Smart Refrigerator Fans Join the Internet of Things

BUS communication for evaporator and condenser fans in display cases and bottle coolers give end users unprecedented control of fan operation, saving energy and limiting down-time

By Lou Moffa

Refrigerated coolers and freezers in retail stores are achieving new levels of efficiency in order to meet the U.S. Department of Energy's strict 2017 energy standards, which went into effect March 27.

Part of what makes this equipment more efficient is the inclusion of hydrocarbon refrigerants and associated components such as more efficient motors, LED lighting and other technologies. But the icing on the cake is the advent of "smart" controllers, software, sensors and network connectivity that allow end users to program and monitor components remotely via BUS data communication in order to maximize efficiency and provide the opportunity for proactive maintenance. Each component is now expected to be able to communicate and provide feedback to the smart controller.

Refrigeration equipment has thus joined the "Internet of Things," a growing cluster of devices or appliances that can be sensed or controlled remotely – and make possible such high-tech scenarios as smart homes and businesses, and smart grids.

A critical part of the refrigeration system that can be empowered by this smart BUS data communication technology is the fan that propels cool air in evaporators and warm air in condensers. BUS communication has been successfully used in larger rooftop condenser fans in supermarket applications for many years; and now, this new option can be used to enhance smaller refrigeration systems like display cases and bottle coolers.

Open protocols that are available from manufacturers allow these smart controllers to "talk" to fans, which actually have a lot to say about how they are being used, such as the speed at which they are operating and the amount of energy they are using.

For example, if the fan is sent a command to rotate at 900 RPM, is it actually rotating at only 500 RPM? That would indicate a problem. Is the fan approaching end-of-life? Is there a something blocking the fan? This information – all available through BUS communication – needs to be discovered before a failure occurs that can sideline the entire refrigeration unit. The service technician called out to investigate the problem can also be alerted as to the exact replacement components to bring to the store for repair work, keeping equipment downtime to a minimum and streamlining the repair process.

The evolution of fans

A separate motor, impeller and basket assembly – the first generation of fans – operate at a "worst-case" single speed with no adjustments for changing conditions. Of course, many refrigeration systems only require worst-case conditions for a short period in their operating life; the net result is wasted energy and excessive noise. Not surprisingly, motors used in these applications have not been equipped with BUS communication.

The next generation of fans offered to OEMs was the complete fan assembly, using energy-efficient, electronically commutated (EC) external rotor motors. Delivered as a pre-assembled fan unit that is optimized for best performance, it allows OEMs to install fan assemblies directly into refrigeration systems during construction, eliminating the need for sub-assembly operations. A shallow mounting depth enables these units to fit into tight spots, providing low-profile refrigeration designs that often result in more internal room in the refrigerated area.

Pre-assembled fans come in several diameters and programmable speeds. The most suitable fan diameter is chosen by the refrigeration designer, who then fine-tunes the air movement by programming the motor to a specific speed setting. Programming the EC motor speed at the OEM level, based on the needs of the installation, allows a speed resolution setting as small as 10 RPM, delivering the optimum air flow without wasted energy or excessive noise.

These EC fans are commonly available with standard two-speed operation. The designer can easily "toggle" between programmed speeds one and two for operation under varying conditions, but is still limited by these two set speeds. As with the older style assemblies, designers have to consider the worst-case operating conditions; but, in this instance, the two programmed speeds could be used in average and worst case conditions, or in other operating conditions such as door openings and after defrost cycles. The two-speed system provides design flexibility, reduced parts inventory for OEMs and lower fan energy consumption during "typical" operating conditions. Currently, these EC fan assemblies are available with the two-speed option and programmable RPM motor – but without BUS communication.

Riding the BUS

The latest offering is the same pre-assembled fan assembly optimized for best overall efficiency, but now equipped with BUS communication. BUS-controlled evaporator and condenser fans are managed by master controllers, which are successfully being incorporated into the latest case designs. These controllers are also being used to communicate with a supervisory system as well as to control components such as expansion valves, lighting, compressors and other mechanical features in the refrigerated display case or bottle cooler.

BUS communication from a master controller replaces two programmed speeds by allowing end users to continuously vary motor RPM fan speed and provide additional motor feedback in a refrigeration application.

Independently regulating the speed of each fan in a loaded display case provides a more uniform temperature throughout the case. The ability to speed-control each fan independently could allow thermal sensors to be placed in specific areas within the case and maintain a specific temperature using closed-loop feedback.

