Versatile power measurements using real-time mathematics

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In recent years, there has been an increased emphasis on energy efficiency in industrial systems, resulting in more penetration of power electronics in equipment such as inverters and motor drives.

Optimising the energy efficiency of power devices used in these systems present considerable challenges for product designers and developers.

Further challenges are presented by electromechanical systems involving motion control and sensing devices, where the effects of multiple electrical and mechanical variables need to be taken into consideration.

In working with these energy-saving devices, various measuring instruments are required for checking and measuring the different parameters affecting their successful and efficient operation. These instruments typically record basic electrical parameters such as voltage and current.

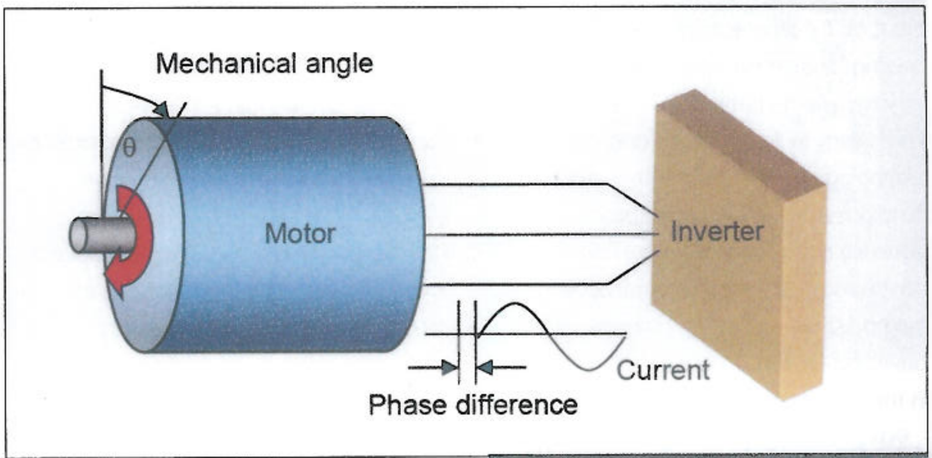

Figure 1: Measuring the electrical angle of a motor to maximise the energy savings.

However, for energy efficiency evaluation other parameters such as power value and power efficiency need to be derived, which involves processing the original data using mathematical operations.

In addition, for overall efficiency measurements in mechatronic applications, physical quantities such as speed of revolution and torque of a motor have to be measured and processed to obtain the amount of mechanical work involved. These measurements are taken using sensors optimised for the particular physical quantities being measured, and the outputs from these sensors then have to be converted into electric signals.

Measuring

The situation is further complicated by the fact that the electric output of the sensor may not always vary in a linear fashion with the physical quantity, so additional signal processing is often required between the sensor and the measuring instrument. The physical quantity measured in this manner is an instantaneous value, so calculations such as time-series integration are required to obtain the amount of mechanical work.

This all means that simple measurement is not sufficient to evaluate the energy-saving efficiency of an industrial device; a large amount of data needs to be collected and then processed.

Conventionally, the data collected by a measuring instrument is transmitted to a PC for linearisation and processing to obtain the derived values needed to evaluate the target device. In traditional test instruments, however, these processes are carried out in sequence, which creates a bottleneck in the measurement process.

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What is required is a measuring instrument that can perform both measurement and data processing tasks, and then produce the results in real time. A new development that enhances the capabilities of the Yokogawa DL850 ScopeCorder introduces a function for processing measured data and recording the results in real time.

The term ScopeCorder has become a generic description of a powerful multi-channel measuring instrument that combines the benefits of a high-speed oscilloscope and those of a traditional data-acquisition recorder in a single versatile portable instrument.

As an oscilloscope, it can capture events using various triggers, measure waveform parameters easily, calculate power-related values in real time and trigger on them. As a data-acquisition recorder, it has multiple isolated input channels (with up to 1kV input), can capture detail with 16bit ADCs, can measure for periods ranging from milliseconds up to 30 days, and combines electrical, physical and CAN/LIN bus measurements.

