VTI Instruments / AMETEK PROGRAMMABLE POWER

APPLICATION NOTE

Data Acquisition Instruments and AC Sources Enable Refrigerator Test

Think consumer products and cellphones, smartwatches, and gaming stations come to mind. But white goods, too, present a significant slice of consumer spending, even though the long lifetimes of durable goods discourage frequent replacement. Research And Markets estimate the global white goods market is growing at a CAGR of 5.8% and will reach $969.9 billion by 2028.

Refrigerators represent a particularly hot segment of the total white goods market. Global Market Insights sees the global refrigerator market growing at a CAGR of 7%, reaching nearly $200 billion in 2032 as consumers adopt connected home appliances, including smart refrigerators. All these refrigerators require extensive testing to assure quality and to ensure the appliances comply with applicable safety standards and government-mandated energy-efficiency specifications.

Accurate, Uniform Temperatures

Manufacturers face many challenges in testing refrigerators and other white goods. Temperature, of course, is a key measurement that any refrigerator test system must make. Manufacturers must ensure that temperatures accurately reach the levels set by the consumer and remain uniform within each refrigerator compartment. In addition, the temperatures of compressors and other components might be required to conform with specifications set by relevant standards bodies such as ANSI and ISO.

In addition to steady-state temperature regulation, refrigerators must recover within specified times to transient events such as occasional or frequent door-opening and -closing cycles or wide, rapid swings in ambient temperature. In addition, they must tolerate swings in power-grid voltage and frequency fluctuations and recover quickly after power outages or brownouts. The tests can take place in a test environment mimicking regular day-to-day operation, and they can be repeated in an accelerated aging test procedure aimed at determining the lifespan of a particular appliance.

Emphasis on Efficiency

With today's focus on green energy and carbon reduction, energy efficiency is a critical specification that manufacturers of refrigerators and other white goods must measure to attract customers and meet government requirements. In the United States, for example, manufacturers of appliances carrying the Energy Star label must prove that their products meet U.S. Environmental Protection Agency guidelines. In addition, the U.S. Federal Trade Commission requires that all appliances, whether or not they have earned the Energy Star designation, carry an EnergyGuide label that reports estimated annual energy consumption and an efficiency ranking that enables consumers to compare each product with similar ones.

The emphasis on efficiency and the stringency of the tests necessary to ensure optimum performance can only be expected to grow as jurisdictions impose ever more stringent standards on energy savings. For example, the U.S. Department of Energy in February 2023 proposed new energy-efficiency standards for refrigerators and clothes washers that aim to lower household energy costs and reduce pollution. The DOE expects the new standards to save American consumers approximately $3.5 billion annually on their energy and water bills. The DOE said that today's typical new refrigerator uses 75% less energy than its 1973 counterpart while offering roughly 20% more storage capacity in response to the DOE having raised efficiency standards for refrigerators three times over the ensuing decades.

Worldwide Manufacturer's Application

One worldwide appliance manufacturer performs extensive tests on refrigerators in large walk-in environmental chambers. The manufacturer monitors temperatures within the refrigerator and freezer compartments and the temperature of the compressors and other subsystems within the refrigerators. It also monitors temperatures within the environmental chambers themselves to see how the refrigerators perform in various ambient temperature conditions, and it needs to vary AC input voltages and frequencies to determine how well the refrigerators under test tolerate AC line-voltage fluctuations. Refrigerators are tested in test stands, each testing as many as six refrigerators. The manufacturer operates four test stands in parallel for a total test capacity of 24 units simultaneously.

The manufacturer was looking to expand the number of tests stands it operates and to upgrade its legacy test systems to provide enhanced reliability, reduced footprint, faster sampling rates, and reduced complexity and wiring costs.

Complicating the upgrade, however, was the manufacturer's requirement that each of its many worldwide testing facilities use the same processes and equipment, so the manufacturer needed to see high cost and productivity advantages in any new system to make the worldwide transition worthwhile. Another key factor was compatibility with the manufacturer's proprietary data acquisition software, which lets engineers worldwide access any test facility and analyze test results. The manufacturer needed a solution that could be deployed to facilities worldwide without different software issues arising at various locations.

Thermocouple Measurements

At the heart of the manufacturer's test system are hundreds of thermocouples. Thermocouple temperature measurements require that each thermocouple's dissimilar electrical conductors connect to the copper wires that lead to a voltage-measurement instrument at a constant "cold junction" temperature. If the cold-junction temperature is not 0°C, the measurement will require cold-junction compensation (CJC) to allow standard thermocouple data. The manufacturer used standalone cold-junction cabinets to establish the cold-junction temperatures, a costly, complex approach that proved challenging to wire. Coupled with the cold-junction cabinets were scanning data loggers. Because of those data loggers' low sample rates, each test system required many data loggers in parallel to avoid excessively long times to read the many hundreds of channels of thermocouple voltages.

The manufacturer turned to AMETEK Programmable Power for a new test solution. AMETEK Programmable Power was able to address both the input-power side of the test system as well as the temperature data acquisition side. To test the refrigerators' ability to operate appropriately in response to input power fluctuations, the manufacturer chose AMETEK Programmable Power's Asterion AC AST 1501 single-phase, 1,500-VA sources. They come with LXI, USB, RS-232, and optional GPIB interfaces to fit smoothly into any automated test system.