BUS-enabled fan assembly for display cases or bottle coolers

The optimum RPM for even cooling can best be mapped out by the OEM at the design level. The designer can divide the case into sections, with each fan and sensor operating independently, while being regulated by the master controller. A command from the master controller can be used to set the RPM of a specific fan, any combination of fans, or all of the fans in the system. The master controller determines the RPM by analyzing collected data.

For example, faster recovery time to the temperature set point following a defrost cycle can be achieved by increasing the fan speed for a short period until the set point is reached. In general, a fan speed can be easily changed as needed to suit changing conditions. Events that can trigger changes include: day/night operation, occupancy feedback, door opening/closing, the use of night curtains, or any other monitored variable. In addition, fan airflow direction can be reversed as needed. For example, running the fan at short intervals in the reverse direction helps "blow out" debris and keeps a condenser clear.

These new EC fans are currently available with a 24 VDC input through a DC power supply, which may already be powering the LED case lighting. Low voltage DC-input fans eliminate high-voltage safety issues, and provide global manufacturers with a "single fan" part number for inventory and repair. Single-phase 115 or 230 VAC, 50/60 Hz input units are also planned.

Maintenance control

BUS communication affords the end user unprecedented maintenance control. The master controller is continually monitoring fan status, sending a notification to the end user if a specific fan is not operating as expected. The master controller can pass this information along by initiating an alarm light; in a more sophisticated configuration, the alarm can be tied to a building automation system. External monitoring using web-based or cellular networks can provide email or text notifications.

Error codes can be created for particular fan-status alarms, including locked rotor, low input voltage, confirmation of commanded RPM, over current, and loss of communication. A technician not familiar with a specific refrigeration system can easily use these codes to assist with the troubleshooting process. Additionally, a technician can access the error codes remotely if the master controller is equipped for this capability. The technician arrives at the customer site prepared with the correct replacement parts.

Moreover, each fan has a specific address in a refrigeration system; alerts are specific to a unique fan in a specific location. This enables quick and efficient troubleshooting and eliminates the need to empty a loaded display case to identify a problem. With an exact fan address, only the specific area of the display case requires unloading. Access to the specific fan is easy and no time is wasted during a repair.

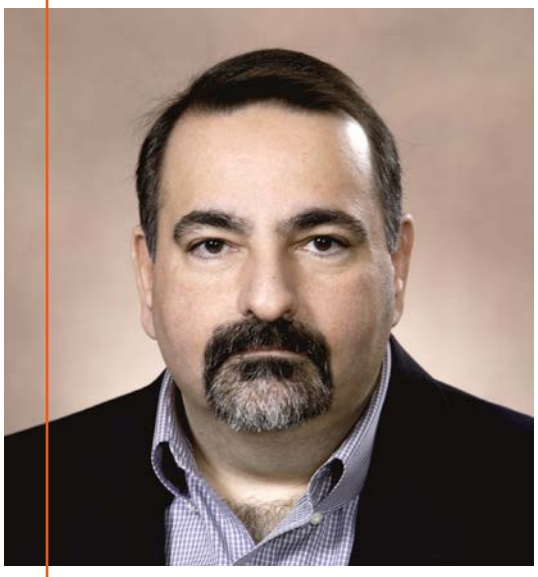
Another key feature of the BUS-enabled fan is that the controller monitors the total run hours that the fan has logged. This is extremely valuable for maintaining a preventative maintenance schedule, which prevents equipment downtime – a significant benefit to end users.

Default settings are also configurable by the end user. If BUS communication is interrupted, the fan speed can default to a user-defined preset speed until communication is restored, allowing for fail-safe operation.

Conclusion

Fans with BUS communication for display case and bottle coolers are currently available to OEMs. The addition of BUS communication to fans offers numerous benefits to OEMs, end users and their customers, and the maintenance personnel responsible for keeping these refrigeration units running daily and reliably.

By providing valuable feedback, BUS-enabled fans help meet demands for reliable, energy-efficient systems without changing the existing design footprint of display cases. These advantages would be both cost prohibitive and technologically challenging using alternative methods, such as a variety of complex mechanical controls or an array of “add-on” sensors. With BUS communication, all the feedback capability is built into the fan itself, which is now part of the Internet of Things ■ LM



Lou Moffa is market manager – commercial refrigeration for Farmington, Conn.-based ebm-papst Inc., where he has been employed for more than 12 years. He recommends air-moving solutions that help refrigeration system engineers, warehouse owners and supermarket managers keep food fresh across a variety of storage and display environments.