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The Impact of Impact – Discussion of shock loading on connectors and interconnection devices

- **Shock Loads**
- **Impact Factor**
- **Kinetic Energy**
- **Impact Energy**
- **Energy Absorbing Capacity**

The next issue of Technical Tidbits will include an informative discussion about stress and strain concepts

Impact Resistance

Mobile phones and other electronic devices are subjected to random shocks and vibrations during normal service. Often, as part of handset qualification, these conditions are simulated in the laboratory by drop tests. **Shock loads** (suddenly applied loads) experienced in drops will place large stresses on electronic components in very short time periods. This may result in sudden failure due to deformation or fracture of connectors and interconnection devices. This, in turn, leads to consumers consulting their warranties and contacting their network provider's customer service representatives.

Impact

Clearly, it is not enough to design electronic components just to make good electrical contact. They must be designed to withstand the high forces created by colliding with solid objects, such as desks, floors, roads, and even the occasional wall. By making the components smaller and lighter, the force of impact will be lower. Also, the individual parts can be designed to absorb more of the impact energy generated by the fall.

Since there is elasticity in all collisions, a drop test can be modeled by the impact of a weight with a spring. A spring that has a weight (W) resting on it will be deflected a certain amount (d_{ST}) from its free height (Figure 1). The force on the spring would be equal to the weight of the object. However, if the object were dropped onto the spring from a given height (h), the spring would be deflected much farther (Figure 2). The force (F) on the spring would be equal to the weight of the object multiplied by an **impact factor** (Figure 3). It is important to note that if an object is held at the top of an uncompressed spring and then released, the force generated would be equal to *twice the weight* of the object. For an object dropped from a height (as in most drops), the force experienced would exceed twice the weight of the object. This is a critical point, since most people lack the foresight to lay an object on the ground before dropping it.

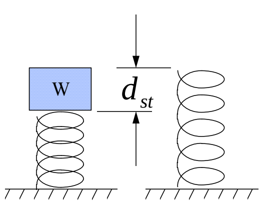

Figure 1. Static Deflection

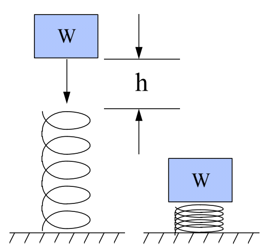

Figure 2. Impact Deflection

$$F = W\left(1 + \sqrt{1 + \frac{2 \cdot h}{d_{ST}}}\right)$$

Figure 3 Impact Force

The **kinetic energy** of a freely falling object that started from rest is equal to the weight of the object multiplied by the distance it has fallen (assuming no air resistance). Objects that have been thrown, kicked, or head-butted will probably have even greater kinetic energy at the time of impact. When the object hits the ground, all energy must be conserved. Some of it will be converted to sound, some will be converted into upward motion as the object bounces, and the rest will go into deforming the device and its individual components.

Impact (continued)

When an object is dropped and the deformation is small enough, the components will elastically return to their original shape. When there is too much energy to absorb, components will permanently deform, and may even break. If deformation is severe enough, the electronic device may fail or be damaged beyond repair. Therefore it is important to design components to absorb as much **impact energy** as possible. The alternative is to keep plenty of replacement parts on hand for dissatisfied customers.

$$U = \frac{\sigma^2 \cdot A \cdot L}{2 \cdot E}$$

Figure 4. Impact Energy

The formula for the amount of energy absorbed by a rod (such as a connecting pin) suddenly exposed to tension or compression by an impact is displayed in Figure 4. Here, U is the energy absorbed by the rod, σ is the stress created by the deformation, A is the cross sectional area, L is the length, and E is the elastic modulus of the material. To determine the amount of energy that can be absorbed without permanent set, substitute the yield strength for the stress term in the equation.

In practice, larger contacts will have more energy absorbing capacity than smaller contacts. However, current trends in the telecommunications and computer industries are towards reduced sizes. This reduces the amount of energy these devices can safely absorb. It thus becomes more important to choose the material properties carefully to offset these losses.

By using a material with a different elastic modulus, it is possible to slightly increase the amount of impact energy that the component can absorb. The elastic moduli of copper alloys vary from 16,000,000 psi to 20,000,000 psi (110 to 138 GPa), a difference of 25%. The alloy with the lowest modulus will only have 25% more energy absorbing capacity than the alloy with the highest modulus. If the volume of the object has been reduced 25% or more, this is not much help for butterfingered consumers.

The value of yield strength has the greatest impact on the amount of energy absorbed. The yield strengths of copper alloys vary from 50,000 psi to 205,000 psi (340 to 1415 MPa) The alloy with the highest strength will have almost sixteen times as much energy absorbing capacity than the lowest strength alloy. A 10% increase in yield strength will create a 21% increase in impact strength. A 20% increase in yield strength will create a 44% increase in impact strength. Clearly, it is important to use a material with as high a yield strength as possible. After all, no one has time to worry about gravity.

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TECHNICAL TIDBITS

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Reference:

Juvinal, Robert C. and Marshek, Kurt M. Fundamentals of Machine Component Design John Wiley and Sons, Inc. New York, 1991.

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