Understanding Vibration and Shock Mounts for Mobile Computers

Overview

VIBRATION AND SHOCK

Generally, **vibration** and **shock** are movements in or from the environment. Smooth movements are often not detrimental to objects and usually not annoying to people. The soft swaying of a palm tree is generally considered a good thing, while an earthquake or a rough road is considered a bad thing. These are examples of vibrations, as they are repeated and often rhythmic. A sharp, single-event motion is considered a shock, an example of which is hitting a pothole in a car.

Most mobile computing equipment is designed to withstand a certain level of both of these types of events. Excessive levels of either vibration or shock often require the addition of a shock/vibration (or isolation) mounting system.

An improperly installed isolation system can be dangerous to the equipment, as well as the end user; however, when properly installed, the isolation system will improve the user experience and extend the life of the equipment.

NATURAL FREQUENCY

All rigid objects have a natural frequency (resonant frequency). The natural frequency of an object is the motion frequency it has when bumped or banged. Just as a bell has a tone when it is rung, any object will vibrate or ring when it is hit. In addition, the object, if mounted to something, may swing at what is called its “free body” natural frequency. Examples of this include the pendulum in a clock or a child in a swing.

We may consider why the natural frequency of anything is important. Just like when bouncing a ball or pushing a child on a swing, energy applied at or near its natural frequency will cause movements to amplify. For example, pushing the child on the swing at the natural frequency of the swing makes them go higher. While this is fun for a child swinging, it needs to be avoided when mounting equipment, so as not to cause damage to the equipment or object to which it is mounted.

Every Solution Has a Price

We have all heard the phrase “There is no free lunch.” This is very true when it comes to an isolation mounting system. Just like when catching a thrown egg, to lower the energy seen by the egg, you need to add a long, slowing movement to your catch so that it does not break the egg. Isolation systems trade peak forces for longer and slower movements to absorb the energy. This means that space is needed around the isolated equipment for that movement.

The space needed around the equipment is directly related to the weight or “mass” of the system being isolated. For example, a standard pillow has enough thickness to isolate the shock of a dropped golf ball, but not nearly enough to withstand a dropped bowling ball. As the pillow is made firmer, the golf ball sinks into the pillow less, but at the same time, the force seen by the ball is greater. An isolation system could be designed for a bowling ball, but it would need to be either much thicker to keep the forces low, or thinner and much stiffer, which transmits more force to the ball.

How a Real-Life Isolation System Works

Many isolation systems use a type of rubber-like material to absorb the energy that is sized for the weight and balance point (mass and center of gravity) of the equipment.

- An isolation system is designed to have a frequency that is not near the natural frequency so that it avoids amplification (see the amplification region in Figure 1).
- Limiting vibration may require one value of stiffness of rubber-like mounts, while limiting shock may require another value.
- Effective isolation systems offer a good compromise of vibration and shock limiting without restricting the usability of the equipment or taking up too much room.

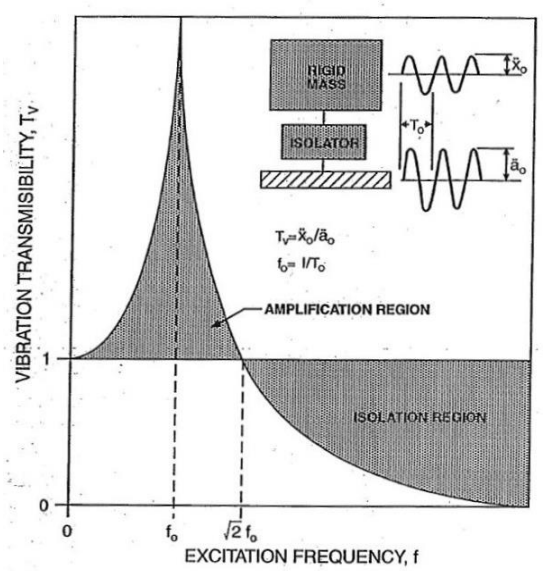

Figure 1: Qualitative Representation of Vibration Transmissibility for an Undamped Linear Isolation System

HOW THESE EFFECTS CONCERN THE MOBILE COMPUTER USER

- Good mounting practices are critical when mounting equipment to a vehicle, as performance degradation and damage may occur.
- Mounting surfaces must be both strong and rigid.
- A soft or elastic surface will act like a spring causing the equipment to bounce. If the equipment also contains a vibration/shock isolation system, it may react like trying to bounce one basketball off another and amplify movement/damage.
- Improperly mounted equipment is both dangerous to the equipment, as well as the user.
- A properly installed isolation system will improve the user experience and extend the life of the mobile computing equipment.

Theory of Vibration and Shock – Mathematic Model

The components that make up an isolation system can be described mathematically, and using the mathematical model they can be tuned for a specific use case.

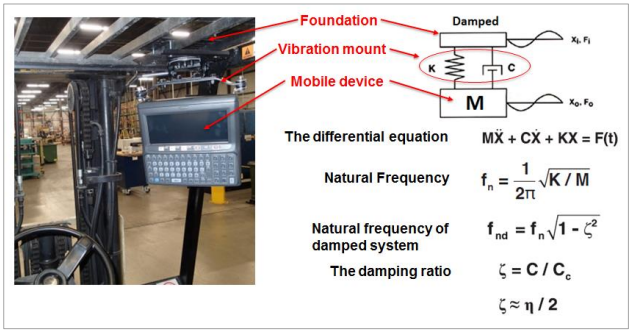

Figure 2: Typical Vehicle Computer Installation with Isolation Mounts

Considerations for Mounting a Vehicle Computer

- Determine the best position for the vehicle computer and all the associated components. If a similar vehicle computer was previously installed, check to see if its position is suitable for the new vehicle computer.
- After installing the vehicle computer, test the installation for at least 30 minutes before duplicating the installation on another vehicle.

