

RUGGED TABLET COMPUTERS: LESSONS LEARNED AND DESIGN RESPONSES

Since the days of the ancient Egyptians, paper has been the medium of choice for capturing data. Today, paper – in the form of notebooks, maps and photographs, to name a few – is being rapidly supplanted by digital technology. The computer has moved from the office into the field. While rugged mobile computers were once used primarily by military personnel and focused applications in the

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commercial and industrial markets, today's rugged computer is for people who perform normal job functions in demanding environments.

As powerful computing and communications technology is packaged in smaller, lighter and more durable form factors, more users in more industries benefit from rugged mobile computers. In order to perform tasks that were once done only at an office computer, as well as field operations and remote communications that were unimagined just a few years ago, users need a high level of durability and reliability. Specifically, they require protection



ARMOR products sealed design protects against dust and moisture infiltration, shielding internal components from damage.

against water, dust, shock, vibration and temperature extremes. They need to be able to view the display, even in direct sunlight. And for those users who are upgrading from earlier generation units, backward compatibility with system components like docking stations is an important consideration.

ENVIRONMENTAL FACTORS

Today's rugged tablet computers are built on lessons learned, often in military environments, and applied to the design, manufacture and service of commercial products. Critical areas where these lessons led to environmental design improvements include keeping out water and dust, blunting the effects of high and low temperatures, and protecting against the harmful effects of shock and vibration.

ARMOR
RUGGED MOBILE SOLUTIONS

DUST AND WATER

Dust is a term used to define small particulate matter. Non-organic matter can clog connections during mating of connectors to port, or decrease the port's useful life. Further, organic matter such as mud can lead to fungal growth or the retention of moisture, leading to corrosion that could take months before intermittent operation occurs. Water, in the smallest amounts, turns to vapor upon operation of electronic equipment and thereby migrates throughout the entire unit. If openings are not present to "back out" the moisture, it collects in trapped areas and condenses, for example, on the LCD screen.



Bright sun or dim light, ARMOR LED technology is fully adjustable for easy reading. The information you need is available to you where and when you need it.

Thus, dust and water are two of a computer's worst enemies. In order to prevent or minimize dust and water ingress, a computer's external housing must be designed and manufactured to very tight tolerances, and all gaps must be carefully sealed. The interfaces between materials that exhibit different coefficients of thermal expansion are especially important because the sealing material must be able to compensate for thermal expansion and contraction and maintain a tight seal.

In addition to selecting the most appropriate gasket materials and locations during the design process, consistent application of these materials during manufacturing is critical to achieving optimal performance. Gaskets that are designed for automated application have been demonstrated to be more consistent, repeatable and reliable than hand-applied materials.

The elimination of a fan for the purpose of cooling internal components is one strategy to ensure continued function in the presence of water and dust. Air-handling openings found in conventional computers can allow water and dust to enter the computer directly. And air intakes can become blocked with dust, leading to excessive heat within the unit and catastrophic failure. Further, this functionality demands a preventative maintenance program that increases the total cost of ownership.

Rugged computers are often ranked by ingress protection (IP) ratings which specify the environmental protection provided by an electronic enclosure. The IP rating (Figure 1) normally has two numbers, indicating the levels of protection that the enclosure provides against the ingress of solid foreign objects, including dust, and the protection it provides equipment inside against the ingress of water. These ratings are applied to electronic enclosures of all types, including those intended for continued submersion. Within the category of rugged computers, the highest levels of dust protection are desired; a water protection level of 6 is considered to be water resistant.



Cold can be your enemy as much as heat. ARMOR uses unique components to insure performance in any environment.

