

Allen-Bradley tests the 87V digital multimeter

Troubleshooting adjustable-speed motor drives

Technology at Work



The problem? The pulse width modulated (PWM) ac voltages created by ASDs contain very high crest factors that can confuse digital multimeters (DMMs) into producing inaccurate readings.

But tests earlier this year at Rockwell Automation in Mequon, Wis. showed that a new digital multimeter, the Fluke 87V, cuts through the clutter to read ASD voltage and frequency with precision.

"You can very easily measure the voltage and the frequency with that meter, and determine what the volts-per-hertz are," says Rockwell Automation principal engineer Dennis Braun, P.E., who took part in the testing. "That's very good information."

The ASD advantage

When connected to the mains, the rotation speed of an AC motor is directly related to the mains frequency and the number of poles of the motor. These motors are robust and require little maintenance, since they have no brushes that would need regular replacement. Traditionally, however, an external gearbox or belts were the only way to provide varying output speeds with ac motors.

This all changed with the introduction of high-power semiconductors, which made it possible to build variable speed drives that electronically create a supply voltage that operates at different frequencies. These ASDs provide a convenient and affordable way to vary the speed of AC motors. AC drives using pulse width modulation have found their way into many applications, such as fans, pumps and conveyor belts driven by

No wonder they're popular. Adjustable-speed AC motor drives help industry save energy, provide precise process control and help motors and equipment last longer.

For the maintenance electrician assigned to keep them operating at peak efficiency, however, adjustable-speed

drives (also known as variable-frequency drives) have posed a challenge. Until now, the hand-held digital multimeter — tool of choice for taking electrical measurements in the field — was incapable of accurately measuring the voltage and frequency created by adjustable-speed drives (ASDs).

squirrel-cage asynchronous AC motors. But this success has created the need for new measurement capabilities, such as those provided by the Fluke 87V.

The motor

AC motors are designed for use with a rotating magnetic field of constant strength. The magnetic field is generated from the applied voltage and its strength is proportional to the V/Hz ratio. Normally the motor is designed to work with the local supply voltage (230 V/480 V or 120 V/208 V) and supply frequency (50 Hz or 60 Hz). When the motor is connected to an ASD, the drive unit changes the frequency of the output voltage, thereby changing the speed of the rotating magnetic field and thus the speed of the motor.

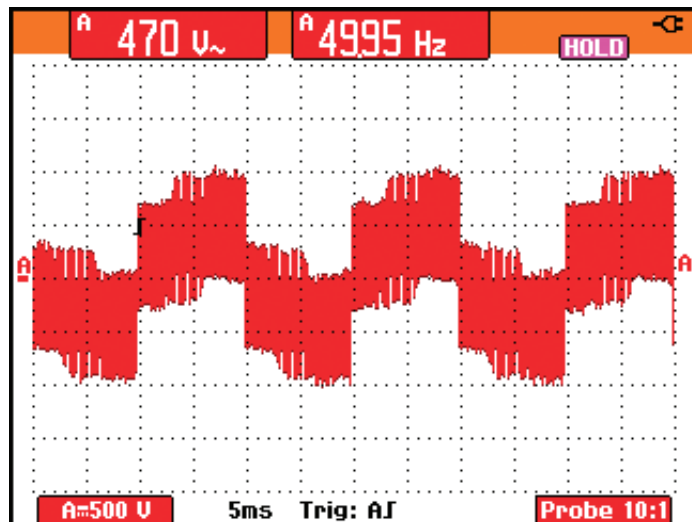
Lowering only the frequency, however, will generate a higher magnetic field since the V/Hz ratio increases. This will result in magnetic saturation, which causes unstable running and generates higher temperatures in the motor. Conversely, increasing the frequency decreases V/Hz ratio, reducing the magnetic field and resulting in lower torque.

To overcome these problems, the ASD also varies the voltage when the frequency is varied, to maintain a constant V/Hz ratio. Preferably this is done over the complete working range of the ASD. For example, you need 460 V at 60 Hz, or 230 V at 30 Hz, and so on. The control type used in this case is called is V/Hz Control, which in its simplest form takes a speed reference command from an external source and varies the voltage and frequency applied to the motor.

A challenge for older meters

The inaccuracy affecting earlier meters stems from two factors: bandwidth and shielding.

Many of today's digital multimeters have bandwidths out to 20 kHz or more. So in addition to the fundamental frequency component, which the motor really responds to, the meters also read the high frequency



Oscilloscope view of a pwm motor drive signal

components generated by the carrier frequency of the PWM drive. And if the DMM isn't shielded for high frequency noise, the drive controller's high noise levels can make the measurement discrepancies even more extreme.

With the bandwidth and shielding issues combined, many multimeters will display readings as much as 30 percent higher than what the drive controller shows. They may read the carrier frequencies instead of the fundamental frequency on the output side of the ASD. This reading would be in kilohertz, a thousand times higher than the fundamental frequency that matters to the motor.

So in the past, field technicians had few good choices: rely on the readings calculated by the drive itself, return to the office for an oscilloscope, or guess.

"If they didn't have a scope, what they would have to do is take a look on the drive, and just hope that its voltage reading is correct," says Rockwell Automation's Rick Hoadley, technical program manager, engineered drives business. Because the ASD output voltage value is calculated, and not an actual reading, the technician could not rule out problems with the ASD itself. In addition, because the motor can be hundreds of feet distant, the voltage at the motor can differ significantly from the reading at the ASD.

The ASD troubleshooting solution

But the new model 87V digital multimeter from Fluke Corporation, a Rockwell Automation Encompass Program™ partner, delivers accurate drive output measurements with the push of a button. Now troubleshooters don't have to guess whether a drive is operating correctly and delivering the correct voltage, current and frequency for a given control setting.

The Fluke model 87V incorporates a button-selectable low pass filter that enables the 87V to precisely measure voltage and frequency on ASDs.

"Those are two parameters which are critical for operating a motor properly," says Hoadley, who tested a pre-production version of the Fluke 87V at the home of Allen-Bradley drive production in Mequon, Wis. Using a mobile demonstration unit equipped with an Allen-Bradley PowerFlex® 700 AD Drive and two 15-horsepower motors—one used to create a load for the drive-controlled motor—the Rockwell Automation team put the Fluke 87V DMM to the test. They assessed performance at frequencies from 5 Hz to more than 60 Hz, measuring voltage and frequency both with and without a special sine wave filter used on the mobile unit to demonstrate harmonic mitigation and reflected waves with ASDs.

Result: The Fluke 87V DMM did its job, and delivered accurate voltage and frequency readings with or without the sine wave filter in place.

"We measured the output voltage with the meter, and it really did track the voltage of the drive," says Hoadley. "To have a meter to do a quick check to see what's going on really is important, especially in the field, for troubleshooting. The technician or engineer can take a quick look, calculate the V/Hz ratio and say, 'all right, I'm basically where I should be for this motor.'"

In addition to its unique ability to accurately measure ASDs, the Fluke 87V boasts a new thermometer function and convenient "third hand" magnetic hanger, and provides an important line of defense against workplace accidents. Rated for use in 600 V CAT (category) IV and 1000 V CAT III environments, the 87V is engineered to withstand voltage spikes of 8 kilovolts and reduce risks related to surges and spikes that can cause arc flashes.