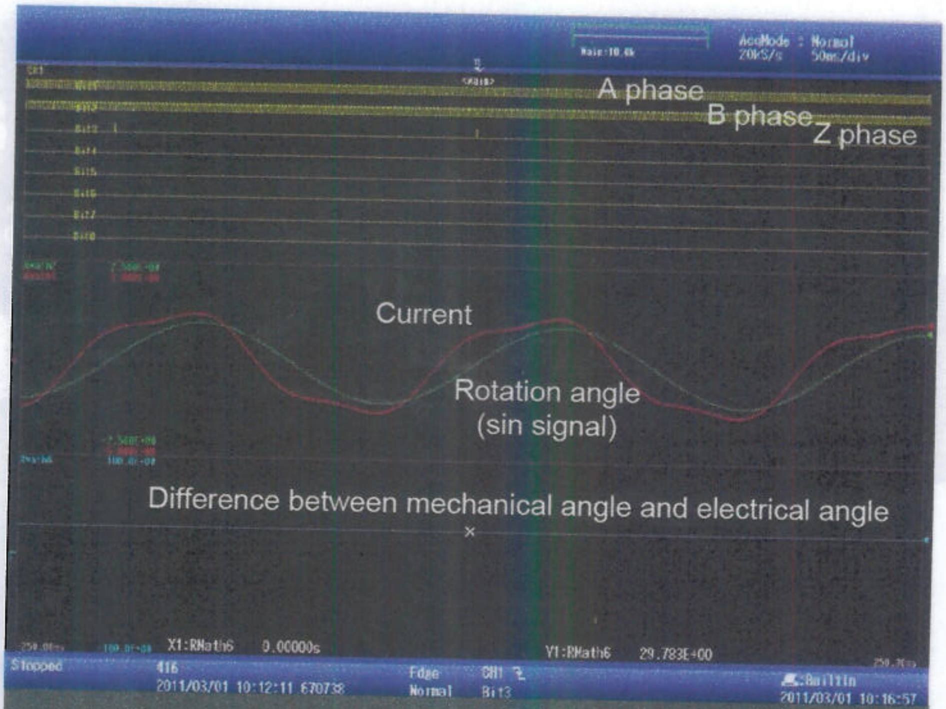

Figure 2: Industrial users value the single overview of electrical, mechanical/physical and calculated waveforms.

Real-time capability

With the real time capability, it enables live evaluation of prototypes and the execution of experiments in order to make quick adjustments and increase efficiency in the development or fault-finding process.

The basic DL850 ScopeCorder has eight slots for input modules. Depending on the target devices, any of 17 different modules can be selected and combined to directly connect various sensors and measure physical quantities. Basic performance covers a sampling rate of up to 100Msample/s and includes a memory capacity of up to 2Gpoints. With the high-speed 100Msample/s 12bit isolation module, it can measure the output voltage of an inverter over a broad bandwidth of 20MHz and up to a high dielectric strength voltage of 1000V. With the 16-channel voltage input module, it can measure the voltage of up to 128 channels. In this way, a single DL850 can perform multi-channel high-speed sampling as well as long-term measurement.

The real-time input module consists of two units: the digital filter unit and the calculation unit. Both units can operate independently and simultaneously, perform processing for 16 channels each.

Filters in the digital filter unit can be selected from low-pass, high-pass, and bandpass filters of a FIR (finite impulse response) or IIR (infinite impulse response) type, or

Gaussian and moving average filters. Processing time of the digital filter is up to 1Msample/s in 16 channels at the same time.

In the calculation unit, a processing method can be set for each channel, and is performed by using one of 28 built-in computing functions. They include fundamental functions such as four arithmetic operations, square root and logarithm, plus applied functions such as electric power calculation and electrical angle calculation. As a result, desired results can be acquired simply by selecting the appropriate computing functions without the need for complicated settings. The results of the real-time calculation can be used in other calculations, for complicated calculations, combining multiple computing functions.

Calculations are implemented in hardware, so high-speed calculations of up to 10Msample/s are possible in 16 channels at the same time.

Applications

Typical applications include combined measurement of transient power, from devices such as inverters and variable-speed drives, along with control signals and other parameters such as temperature. Measurement of the electrical angle of a motor to maximise the energy savings by optimising the torque characteristics of motors (Figure 1) depends on the phase difference between the mechanical angle of a motor - the absolute angle of the motor rotating shaft - and the electrical angle of an exciting current enabling measurement results of a rotating body to be displayed in polar co-ordinates in real time. This is useful, for example, when measuring the wobbling of a rotating body.