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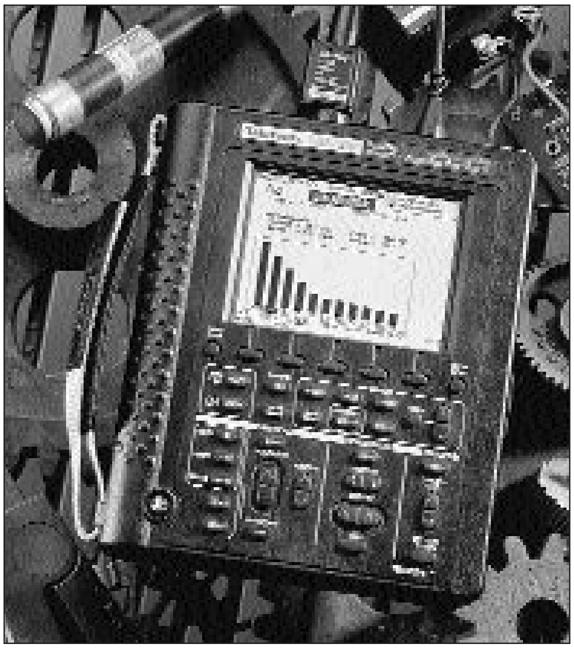
Application Note

Power Quality Measurements Solve Problems in Industrial Motor Circuits



The Tektronix THS720P Oscilloscope/DMM offers harmonics measurements and motor trigger capabilities for power quality applications.

Power quality measurements are key indicators of the performance, efficiency, and safety of a power circuit. As always, selecting the right tools is a basic step in making such measurements. This application note explains the use of a Tektronix THS720P TekScope® handheld Digital Real-Time oscilloscope and an A621 Current Probe in analyzing power quality in an AC induction motor circuit powered by a flux-vector control drive.

Power Quality is a Two-Way Street

Industrial equipment ranging from computers to conveyor motors relies on clean sinusoidal power, both voltage and current. Yet ironically, that same equipment can cause voltage and current waveform distortions along with increased neutral currents that can damage or disrupt other equipment. Measuring and analyzing a power circuit's harmonic structure can help locate the cause and point toward solutions for the problem.

In particular, the odd harmonics are of interest in motor circuits. The "zero-sequence" harmonics (the 3rd and its odd multiples) tend to create high currents in the neutral return path connection. Negative-sequence harmonics such as the 5th produce a subtractive torque in the rotor-energy in the direction opposite the normal rotation. The motor delivers less usable energy to the load, with the remainder becoming wasted heat that degrades the motor's service life. In addition, voltage distortion can show up on the output from the motor drive if there are long conductors between the drive and the motor.

The Oscilloscope's Role in Power Measurement

IEEE Std 519-1992 lists recommended power harmonic measurement tools, including oscilloscopes. The publication cites the scope's ability to provide qualitative information about waveform distortions. The Tektronix THS720P Digital Real-Time oscilloscope has several advantages over conventional scopes in this type of application. It's optimized to provide safe, isolated-channel measurements on grounded or floating power circuits and it features comprehensive built-in facilities for measuring and analyzing line harmonics. The matching A621 Current Probe is a non-invasive clamp-on probe of a type also recommended in IEEE Std 519-1992.

The Application

Flux-vector AC motor drives are often used in applications where a smooth, steady torque output is required; for example, cranes, extruders, and robots. The flux-vector motor drive makes a simple AC induction motor behave much like a DC motor; that is, it provides up to 100% of continuous rated motor torque at 0 RPM. Flux-vector drives are current-source drives that deliver and regulate the torque-producing current to the motor. Their voltage output is of secondary interest only. Current sensors in the drive unit send feedback signals to a control board to achieve flux-vector control.

The unit-under-test (UUT) in this application is a flux-vector motor drive connected to a three phase 480 V/40 HP AC induction motor driving a 10-ton tank-house crane. The tank-house crane is used to lift wet-cell collector plates which are extracting copper from an electrolytic bath solution. Although massive currents flow through the collector plates (on the order of 35,000 A at 2 V!), currents in the motor circuit are more docile – on the order of 52 A under full load. The problem is a failure in the motor's winding insulation, an unusual occurrence considering the short time the motor has been in operation.

