Electromechanical system testing

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One of the challenges for engineers involved with the development or maintenance of complex electromechanical systems is to link the behaviour in one part of a system to control signals in another. In particular, engineers often need to understand causality: the relationship between an event (the cause) and a second event (the effect) to obtain an insight into an electromechanical system's overall behaviour and to plan corrective actions accordingly.

Typical examples might be: relating a misalignment in a paper press to a failure of an actuator or a missing control signal; how the efficiency of a wind turbine can be affected by failure in an electric drive for controlling the pitch of the turbine blades; and what might cause an unexpected failure in a vehicle's power train?

For many years, the instrument typically used in the electronics sector for recording varying signals across multiple channels was a 2- or 4-channel oscilloscope. However as a mechanical system typically contains a variety of signals from multiple control channels, sensors and actuators, four measurement channels are often insufficient to find the cause of an event. The result is that the engineer is faced with a challenge in relating the behaviour of an individual component to the overall performance of the system using an oscilloscope type of instrument.

Waveform recorder

One possible solution is to use an instrument which combines the properties of a digital oscilloscope with those of a multi-channel waveform recorder. An instrument that offers oscilloscope users a familiar interface but adds a diverse set of electrical and mechanical inputs. In order to connect a sufficient number of signals and sensor outputs, this instrument can be configured with up to 128 measurement channels which can include a variety of electronic, power and mechanical signals. The ScopeCorder also offers some advanced analysis tools to support causality analysis over longer measurement periods than a normal oscilloscope can handle. Yokogawa's DL850 ScopeCorder is a portable instrument that combines the benefits of a high-speed oscilloscope and those of a traditional data acquisition recorder. Due to its large acquisition memory, it is able to capture and analyse both long-term trends (recording up to 30 days) and microsecond events (sampling at 100 MS/s), making it suitable for the measurement and fault analysis of nearly any type of electromechanical system. The ability to handle multiple input signals results from the use of a diverse range of plug-in input modules which have built-in isolation and signal conditioning to allow

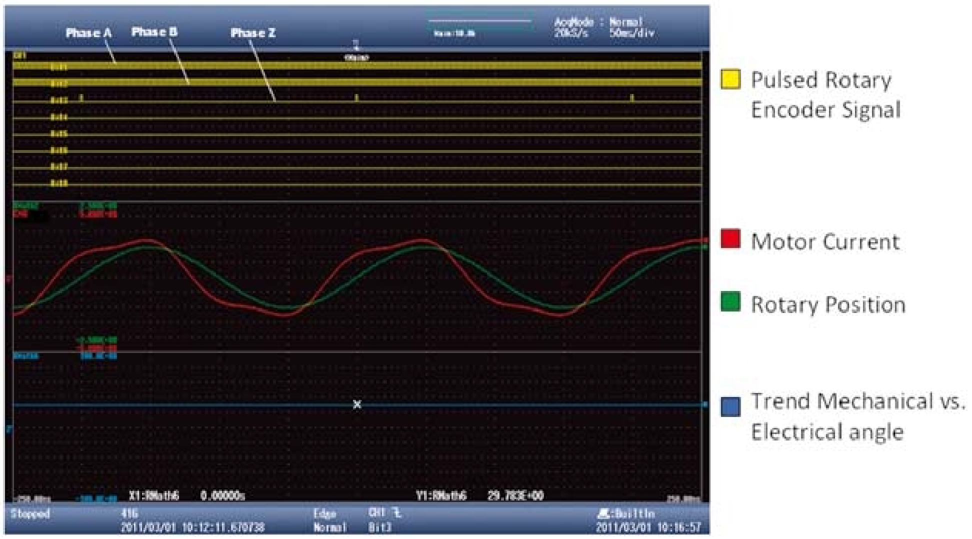

Figure 1. DL850 screen display showing a rotary encoder signal plotted against motor current

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the direct connection of high voltages (up to 1 kV) and high currents (using passive and current probes). Furthermore, a wide range of sensors can be connected to dedicated input modules to measure physical parameters such as temperature, vibration, strain, torque, rotation and frequency. The ability to combine these electrical and physical parameters makes this instrument applicable for analysing equipment such as inverters, transformers, control signals and actuators that are found in electromechanical systems. The use of on-board analysis tools like cursor and waveform parameter measurement provides easy access to waveform data over longer periods of time. In addition, a recently introduced real-time mathematics option uses digital signal processing (DSP) technology to offers a set of functions that are uniquely suited to supporting specific electromechanical applications.
One example of such a DSP function is the support for connecting a rotary encoder. A rotary encoder, also called a shaft encoder, is an electromechanical device that converts the angular position or motion of a shaft or axle to an analogue or digital code. The output of incremental encoders provides information about the motion of the shaft, which is typically further processed elsewhere into information such as speed, distance, RPM and position. Rotary encoders are used in many applications - including industrial controls and robotics - that require precise unlimited shaft rotation. A rotary encoder's output signal can be connected directly to the oscilloscope without the need for any other signal conditioning. The instrument will process these signals and provide a trend display of the encoder position as a waveform on the screen.

