Slip rings connect reliably CAN bus-lines

Especially in construction machine and equipment, slip rings are used to transfer data signals and power to rotating cabs. Intermittent open or high resistance needs to be avoided, to guarantee a reliable signal transmission.

Slip ring for power and signals (Source: Moog)

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There are slip rings available, which enable CAN communication with bit-rates up to 1 Mbit/s and above. They achieve this with an excellent Bit Error Rate (BER) over the life of the system. When we refer to BER, we are speaking the “language” of data reliability. A stable, well-formed eye pattern is the most important element of low BER and reliable data transmission. But in the case of electrical contacts, bit errors can also be caused by intermittent open circuits in the transmission line as a result of high (or even open) resistance between the contacting members of electrical contacts. These resistance changes are often called contact noise or sometimes “microcuts.” For example, fretting wear/corrosion can cause resistance in electrical connector pins to go high enough to create intermittent open circuits (bit errors). Slip rings are constructed with sliding electrical contacts where conducting brushes, or wipers, slide along circular conductive ring surfaces to allow electrical contact during rotation.

Slip rings in construction equipment

Reliable data transmission through slip rings requires control of the conditions that cause closed eye patterns as well as intermittence opens or high resistance. Proper materials, good electrical design, and environmental protection of the sliding contacts accomplish this control. It is important to understand that many of these design aspects are also crucial for the reliable transfer of power, as well as data. For example, the transfer of power on sliding electrical contacts is very dependent upon an enclosure that protects the contacts from the environmental effects of contamination and most especially moisture.

Ring brush assembly showing six contact elements (Source: Moog)

Proper contact materials and contact design

CAN data transmission through electrical contacts has had a significant impact on the contact materials used to transfer the data. Some contact materials that have been used successfully in the past cannot transmit error-free digital data because of unreliable contact resistance. Contaminants produced by wear debris and surface films can produce high resistance events that produce bit errors. Noble metal electrical contacts should be used for electrical contacts transmitting digital data. These un-reactive (i.e., noble) metals resist corrosion and surface filming thereby providing consistently low contact resistance. The reliability of electrical contacts is greatly improved with redundancy.

Figure 2 shows a ring with a brush assembly with six independent precious metal contact elements per ring. This redundant contact arrangement virtually eliminates the potential for an anomaly (e.g., contaminating particle) to effect all brushes simultaneously resulting in very low BER (10-12 or better). Proper brush design must also take into account the shock and vibration environment found on construction equipment. Again, redundancy is important as is the contact force and the relative mass of the brush in order to keep the resonant frequency of the brush well above operating excitation frequencies.

Electrical design for RF

It is generally believed that resistive contact noise (intermittent high resistance events) is the primary limit to slip ring bandwidth. But just as important to reliable data transfer is proper electrical design that does not filter the high frequency components of a digital signal (see Figure 3). Any component (slip ring, connector, relay, etc.) inserted into a digital data transmission line will have an effect on the BER of the data transmission because of the impedance discontinuity or mismatch placed in the data path.

The magnitude of the impact on the signal transmission is a function of the length and magnitude of the impedance mismatch as well as any phase imbalance introduced into the transmission line. Connector selection, lead and shield termination, ring and brush impedance, as well as a number of other design and manufacturing considerations, have a significant impact on data reliability. Slip ring engineers who design slip rings to handle communication data must specify proper internal design features to control the amplitude and length of the impedance mismatch as a function of the data speed and type. Crosstalk can also be problematic in slip ring design. Placing a number of power and data circuits in relative close proximity in a housing requires careful attention to the isolation of noise sensitive channels from noise producing channels. Careful physical spacing and shielding accomplish this.

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