Laird Thermal Systems Application Note

Precise Temperature Control for Medical Analytical, Diagnostic and Instrumentation Equipment
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Overview

The trend to miniaturize medical analytical, diagnostic and instrumentation equipment to improve portability while increasing performance has led engineers to pack more electronics into smaller spaces. The increase in heat generating electronics in a smaller box has led to significant thermal management challenges. Waste heat must be efficiently managed to meet conflicting requirements of increased performance with lower power consumption and quieter operation in a compact design. 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 utilizes programmable temperature controllers with thermoelectric assemblies (TEAs). The temperature controller compliments the TEA to deliver a precise thermal management system.

Thermal Management Techniques

To dissipate heat in 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 pumps (thermoelectrics) to enhance the heat transfer process.

Passive thermal management solutions solely rely on the thermo-dynamics of conduction, convection and radiation to transfer heat and are comprised of heat sinks with forced air (fans). Passive technologies are most commonly used, because they are less expensive and easier to implement. However, the major drawback is they cannot cool below ambient temperatures.

Application Examples

Automated biological analysis devices, including blood analyzers and DNA sequencing equipment, are used in healthcare, forensic and bioscience labs. This equipment requires precise temperatures to properly analyze blood or replicate DNA. Formerly, these machines utilized embedded heat pipes, vapor chambers, and APG cold plate technologies to enable this type of thermal control. Today, many modern systems are turning to active thermoelectrics for superior thermal management to improve overall system performance.

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 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 onboard 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.

Figure 1. Clinical chemistry analyzer equipment

Liquid chromatography is a technique used for analysis of mixtures by separating, identifying, and quantifying their constituent components. Liquid chromatography normally operates with smaller amounts of material and seeks to measure the relative proportions of analytes in a mixture. R&D laboratories in the pharmaceutical, food science and oil industries use these instruments for product development or reverse engineering. Temperature control plays a major role in the liquid chromatography separation process by influencing the interactions taking place between the sample components and adsorbent. There are two major uses of thermoelectric Peltier technology in controlling the temperature of high-performance liquid chromatography (HPLC) instruments; temperature control of the sample tray by thermoelectric cooling and heating, and the heating and cooling of the separation column. In modern HPLC
equipment, thermal management systems are used to provide temperature stability and condensation protection. Depending on the mixture, precise temperature control ranging from 4 to 40 degrees C is required. Heat load requirements typically range from 25 to 100W, with some new machines requiring up to 200W to increase sample testing throughput. In addition, many new HPLC instruments feature multiple sample storage chambers that have different cooling/heating requirements, increasing the overall system heat load.

Figure 2. Liquid chromatography - mass spectrometry equipment

Thermoelectric Assembly Solution

Laird has expanded its thermoelectric assembly (TEA) product offering with a series that includes a higher capacity range in a smaller package for critical medical analysis, diagnostic and instrumentation equipment. Previously, the Tunnel Series TEAs offered cooling for capacities up to 39 Watts. The new boosted Tunnel Series offers cooling capacities that exceed 100 Watts to support a wider range of cooling applications. Available in standard and custom configurations, the boosted Tunnel Series offers a compact form factor that fits inside medical equipment with tight space constraints.
Laird designs and manufactures customized, performance-critical products for wireless and other advanced electronics applications. The company is a global market leader in the design and supply of electromagnetic interference (EMI) shielding, thermal management products, signal integrity components, antenna solutions, as well as radio frequency (RF) modules and wireless remote controls and systems.

Laird’s Tunnel Series feature air-to-air or direct-to-air heat transfer mechanisms designed with optimized thermoelectric modules (TEMs) for high efficiency and improved reliability. Depending on the cooling capacity requirements, the thermoelectric assemblies can utilize one or more thermoelectric modules. Additional design features include low-noise fans, improved sealing to prevent moisture intrusion when running in dew point conditions and reduced number of airflow paths required to operate more efficiently compared to traditional impingement flow TEAs.

![Image of Laird Tunnel Series](image)

**Figure 3.** The space-saving Tunnel Series thermoelectric assemblies offer compact cooling performance for analytical and medical instrumentation

**Precise Temperature Control**

In addition, when combined with an advanced SR-54 Series temperature controller, the assembly offers temperature control to within +/- 1 °C. The SR-54 temperature controller also provides monitoring and alarm functionality, including identification of a problematic fan, over-temperature thermostat and temperature sensor failure — all of which are critical to maximizing medical equipment uptime. The controller requires minimal programming and can be easily adhered to a TEA or system enclosure. The controller also lowers operational noise, as fan speeds can be reduced once the specified temperature has been reached.
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More information on the SR-54 programmable controller can be found by visiting [http://www.lairdtech.com/products/tc-xx-sr-54](http://www.lairdtech.com/products/tc-xx-sr-54)

**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. Laird’s space-saving thermoelectric assemblies provide temperature stability and condensation protection for analytical and medical instrumentation. The advantages of thermoelectric assemblies over other cooling technologies are precise temperature control, compactness, faster temperature ramp rates, better efficiency, greater reliability and lower noise. Laird’s new boosted Tunnel Series TEAs meet the stringent temperature control requirements and mean time before failure demands of sensitive medical equipment.
About Laird
Laird is a global technology business focused on enabling wireless communication and smart systems, and providing components and systems that protect electronics. Laird operates through two divisions, Wireless Systems and Performance Materials. Wireless Systems solutions include antenna systems, embedded wireless modules, telematics products and wireless automation and control solutions. Performance Materials solutions include electromagnetic interference shielding, thermal management and signal integrity products. As a leader in the design, supply and support of innovative technology, our products allow people, organizations, machines and applications to connect effectively, helping to build a world where smart technology transforms the way of life. Custom products are supplied to major sectors of the electronics industry including the handset, telecommunications, IT, automotive, public safety, consumer, medical, rail, mining and industrial markets. Providing value and differentiation to our customers through innovation, reliable fulfilment and speed, Laird PLC is listed and headquartered in London, and employs over 9,000 people in more than 58 facilities located in 18 countries.

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