller package envelopes and high component density. These space constraints effectively establish a limit on the shock magnitude that can be accommodated. Limited space also requires that vibration amplification at resonance be closely controlled and that displacement from shock be minimized. Both requirements call for high damping in isolator materials.

Limiting system response

All components possess mass and stiffness and therefore are subject to resonance, a phenomenon that sometimes results in damaging vibration amplification. System response at resonance usual-

ly can be controlled by specifying required damping properties for isolator materials. Generally, materials with a high loss factor η_m are preferred. Parameter η_m is numerically equal to twice the material's critical damping ratio c_m/c_c (or ζ). As an example, loss factors can range from 0.05 for natural rubber to greater than 1.0 for certain engineered materials.

Resonance problems in large, massive structures often can be minimized or eliminated by designing for a relatively low system natural frequency f_n , which falls out of the range of excitation frequencies. This approach is virtually impossible for many electronic packages, especially portables, because the resulting required isolator deflection exceeds the available sway space.

Shock transmissibility

The combined damping of the isolation mounts and other system components controls transmissibility, which is the normalized magnitude of system response to shock or vibration. High loss factor materials effectively address shock

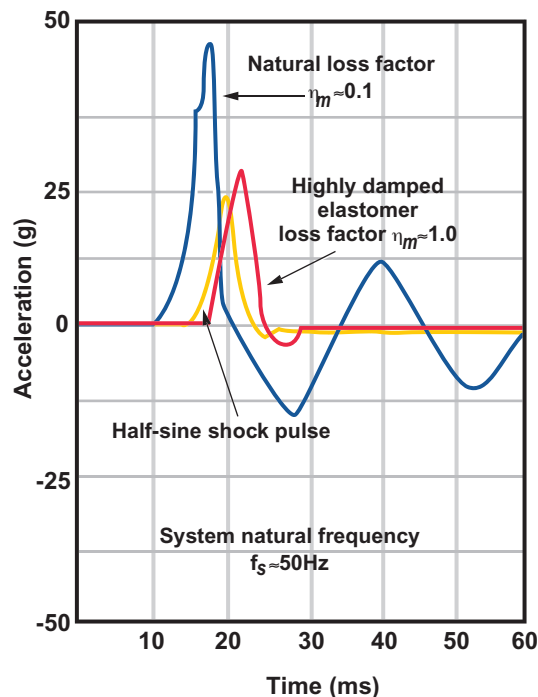


Figure 1

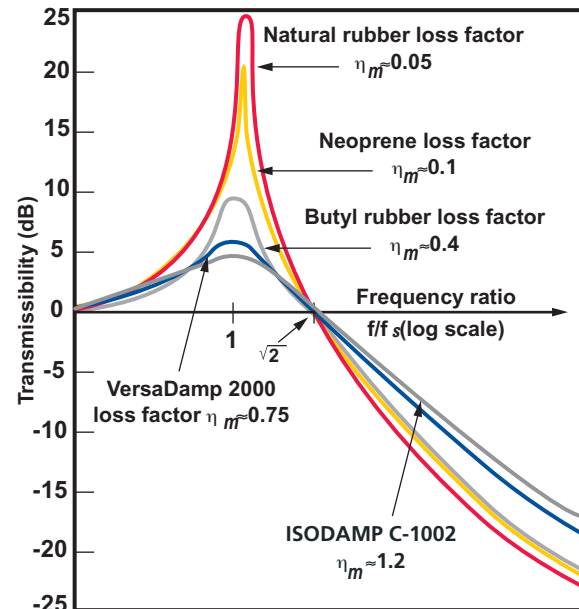


Figure 2

energy in a system by limiting response to shock pulse input (Figure 1). With a lightly damped material, such as neoprene, shock transmissibility is over 2.0 when a half-sine shock pulse is applied to a suspended rigid-body system.

