Effective Isolation for Better Protection in Test and Measurement Equipment

White Paper

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For higher accuracy data acquisition systems, it is a challenge for the test and measurement equipment designer to measure small signal variations when high common mode voltages (wanted or unwanted) are present. These high voltages exist due to the different potential in the two grounds or any sudden transient over voltages due to lightning strikes or power surges from motors or switching devices. These voltages do not only impact on the accuracy of the measurement, but also damages the test systems and cause hazards to people operating the tester.

Isolators are needed to physically and electrically separate two systems to protect against sudden voltage surges between two circuits or systems. They are used to provide a higher common mode voltage range; common mode voltage is that voltage that appears simultaneously between both measurement signal leads and a common ground. For example, when measuring the voltage across a specific cell in a series connected string of battery cells a high common voltage range is important. Isolators are also needed to break up ground loops, which are the unwanted currents between two points that share a common path in an electrical system. This is widely used in instrumentation probing systems that measure differential voltages. In addition, isolators can serve as a level shifter to solve incompatibility of voltage levels between systems or circuits.

Isolators used in measurement equipment are important not only to safeguard the system itself but also to protect people. Equipment manufacturers are governed by safety standards which cover the design of high voltage instruments. Currently, there are two main standards: the IEC 61010-1 for test-and-measurement instruments and the IEC 60950-1 for information-technology equipment. In these standards, 30 Vrms and 42.2 Vpeak or 60 VDC are considered dangerous voltages. Isolators are needed in these user-accessible, safety-extra-low-voltage circuits.

There are many different types of isolators with different insulation ratings on the market. They are grouped into functional, basic, double and reinforced categories. Functional isolators do not provide protection against electrical shock. Basic insulation provides only a single basic insulation level not accessible by the user. Double insulation consists of additional supplementary insulation on top of the basic insulation to provide protection against shock. Reinforced insulation is a single insulation that provides electrical shock protection equivalent to the double insulation and ensures the failsafe mode.

Failsafe is a mode of system termination that automatically leaves the system processes and components in a secure state when a failure occurs or is detected in the system and thus allows user accessibility. Besides the insulation type and the working voltage rating, the standard also specifies the required spacing, creepage and clearance of isolators for different types of equipment. The creepage distance is defined as the shortest surface path over a solid dialectic between two galvanically isolated conductors. The external clearance distance is the shortest distance through air or "line of sight" distance between two galvanically isolated conductors. For example, 3 to 4 mm of creepage is required for systems operating with a peak working voltage of 300 V.

Isolators are grouped depending on the signal transmission technology. There are three main types: magnetic, capacitive and optical isolators. Transformer-based (using magnetic coupling) isolators are generally more efficient and are used for very long distance applications. They absorb unwanted frequency instead of providing "true" isolation and are susceptible to magnetic interference. Capacitive isolators transmit data across an oxide barrier. Due to the capacitive nature of the device, it is subject to high frequency noise at high operating frequency, with lower transient immunity and lower isolation voltage. The most popular isolator is the optical isolator (also known as the optocoupler). Optocouplers use an optical signal transmission through air. These optical signals are immune to EMI interference. In addition, the galvanic isolation, up to 5 kV, is achievable in various package sizes to meet system space or 8 mm creepage/clearance requirements. In the past, the operating frequency range for optocouplers was limited. With new breakthroughs in technology, optocouplers can now transmit signals as high as 50 MBd, with low propagation delay, 22 ns, to transmit high frequency data.

Avago Technologies' optocouplers are designed to provide reinforced isolation and are certified and approved under IEC/EN/DIN EN 60747-5-2, which is an international standard for optically isolated semiconductor components. In addition, Avago optocouplers, with common mode rejection as high as 30 kV/μs, ensure that high common mode transients will not impact the output logic levels

Optocouplers are effective components in passing the intended differential-mode signals while blocking the unintended common mode currents (and the resulting ground offset voltage) that can result from ground loop currents. Figure 1 shows an example of how optocouplers are used in a data acquisition module.

Safety isolation is important for test and measurement equipment to ensure data integrity and to protect the equipment operator. Isolators are selected not only for their speed performance, but also – and most importantly – on the insulation level and rating to conform to internationally recognized safety standard requirements.

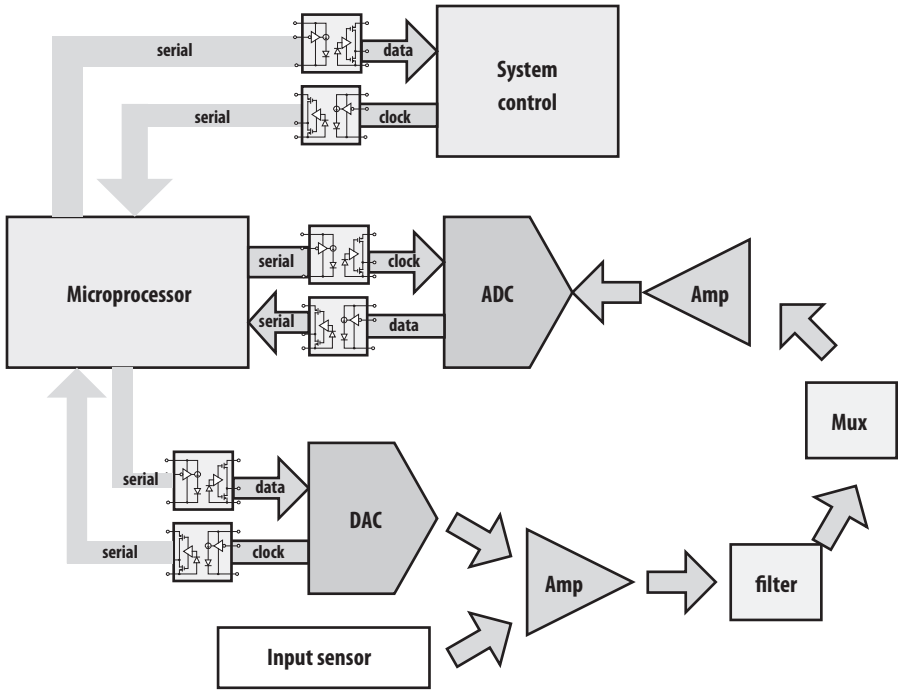

Figure 1. Avago digital optocouplers (ACPL-072L-000E, HCPL-0723-000E and ACSL-6400) used in the data acquisition module of a test and measurement instrument

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AV02-2425EN - March 23, 2010