FIRST DIGIT (SOLID OBJECTS)

0	No protection
1	Protected against solid objects up to 50mm, e.g. accidental touch by hands
2	Protected against solid objects up to 12mm, e.g. fingers
3	Protected against solid objects over 2.5mm (tools and wires)
4	Protected against solid objects over 1mm (tools, wire, and small wires).
5	Protected against dust limited ingress (no harmful deposit)
6	Totally protected against dust

SECOND DIGIT (WATER)

0	No protection
1	Protected against vertically falling drops of water (condensation)
2	Protected against direct sprays of water up to 15° from the vertical
3	Protected against direct sprays of water up to 60° from the vertical
4	Protected against water sprayed from all directions
5	Protected against low pressure jets of water from all directions
6	Protected against powerful jets of water
7	Protected against the effect of immersion between 15cm and 1m for 30 min
8	Protected against long periods of immersion under pressure

HIGH AND LOW TEMPERATURES

Mobile devices are subjected to a much broader range of temperatures, ranging from winter nights in Minnesota to summer days in Arizona. These extremes are quite different from the office. Sound thermal design practices not only address electronic components, but also the liquid crystal display (LCD), battery, and spinning storage media. In addition, overall thermal design establishes a "cold boot" lower limit and maximum hot operation. The ability of a computer to operate at high and low temperatures also depends in part on the selection of materials and how they relate to other materials in environments that can cause differential expansion and contraction.

The liquid crystal chemistries of LCDs is affected by temperature. At low temperatures, the viscosity of the liquid increases, and if inappropriate vendor specification and/or design techniques are used, the display updates are slow, leading to "ghosting" of images. At high temperatures, the viscosity decreases to almost that of water, resulting in "brownout" of the screen.

Batteries function by chemical reaction to release stored potential energy as electrical power. A battery that is fully charged provides its stated capacity at room temperature. However, this capacity will decrease as temperatures rise or lower to extreme operational limits. Rugged designs leverage trades between weight and total available battery capacity, selection of battery chemistries, thermal design, and power management to optimize user performance over broad temperature ranges.

The spindles of rotating mass storage devices use lubricants that are sensitive to temperature, again due to changes in viscosity. At low temperatures, the viscosity increase, requiring the more energy from the motor to spin. At extremely low temperatures, the drive can freeze up and stop spinning. At extremely high temperatures the viscosity is so low that using the drive increases the mechanical wear and thereby reduces useful life.

Designs that leverage fans for heat convection run the risk of single point failures, may become clogged, or are difficult to clean and/or decontaminate. A computer designed for use in harsh environments uses mechanical design to transfer heat away from internal components, such as chip sets, to the housing where heat is dissipated into the ambient air. This “heat pipe” approach, where heat-generating components are connected directly to the housing via a path presenting the least thermal resistance, has proven superior to an internal fan.

SHOCK AND VIBRATION

Mobile devices are subjected to a broad range of intentional and non-intentional usage environments not present with office equipment. Non-intentional shock includes dropping and sliding off surfaces, while intentional shocks occur through operations such as a vehicle backing up to a loading dock, a rail car engaging, or a tow truck winch operating. Vibration, on the other hand, is specific to the vehicle or stationary equipment on which the device is mounted. While most applications are typified by random vibration, in some cases, such as onboard a ship, there is an overlay of a strong periodic vibrating component induced by engines.

Careful attention to material properties such as malleability (too malleable leads to wear) and fragility (such as glass shatter) are required. All components, boards, brackets, and cables need to have rigid mounting to move the device's natural frequencies outside of excitation ranges. The value of this design regimen is illustrated by the classic films of a bridge that wobbles to destruction after a group walks across. The excitation – the group walking – becomes a repetitive excitation at the bridge's natural frequency. This excitation at the natural frequency amplifies to the point of destruction. At the tablet computer level, vehicle vibrations must be considered not to excite internal natural frequencies leading to excessive wear.



Temperature, vibration, altitude, dust, sand and extremes of every kind, ARMOR products keep your data safe, secure and at your fingertips.

Tablets require attention to the mounting of the LCD and glass. Chemically strengthened glass and shock isolation techniques are critical to keep shocks/drops from leading to damage.