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Two Data Acquisition Solutions

For the data acquisition side, AMETEK Programmable Power's VTI Instruments brand presented two possible solutions to provide the manufacturer with maximum flexibility. The first involved replacing the legacy data loggers with the EX1048A 48-channel precision thermocouple measurement instruments. This solution would provide accuracy equal to or better than the legacy system at a lower cost. With a sampling rate of 1,000 samples per second per channel, the EX1048A instruments are much faster than the scanning instruments used in the legacy system. The EX1048A features LXI connectivity and supports the IEEE 1588 precision time protocol standard. It enables it to fit seamlessly into multi-instrument automated systems while providing time stamping and data synchronization from multiple instruments.

In addition, these instruments feature internal CJC, combining multiple precision thermistors, a significant thermal mass, and careful parts placement to establish a cold-junction reference temperature, enabling them to provide world-class measurement performance without the need for external cold-junction reference boxes. The EX1048A instruments allow easy thermocouple connection via Mini-TC connectors. The EX1048A also implements an open transducer detection (OTD) function, which applies a nanoampere-level bias current to each input. When the bias current is interrupted, an LED illuminates to indicate a bad channel, simplifying setup and troubleshooting. This first solution essentially represented a drop-in replacement option for the manufacturer's legacy centralized test approach, allowing the reuse of existing cables and patch panels while using only half of the rack space of the legacy solution.

The second solution proposed by VTI Instruments paved the way for a more decentralized testing approach based on the EX1401 16-channel isolated thermocouple and voltage measurement instruments. The EX1401 features a sample rate of 20k samples per second per channel with a 24-bit analog/digital converter for each channel. Like the EX1048A, the EX1401 features LXI connectivity and support for IEEE 1588.

The proposed solution would make use of two EX1401 instruments per refrigerator. The instruments' operating temperature range exceeds the temperature excursions inside the test chamber so that the instruments could be located on top of each refrigerator under test. Each refrigerator could be instrumented outside the chamber using very short wires and rolled in as the test was about to begin. Like the EX1048A, the EX1401 includes an OTD function, internal CJC, and easy-to-use Mini-TC connectors.

The manufacturer ultimately chose a hybrid approach that used the EX1401 instruments but in a more centralized rack-based architecture. The manufacturer appreciated having various options to evaluate and tailor to its specific needs. Also critical to success was AMETEK Programmable Power's ability to provide sample units to the manufacturer's headquarters as well as a remote test facility so different engineering teams could fully evaluate the proposed system and ensure compatibility with the manufacturer's proprietary software.

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From Proprietary to Turnkey Software

To support any customer's programming environment, AMETEK Programmable Power offers a comprehensive suite of drivers, including LabVIEW, IVI-COM, IVI-C, Linux, and Windows drivers. Instruments are also available that can operate without a driver. Such instruments support the Representational State Transfer (REST) architecture and can be controlled using Python or similar, and are operating system independent.

Although the refrigerator manufacturer cited in this application note employed proprietary custom software, AMETEK Programmable Power recognizes that not all customers want or need to write test programs. For such customers, AMETEK Programmable Power offers turnkey software solutions that can get a system up and running quickly with no programming required. The company provides its Virtual Panels graphical user interface that allows remote control and monitoring of its Asterion AC power sources. For VTI Instruments' data acquisition instruments, the company offers EXLab full-featured turnkey software, which offers icon-based setup and control, spreadsheet-style channel configuration, and real-time graphical data analysis. EXLab also supports multiple sample rates, allowing users to record low-speed and high-speed data using the same measurement system.

Beyond Temperature

Refrigerators and other white goods often require measurement of parameters beyond input power and temperatures. Vibration and audible noise measurements are also of key concern as manufacturers strive to minimize noise from compressors and fans. In addition, appliances must undergo durability testing involving materials testing and measurement of stress and strain on hinges, handles, and other mechanical components. Electrical safety testing can involve insulation-resistance tests and leakage-current measurements to ensure compliance with relevant safety regulations.

AMETEK Programmable Power offers a range of products that help measure the gamut of parameters of interest during the white goods test. To simulate the AC input, it provides single- and three-phase AC sources to 18 kVA (to a 6-kW maximum per phase). On the data acquisition side, it offers a wide variety of instruments that can measure parameters, including voltage, temperature, vibration, and strain. AMETEK Programmable Power can streamline your purchase of accurate, reliable power and data acquisition systems for all your white goods testing needs.

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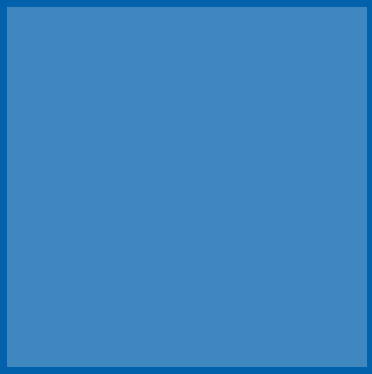
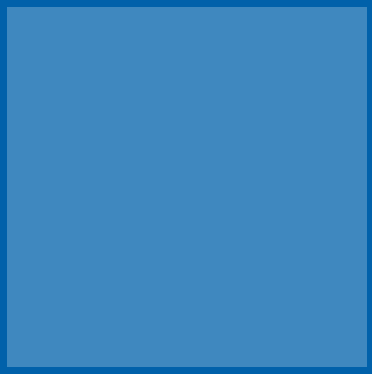

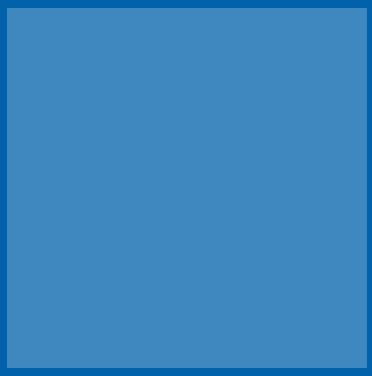

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