Theoretical data analysis predicts that transmissibility should be about 1.6, given a material loss factor of 0.1. In practice, transmissibility is greater than this because the isolator “bottoms out” due to its inherent deflection limitations, producing a rapid, nonlinear increase in mount stiffness. The point at which the mount stiffens rapidly shows up as a “knee” in the acceleration response curve for neoprene.

In contrast, a highly damped material avoids significant shock amplification. Given a half-sine shock pulse, the suspended system response is only about 1.1 times the input acceleration of 25 g.

Vibration transmissibility

Figure 2 illustrates the levels of damping that various materials can introduce into a system via their specific loss factors. When transmissibility exceeds 0 dB, the system response is actually greater than

the vibration input; the higher the peak, the more uncontrolled the response.

Damped, proprietary elastomers

E-A-R Specialty Composites has kept pace with the stringent energy control needs of increasingly downsized equipment, with the company's long-established ISODAMP® line of energy-absorbing thermoplastics, ISOLOSS® family of highly damped urethane elastomers, and with the more recent development of the VersaDamp™ family of damped thermoplastic rubber and CONFOR® line of highly damped urethane foams.

With their high material loss factors, these high performance materials are formulated to effectively absorb and dissipate shock and vibration energy and quickly restore system equilibrium. Their high internal damping properties enable the materials also to control system response at resonance, by internally dissipating vibration energy at the molecular level.

E-A-R offers its proprietary materials in a broad range of formulations that provide the optimum combinations of physical and performance properties for virtually any application. A wide variety of standard ISODAMP, VersaDamp and ISOLOSS molded isolators are available, including grommets, bushings, and metal-bonded and non-metal bonded mounts. E-A-R has the capability to mold custom configurations as well. CONFOR foams are available in die-cut parts, sheet format or in buns.

Applications

Smaller format LCD – PDA or handheld devices

Most manufacturers of PDAs or handheld devices specify a maximum height from which the units would survive damage if dropped accidentally. The LCD is one of the most sensitive components that need shock protection. In most cases, there is little or no gap between the LCD and cover or PCB or battery.

Drop Shock Performance
PDA Touch Panel & LCD Breakage,
with and without CONFOR Shock Pad

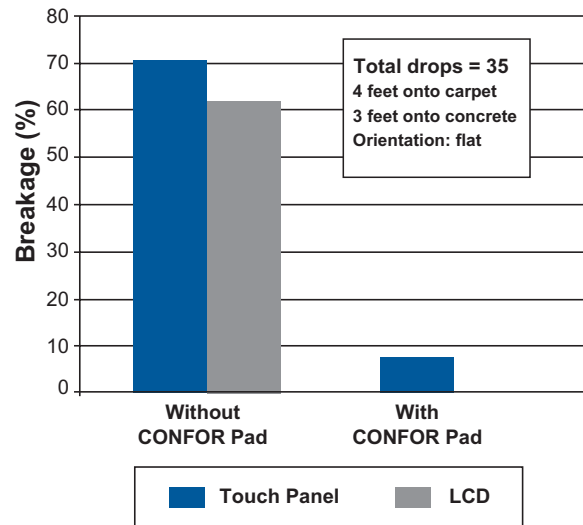


Figure 3

Figure 3 describes experimental work done at E-A-R Specialty Composites on protection of the LCD panel in a PDA. To simulate an accidental drop, a PDA was subjected to free-fall drop tests of 48 inches onto carpet and 36 inches onto concrete. The baseline testing involved dropping the PDA without any shock isolation treatment.

When the impact of the PDA was studied using a high-speed video camera, it was observed that after impacting the hard surface, the PDA would typically rebound and bending waves were set up in the PDA. These bending waves were similar to the resonant bending waves set up in a beam under free-free boundary conditions when excited by a broadband source. It was also noted that the LCD and touch panel might not crack at the first impact but on the rebound. The challenge was not only to reduce the G levels but to also prevent or at least reduce resonant flexure in the PDA assembly, which in turn will reduce the flexure in the LCD. During flexure, the tendency to crack would be in a zone that had maximum bending stress concentration.