Physical Position

This could represent, for example, the shaft position of the bar roll of a printing machine or a shaft driving the turbine of a wind-powered generator. Linking this physical position to the voltage, current and control signals in an electrical drive will provide a unique insight into the system's behaviour.
Similar applications are encountered with electric motors, which are frequently found in an electromechanical system and can range from the smallest - in a digital watch, for example - to the largest - that might be found in a ship's propulsion system. When an electric motor is operating, load conditions may vary and the motor can take a few seconds to "catch up". When an in-depth analysis of an electric motor and its drive is required during these varying load conditions, the instrument can automatically determine and display the angle between the motor's mechanical position (derived from a rotary encoder) and the fundamental current waveform of the motor drive (using a Discrete Fourier Transform). The effects on system performance due to load variation can therefore be analysed.
To further investigate the performance, a set of the steepest digital frequency filters of low-, high- and band-pass characteristics are provided with the instrument to help to isolate specific frequency components. Another area where the DSP capabilities provide assistance is in basic power measurement on either single- or 3-phase devices. Using the instantaneous power graph, a cycle-by-cycle waveform of the active power is displayed. This provides valuable insight into power behaviour during mechanical displacement cycles. To determine the electrical power consumption during a complete mechanical process, a function called "power integration" monitors the consumption in real time as the mechanical process progresses.

Temperature measurement

A recent enhancement to the DL850 ScopeCorder is a 16-channel temperature/voltage module, designed to be used in conjunction with a scanner box, which allows the instrument to be used for simultaneous measurements on temperature and voltage inputs. This is often required in electromechanical tests where temperature change or heating is expected and needs to be monitored along with electrical parameters and physical ones such as pressure and strain. Up to 16 channels of temperature or DC voltage data can be measured by the module, with the thermocouple or electrical connection being provided by a screw terminal on the external scanner

box. Input terminal blocks contain the reference junction compensation circuitry and are isolated from ground. Isolation is also provided between channels within the input terminal block.
Excellent noise rejection is provided by using a delta-sigma analogue/digital converter which uses oversampling and digital filtering technologies to eliminate noise.

Transport applications

A Vehicle Edition is a version of the ScopeCorder waveform acquisition and recording instrument is designed to meet the requirements of the automotive and transportation industry. An important new feature of this instrument is a CAN and LIN Bus monitor module for carrying out key tests on these increasingly popular automotive bus protocols. The CAN and LIN Bus monitor module interprets CAN and LIN protocols, monitors communication data on these buses, and displays this data as waveforms on the screen. Instead of digital code (hex or numeric), the user can define and monitor the target signals using CAN DBC or LIN LDF network definition files. Using this instrument with this new input module, a great deal of measurement time is saved as an engineer can decode the bus signal and retrieve information on physical data, like engine temperature, wheel speed and braking, and compare this with the data coming from real sensors. A 12V DC power supply option allows the instrument to be taken for a test drive in a car, train or other vehicle by supplying the instrument with power from a vehicle's battery. Moreover, the DC power supply can be used together with AC power to ensure measurement data protection in, for instance, railway environments where there is an unstable power supply. If the AC power goes down, the instrument instantly switches to the DC input without interrupting the measurement itself.

Figure 2. Typical electromechanical system that presents a challenge to conventional test & measurement techniques but which can be analysed using the DL850 ScopeCorder

Conclusion

Electromechanical systems are assuming increasing importance in many different walks of life, and the special challenges involved in testing and debugging their operation call for measuring instruments with new combinations of features. The ability not only to make multi-channel measurements on a variety of electrical, electronic and mechanical signals, but also to display and analyse the results in a form that greatly assists in understanding the "cause and effect" processes at the heart of many system problems. Industries as diverse as alternative energy, transport and industrial automation will greatly benefit from the use of these versatile measurement tools.

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