  Record all the following details:

  – Check that the position of the vehicle computer does not obstruct vehicle controls
  – Check that the vehicle computer does not obstruct the driver's view (see Figure 3)
  – Check the position of the vehicle computer for user comfort over long periods
  – Check positioning to avoid extreme wrist angles that may cause injury

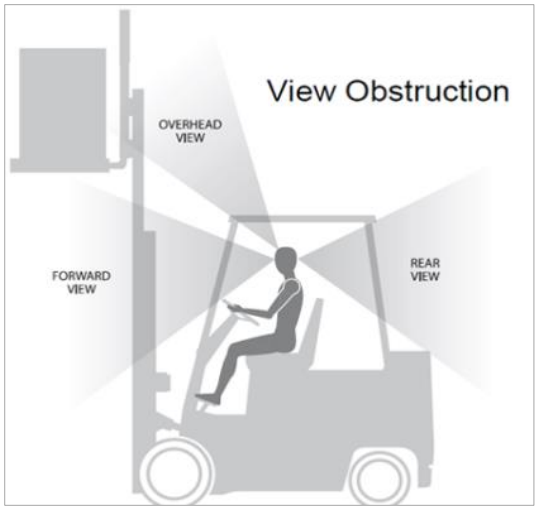

Figure 3: Vehicle Computer Should Not Obstruct Driver's View

RAM Mount vs. Fixed U-Mount Installations

Many products are compatible with RAM mounting systems, which allow easy user adjustability when mounted to a vehicle, as opposed to fixed U-mount systems.

As with isolation systems, every solution comes with a price. Some trade-offs are as follows:

Mounting Option	Stiffness Reqs. of Mounting Surface	Positioning	Shock/ Vibration Stability	Safety
RAM Mount	Higher	Quick change	Tightening force is dependent; loosening easily	Will need tether for safety
U-Mount	Normal	Fixed	Stable	Tether is optional

Best Practices for Vehicle Device Mounting

DOS

The following best practices must be strictly enforced:

- ✓ Do let a qualified engineer perform the installation in a vehicle.
- ✓ Do read your Installation Guide and follow the instructions.
- ✓ Do use the specified mount and hardware.
- ✓ Do use calibrated torque wrench when fastening the mount.
- ✓ Do install the mounts on a “secured” foundation. The structure of the mounting foundation and beam/wall must have sufficient strength and stiffness to support the vehicle computer.
- ✓ Do install the mount on a flat surface. An uneven surface may cause mounting bracket deformation. It will stress the mobile device and result in unexpected damages to the mounts and property.
- ✓ Do use the mounts for specified devices only.
- ✓ Do inspect the mounting hardware periodically. Retighten the fasteners to the specified torque. Replace the unsafe/damaged parts immediately.
- ✓ Do give the cable routing within a vehicle cab careful consideration, especially for separately connected scanners and other devices with loose cables.
- ✓ Do consider a tether as a safety component for extra protection.
- ✓ Do contact Technical Support or your sales representative for advice.

DON’TS

The following restrictions must be strictly enforced:

- ✗ Do not modify the mount without Technical Support staff approval.
- ✗ Do not use non-approved fasteners, brackets, or other hardware.
- ✗ Do not install the mounts on a non-secured foundation, such as a thin wall or a flexible beam.
- Do not use the mount and/or the device as a hand-held device. Using the mount in this manner may cause the person to fall or dislodge the mounting hardware and/or mounts.
- Do not add weight or attach any other items to the mount or device. Additional elements may fall, causing injury; or may increase the chance of failure of, and/or damage to, the mounting hardware and/or mounts.

Examples of Failures Due to Improper Installation

Figure 4: Sharp Edge of the Washer Against the Shock Isolator

Figure 5: Non-Specified Bolts, Washers, and Nuts

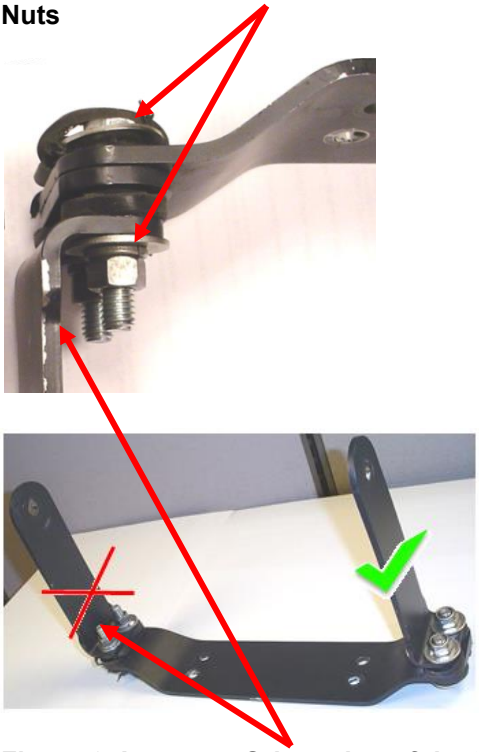

Figure 6: Incorrect Orientation of the “U-Leg”