E-A-R's approach in solving this issue was unconventional. It was proven, not only in this test but other applications in the field, that a CONFOR pad with the right stiffness and thickness "behind" the LCD as a snubber provides the most shock protection. Energy-absorbent CONFOR foam is soft and flexible. When sandwiched between an LCD and PCB, it typically exerts little or no force statically. But under dynamic loading, such as a shock event, the material stiffens to limit the flexure of the LCD. The compression and shearing of highly damped CONFOR material also work to dissipate mechanical energy.

Larger format LCD – notebook or tablet PC
E-A-R Specialty Composites has also done considerable work in protecting larger format LCDs in notebooks and tablet PCs from shock and vibration. Except for ruggedized versions, such equipment usually has a lower drop height requirement and higher vibration input than the smaller format LCDs. In addition, the definition for LCD failures includes not only breakage but also scuff marks, scratches or paint residue transferred to the LCD during vibration testing.

When the notebook is in its closed position, the gap between the LCD's front surface and the keyboard, palmrest, or point stick is often minimal (refer to Figure 4). During shock or vibration, the abrasion action of the keyboards, point stick or other area on the palmrest will leave scuff marks on or crack the LCD.

One preventive measure for this type of failure is to strategically place a CONFOR pad between the LCD and top cover. The CONFOR pad acts like a damped snubber that easily conforms to the often uneven gap between the LCD assembly and top cover. This limits the flexure of the LCD and protects it from contacting adjacent surfaces such as the keyboard, palmrest or point stick and therefore reduces scuffing or scratching.

Molded ISODAMP isolators can also be used to mount the LCD to the frame structure to provide compliance to the mounting points of the LCD so that there is not a direct path for energy transfer from the frame or structure in shock events.

Laptop Computer and Cross Section Side View

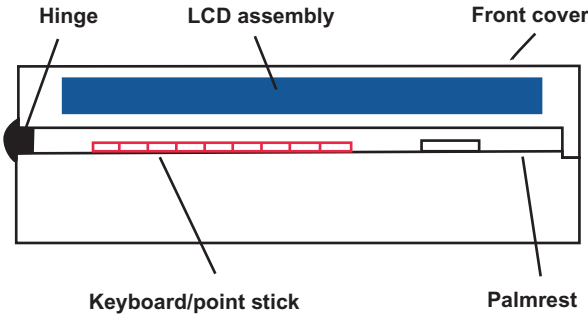
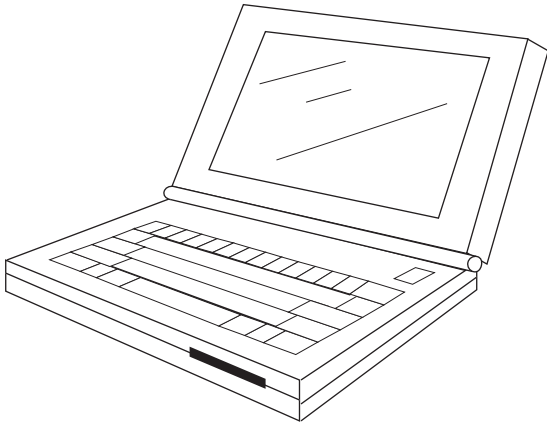


Figure 4

Design Guidelines

Use CONFOR foams as a snubber pad behind LCD to limit resonant response to shock and vibration input and thereby reduce LCD cracking.

Use CONFOR foam pads to help reduce LCD scuffing behavior typical in notebook computers.

Place small isolation mounts at LCD attachment points to reduce transmission of shock and vibration energy to the LCD.

Optimize the LCD shock pad design (material grade and thickness), based on shock levels, LCD size and surrounding gap dimensions. Typical compression is 25 percent to 75 percent.

Contact an E-A-R Applications Engineer to determine optimum shock pad configuration options for your application.



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