The first step in troubleshooting this problem is to characterize the harmonic structure of the power waveform supplying the motor drive itself. Using the A621 current probe with the THS720P scope, the measurement is a straight forward waveform capture. The probe's jaws encircle one conductor of the three-phase power line and pick up the current field magnetically without disturbing the circuit.

Having acquired the current waveform, the next step is to examine its harmonic content. The THS720P's Harmonics

[1] IEEE Std 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems," IEEE, Inc., New York, New York, 1993.

mode can display the fundamental frequency plus selected harmonics through the 31st harmonic. The information is calculated by an automated internal Discrete Fourier Transform (DFT) function. In this measurement, since the odd harmonics are a potential cause of the problem, the "Odd from F to 21" mode is selected. Figure 1 shows the resulting display.

This waveform has some 5th harmonic content, plus small contributions from the other odd harmonics, with the exception of the odd harmonics divisible by 3 (9th, 15th etc). This is typical of the current waveform from a motor-drive load with a rectifier bridge at its input. The absence of the odd harmonics divisible by 3 is characteristic of drives using a three-phase, six-pulse bridge rectifier. All in all, the harmonics display reveals that harmonic currents are not likely to be the source of the problem.

The next step is to use the THS720P and its standard P5102 High Voltage probe to measure the voltage at the output of the drive system. The scope's Motor Trigger function helps to capture the critical part of the waveform cycle. Figure 2 proves that the motor drive output voltage waveform has excessive ringing, on the order of 700 volts above nominal.

The motor in this tank-house crane application is rated for 480 VAC operation, and the overvoltage is causing the motor insulation to break down. The ringing is caused by the fact that the drive unit is almost 300 ft away from the motor, which is mounted high above on the crane boom. The best temporary solution is to install reactors (inductors) in series between the drive and the motor to alter the resonant frequency and reduce ringing. Then when production schedules permit, facility engineers can take the crane out of service and relocate the drive physically closer to the motor.

Conclusion

The THS720P combines the features of an oscilloscope, power meter, and a harmonic analyzer. It makes a powerful and very portable toolset for critical troubleshooting measurements in industrial motor systems.

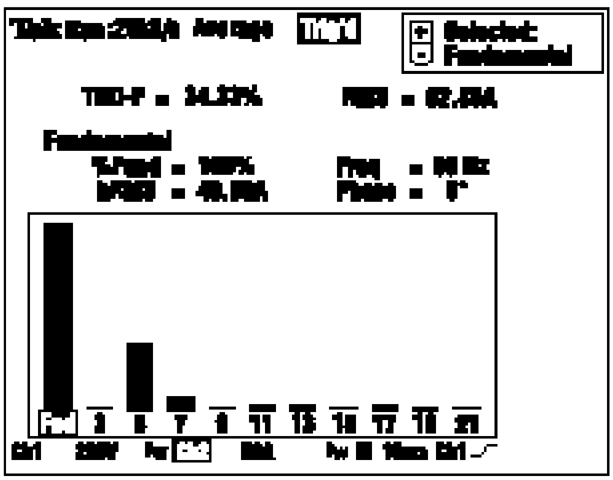


Figure 1. The harmonic structure of the power waveform.

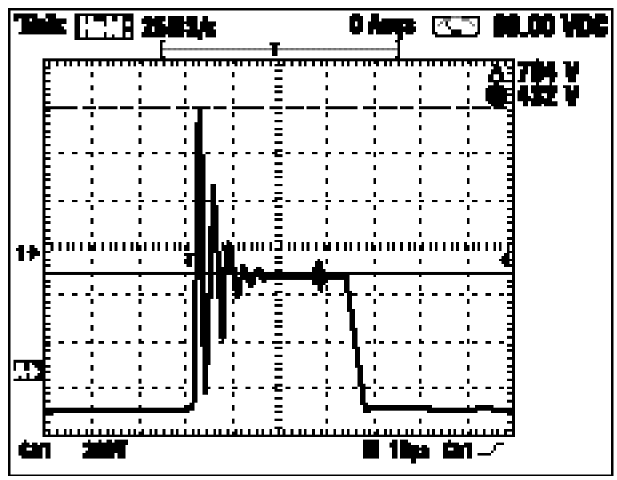


Figure 2. The power output voltage waveform, showing excessive ringing.

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