Bi-directional Microcontrollers Monitor and Protect Medical Equipment

Laird Thermal Systems Application Note
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Introduction

Product innovations in medical diagnostic equipment and analytical instrumentation are primarily aimed at improving testing reliability to ensure repeatable results, decreasing equipment size, and reducing both equipment and procedural costs. Satisfying conflicting requirements of increased performance with lower power consumption and quieter operation in a compact design is a continuing challenge facing design engineers. For systems that require refrigeration or specific reaction temperatures, such as benchtop incubators, laboratory centrifuges, chromatography and clinical chemistry analyzers, temperature control and cooling/heating systems play a large role in performance, size and cost considerations. One popular cooling solution that enables OEMs to meet these design challenges is the use of programmable temperature controllers with thermoelectric cooler assemblies. The temperature controller compliments the thermoelectric cooler assembly to deliver a precise thermal management system.

Thermal Management Technologies

To dissipate heat from medical diagnostic equipment and analytical instrumentation manufacturers utilize a wide range of thermal management solutions that predominantly fall into two categories: active and passive technologies. Active cooling systems utilize compressor based or solid-state heat pump (thermoelectrics) to enhance the heat transfer process.

Passive thermal management solely relies on the thermo-dynamics of conduction, convection and radiation to transfer heat and are predominately heat sinks with forced air (fans). These technologies are the most commonly used, as they are less expensive and easier to implement. However, they cannot cool to below ambient temperatures as active cooling methods provide.

Design Example

Immunoassay and clinical chemistry analyzers are instruments used in the clinical laboratories of hospitals and specialty labs for diagnosing diseases, monitoring diseases, and drug testing. Commercial systems today can test for hundreds of different parameters in patient fluid samples.

These analyzers use chemical reactions to quantify substances such as glucose, cholesterol, proteins and enzymes in patient fluid samples. There are a number of different types of measurement technologies used, including photometry, colorimetry, potentiometry, and others.

Immunoassay analyzers are also systems that are used to detect and quantify chemical substances in patient samples. These systems, however, are specifically designed to measure the concentration of a substance using the reaction of an antibody to its antigen. Again, there are a number of different types of measurement technologies that are used, such as colorimetry and photometry.

There are standalone clinical chemistry and immunoassay analyzers, as well as integrated systems that perform both kinds of tests. Automated systems range in size from smaller systems that hold a limited number of reagent samples and run a limited number of tests to larger systems that hold a large number of reagent samples and run a wide range of tests.

Clinical chemistry and immunoassay analyzers require reaction reagents. Reagents are often stored on-board the system, and the reagent chamber is sometimes cooled to increase reagent shelf-life. Cooled reagent chambers are typically held at a constant temperature, typically

between 2°C to 8°C or 4°C to 10°C. Thermoelectric cooler solutions can be used to cool the reagent chamber as an alternative to conventional compressor based systems.

Thermoelectric Cooler Assembly Solution

The development of bi-polar temperature controllers, designed to operate thermoelectric cooler assemblies, can save engineers hundreds of product development hours. When installed, programmable temperature controllers can be incorporated into a thermoelectric cooler assembly to remove up to 250 watts of heat. Temperature controllers, like the SR-54 Series from Laird Thermal Systems, add integrated, customizable and precise temperature control for medical diagnostic and other medical instrumentation equipment.

Bi-directional microcontroller-based devices drive thermoelectric cooler assemblies to exact temperature set points in cooling and heating mode. Tested to temperatures ranging from -20°C to +100°C, the programmable controller can control immunoassay and clinical chemistry analyzer temperature to within ± 0.15°C under steady state conditions. The controller can be easily mounted onto a thermoelectric cooler assembly or system enclosure wall.

Image 1: The bi-directional SR-54 Series is a microcontroller based device with built-in monitoring and closed loop feedback control intelligence

Controllers that feature built-in monitoring and closed loop feedback provide control intelligence. Easily programmable with up to three sensors inputs (NTC thermistors), the controllers can accommodate a wide range of temperature sensors and monitor critical components. For example, the controller can identify a problematic fan, thermoelectric cooler, open over-temperature thermostat, and temperature sensor failure, all of which are vital to maximizing medical and lab equipment uptime. They can also be replaced with a humidity sensor to monitor condensation and high relative humidity. The microcontroller can monitor current, PWM and RPM of fans. The temperature controller can output alarms and signal through LEDs that there is a problem with the thermoelectric cooler assembly.

Traditional off the shelf controllers have “on/off” switch functionality. However, this controller uses a more advanced system feature with unique control algorithms that drives the thermoelectric coolers less hard than standard controllers. This reduces the stress of the thermoelectric cooler with a smoother ramp rate and extends operation life, which lowers maintenance costs. The fan speed can also be adjusted to operate at its lowest required speed

to minimize noise. This has become very important to lab technicians running the medical instruments.

With optional self-check start capability, temperature controllers with advanced algorithms go through 30, 60 or 90 second checklists to ensure performance of all components at start-up.

Key System Features

- Compact design with significant power and functionality.
- Shortens development cycle.
- Ideal for thermal management systems seeking closed loop feedback control.
- Input power accommodates a supply voltage ranging from 16 to 60 VDC.
- Output power supports thermoelectric coolers and three DC fans with a maximum available current of 20 Amps.
- Additional outputs provide an LED feature that displays the health of the thermoelectric cooler assembly.
- Fans can be controlled for noise optimization.
- Hardware circuit protection guards against reverse polarity conditions.

Conclusion

Temperature stability is vital in medical diagnostic and analytical instrumentation equipment like immunoassay and clinical chemistry analyzers. Operating temperature fluctuations in these machines can significantly affect the test results and produce inaccurate data. Temperature controllers like the SR-54 Series provide precise thermal management for applications where maximum uptime and optimal performance are top priorities. When operating thermoelectric cooler assemblies, the temperature controllers offer higher reliability and/or lower maintenance compared to conventional refrigeration – with no harmful refrigerant.

About Laird Thermal Systems

Laird Thermal Systems develops thermal management solutions for demanding applications across global medical, industrial, transportation and telecommunications markets. We manufacture one of the most diverse product portfolios in the industry ranging from active thermoelectric coolers and assemblies to temperature controllers and liquid cooling systems. Our engineers use advanced thermal modeling and management techniques to solve complex heat and temperature control problems. By offering a broad range of design, prototyping and in-house testing capabilities, we partner closely with our customers across the entire product development lifecycle to reduce risk and accelerate their time-to-market. Our global manufacturing and support resources help customers maximize productivity, uptime, performance and product quality. Laird Thermal Systems is the optimum choice for standard or custom thermal solutions. Learn more by visiting www.lairdthermal.com

Contact Laird Thermal Systems

Have a question or need more information about Laird Thermal Systems? Please contact us at www.lairdthermal.com

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