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Honey, I Shrunk the Connector! - This discussion will explain why miniaturization does not always result in sacrificed performance.

- **Bulk Resistance**
- **Contact Resistance**
- **Contact Force**
- **Fatigue Resistance**
- **Stress Relaxation**
- **Formability**

Size Reduction

Smaller component size has become the main design criterion in the telecommunications and computer electronics markets. Corporations are constantly looking for ways to reduce the size and weight of their products without sacrificing performance. After all, when was the last time a cellular phone or notebook computer was advertised as being “bigger and heavier than ever” ? This issue of Technical Tidbits will discuss the necessary design considerations and trade-offs driven by size reduction.

The purpose of an electronic connector is to transmit an electrical current or signal from one component to another with as little alteration of the signal as possible. The ideal connector is one that is transparent to the signal it is carrying (similar to light passing through a clear window). No matter how many times the connection may be engaged or disengaged, the signal quality should remain the same. Over time, an improperly designed connector may lose transparency (much like a window becoming dirty over time will limit the amount of light passing through).

As a signal passes through a connector, it experiences electrical resistance. This causes some of the power in the signal to be converted to thermal energy by resistive heating. If the resistance is great enough, the signal will be completely blocked. Additionally, a large temperature rise in some higher current applications may have several negative effects. Therefore, it is important to keep the resistance to a minimum.

The total resistance of a contact has two components: **Bulk resistance** and **contact resistance**. Bulk resistance is a constant associated with the particular material comprising the contact, and is determined by the conductivity of the metal. Contact resistance is variable and is driven by the interface between two separable contacts. Bulk resistance can be minimized by using a material with high conductivity. Contact resistance can be minimized by maintaining a high normal force between the two contact interfaces. Therefore, contacts are designed to provide the highest practical force.

Contact force is a function of contact geometry and stress. Higher stress means greater force. On the other hand, smaller size means that less contact force is generated. Therefore, as the size of a part decreases, the design stress will have to increase to maintain the same level of normal force. This relationship drives the need for higher yield strength materials which are able to withstand higher stresses. Therefore, high yield strength materials allow a greater decrease in the size and weight of components.

The next issue of Technical Tidbits will include an informative discussion about Cumulative Stress and the Bauschinger Effect.

Size Reduction (continued)

Fatigue resistance is important if a connector is to be engaged and disengaged many times. Higher stress levels will result in fewer mating cycles before failure. The material with the highest fatigue strength for the required number of cycles is the material of choice.

If an engaged contact is exposed to elevated temperatures, it may experience **stress relaxation**. This gradual decrease in remaining stress over time results in a reduced contact force, which in turn increases the contact resistance. This occurs because the apparent contact area decreases, and because there is less force available to push through naturally forming tarnishes or corrosion films. Stress relaxation increases over time, with a rate dependent upon the temperature and the contact's initial stress level. (Similarly, looking out a window at cold weather will do nothing to reduce a person's stress, whereas the appearance of sunshine and warmth may relax a person's stress.) Therefore, it is important to choose a material with good stress relaxation resistance, and to minimize the temperature rise in order to preserve a good contact force.

In power transmission applications, current carrying capacity is related to the amount (mass) of metal in a contact. For example, washing machines require much thicker power cords than electric toothbrushes. As connector size decreases, the current carrying capacity is reduced as well. At the same time, the temperature will rise to a higher level, since there will be less surface area to carry away heat (by convection). Additionally, the bulk resistance will increase with temperature. This forces designers to use higher conductivity materials to make up for the loss in mass of the contact in order to minimize the resistance and temperature rise.

As products get smaller, limitations in the available design space also come into play. To compensate for a reduction in available space, bend radii are made smaller. This has two effects. First, a tighter bend radius will concentrate stress at the bend (obvious to anyone who has driven around a tight curve on a highway at rush hour). The greater stress concentration necessitates the use of a stronger material. Second, the material must have greater formability to withstand a tighter bend without fracturing. As higher strength and formability are not necessarily compatible, the best combination of the two must be selected.

Performance requirements dictate the relative importance of material characteristics in product design. Miniaturization changes the impact of each of the material characteristics discussed above. When designing smaller components, the optimal material will be the one that provides the best combination of yield strength, conductivity, fatigue strength, stress relaxation resistance, and formability given the design requirements. Proper alloy selection will pay big dividends in reduced product failure, warranty costs, and customer satisfaction

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