Tablet spinning media is also highly sensitive to vibration and shock. Isolation techniques are used to absorb shock and vibration energy so the drive head does not crash leading to loss of data. For shock, materials that deform and then relax at a slow rate are used. For vibration, materials that absorb the vibration energy and dissipate as heat are used.

Vibration testing involves attaching the unit to a test fixture that represents actual conditions, such as a vehicle being operated at a certain speed over a rough road. Transducers measure and monitor vibration throughout the test. When the proscribed time has elapsed the computer is examined for failure, wear, looseness, or other changes attributed to vibration.

OPERATIONAL FACTORS

In addition to the environmental factors discussed above, a rugged computer must meet certain operational benchmarks in order to be useful in a mobile environment. These factors include weight, display technology, communications functionality, and compatibility with existing hardware.

WEIGHT

The weight of the mobile device is a critical concern for user fatigue. Devices over 5.5 lbs. quickly limit the duration of holding and lead to errors during use of stylus devices. Thus the design objective may be summed up as the smallest form factor and the lightest weight. Optimizing the density of design while simultaneously reducing weight was achieved by balancing design and material selection with the requirements of a rugged environment, including the 4-ft. drop test. A lightweight housing provides a high level of protection and helps to reduce weight. Still, keeping the size of the housing as small as possible is a primary objective. Thus, the size and weight of the housing are determined by the arrangement of internal components that keep the “box” as compact and light as possible.

DISPLAY TECHNOLOGY

The principal medium to retrieve and input information on a table device is the display. The most critical measure is Contrast Ratio (measured as the difference in black/white under varying lighting conditions). An example is the wash-out of contrast ratio experienced when using a cell phone outdoors during a bright day. Meantime, the device may be used at night and should be adaptable to ambient lighting so not to become difficult to read because it is too bright. Not only must the display be fully visible in these light conditions, it must perform consistently across the entire temperature range.

A liquid crystal display may be characterized as transmissive, reflective, and transreflective. Transmissive displays, such as those on conventional computers, employ an LCD screen with a backlight that provides excellent indoor viewability. The user sees the display image by virtue of the light that passes through the panel from the backlight. These displays are difficult to see in bright light because the brightness of the ambient light overpowers the light coming through the display from the backlight. A reflective LCD uses ambient light which passes through the LCD to a mirror and is reflected back to the viewer, providing good performance in bright conditions. However, these displays provide minimal viewing in dim light because there is little light to bounce off the mirror. A transreflective display combines elements of both with LED backlighting for low-light conditions and a reflective component that improves outdoor viewability.

Glass used in displays is chemically treated to improve its strength and performance. For example, touch screens use a sacrificial overlay with anti-glare properties to enhance screen protection. Coatings may also be used to control the effects of direct and indirect sunlight on the screen image.



What good is connectivity if you can't see the information you need it?

ARMOR LED technology is fully adjustable for easy reading.

CONNECTORS

One of the lessons learned during years of experience with fully rugged computers is the vulnerability of connectors. The use of straight-on rather than angled connectors and, where possible, the use of recessed ports have reduced damage to connectors. Further, sealing on the computer side of the connectors eliminates the need for a user to put a cap onto a connector to seal the unit.



Military tested in the harshest conditions, the versatile ARMOR rugged tablet computers, to keep your data safe and available wherever you need it.

SUMMARY

The development of next-generation rugged tablet computers demonstrates how lessons learned through years of experience with military rugged computers translate into design improvements. The demands of today's mobile worker are such that it is no longer possible to wrap a hardened cover around a regular computer and expect it to function in the field. Today's rugged mobile computers are designed from the inside out, and apply proven technology to deliver reliable performance.

The growing market for rugged computers is characterized by a degree of confusion about the meaning of the term rugged. There are some specific ratings, such as ingress protection that may be used to gauge specific performance criteria. And there are categories like "semi-rugged," "rugged" and "fully rugged" that are often used, but are not easily defined. Thus, users must evaluate levels of protection in light of the specific environment in which the computer will be deployed.