Improvements in the **R** eliability of **E** lectrical **C** onnectors in **A** utomotive **S** ystems

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Context

Future vehicles will rely to an increasing extent on electronics to control safety critical functions. The development of advanced electronic systems in vehicles is constrained by the reliability of electrical connectors. Multiplexed wiring systems will reduce the number of demountable contacts, but increasingly reliance will then be placed on those remaining.

Aims and Objectives

This part of the RECAS program deals with the environmental conditions to which automotive connectors are exposed and techniques for measuring the actual constriction resistance (see below) of electrical contacts.

Automotive Environment

The harsh conditions connectors have to contend in the automotive environment often make them the weak link in the reliability chain. High levels of vibration, corrosive gases, humidity and temperatures as well as rapid changes in temperature lead to deterioration of the connector.

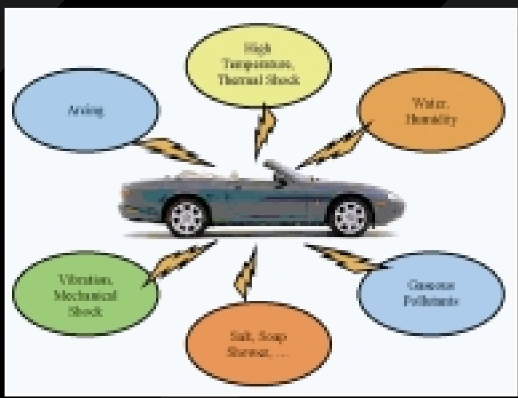

Figure 1: Stresses on Electrical Contacts in an Automotive Environment

Figure 1 shows the stresses on electrical contacts in an automotive environment. High temperature, thermal shocks, water, humidity, gaseous pollutants, salt, soap showers, vibrations and mechanical shocks influence the connector performance. Arcing is rather a problem for switching contacts.

In order to define the automotive environment, we have placed sensors for measuring temperature, humidity and vibration in a Jaguar XKR. The car is running a durability and reliability test under various climatic environments and gives us long term information about what the connector sees during its lifetime.

The data acquisition is currently ongoing. Results are expected in the first quarter of 1999.

Constriction Resistance Measurement

The quantities that are of interest for a detailed investigation into the behaviour of a connector are its constriction resistance and its film resistance. The common method for measuring these values is the four-wire method, although it is well known that the measured value always contains some unwanted bulk resistance. In any one measurement the amount of bulk resistance is unknown, making it difficult to conduct detailed research on contact performance.

Non-linear methods make it possible to measure only the constriction resistance, without being influenced by the bulk resistance. These methods make use of the fact that the constriction resistance exhibits a non-linear behaviour, whereas the bulk resistance behaves linearly. When measuring the overall resistance of a connector, the linear term can be eliminated. The remainder gives the true constriction resistance of the connector.

The usual contact surface has a surface roughness of about 0.2 um. Furthermore the surface is covered with a semi-conducting or non-conducting oxide film as shown in Figure 2. Neglecting surface films an applied current I can be thought to flow through the areas of metal to metal contact called a-spots.

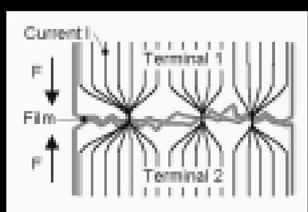

Figure 2: Stresses on Electrical Contacts in an Automotive Environment

This entails a constriction of the current and results in a constriction resistance that produces a voltage drop across the contact.

Because the current density through the a-spots is rather high, the temperature of the a-spot increases and therefore the resistivity and with it the voltage drop across the contact increases even further.

James Whitley suggested several different ways of measuring the true constriction resistance, all based on the non-linear characteristic of the contact. In contrast to the four-wire method, these techniques use an ac current.

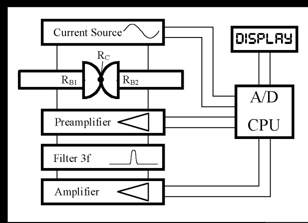

Figure 3: Measuring Arrangement for the Sinusoidal Method

The measuring arrangement for the sinusoidal method is shown in Figure 3. A CPU controls the current source, which produces a sinusoidal current that is applied to the contact. The voltage across the contact is preamplified and passed through a filter, sharply tuned to the third harmonic of the fundamental frequency.

The filtered signal is then amplified and converted into a digital value. Now the CPU can calculate the true constriction resistance and display it. When the CPU also measures the voltage across the contact, it can at the same time display the resistance measured using the four-wire method. This gives a measuring device that can be used universally for measuring constriction and ohmic resistances.

The future objectives are the improvement of the measuring device by applying refined contact theory and to build a device that can directly be used in an industrial environment.

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