

Thermoelectric Assembly

HANDBOOK

Product Information
Assembly Information
Performance and Properties



Laird
TECHNOLOGIES®

Innovative Technology
for a Connected World

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Introduction

Laird Technologies offers the widest selection of standard Thermoelectric Assemblies (TEAs) on the market. TEAs are compact units that control the temperature of a wide variety of applications, such as laser diode packages in active optics, lasers in medical and industrial instrumentation, electronic enclosures, sample storage chambers in medical diagnostics and analytical instruments and batteries in various automotive and telecom applications. TEAs serve a cooling capacity spectrum from approximately 10 to 400 Watts, and can cool by removing heat from control sources through convection, conduction, or liquid means.

TEAs offer several advantages over other cooling technologies. For example, conventional fan trays do not cool to below ambient and requires an air exchange with the outside environment. On the other hand, TEAs can cool to well below ambient and protect electronics inside enclosures from outside contaminants, and also limit moisture exposure from the ambient environment. TEAs also offer precise temperature control, such as accuracies to within 0.01°C achieved under steady-state conditions.

TEAs have several advantages over conventional compressor-based systems:

- Compact in size and weigh less than conventional compressor-based systems
- Mountable in any orientation and have lower noise and vibration
- Environmentally friendly, as TEAs do not use CFCs and are RoHS compliant
- Low to no field maintenance requirement, which lowers the total cost of ownership.

When a designer is assigned to solve a new thermal problem, many times the engineer starts from a Thermoelectric Module (TEM) perspective and proceeds to design a custom TEA solution. However, with limited design resources available, product launches cannot afford the time it takes to design and validate a custom TEA solution. Products can reach market faster if the designer starts from a standard TEA platform and modifies it, if necessary, to meet unique attributes of the application. Most changes are geometric in nature due to size constraints imposed by system level interference, and can be adjusted to accommodate a standard TEA if designed early during the concept stage.

A standard TEA allows the designer to start with a basic set of thermal components or building blocks that mate fans and TEMs to heat exchangers. Laird Technologies has conducted two decades worth of design and validation testing on various combinations of thermal components to optimize cooling power and efficiency at various heat loads. This results in engineers saving time with redesign and validation testing a TEA that has already been perfected by Laird Technologies.

Below is a summary of inherent benefits of initiating a thermal design with a standard TEA versus a custom solution:

1. Reduce time to development. TEM, heat exchanger and fan combinations have been optimized to maximize performance and efficiency at specific cooling capacities. Less time is required to conduct mechanical design, thermal analysis, prototype development and validation testing.
2. Reduce cost by utilizing components that are established in the supply chain. Sharing components on TEA platforms with multiple customers builds economies of scale and reduces the need to design custom components with high non-recurring engineering (NRE) charges. Designing from an established supply line also assists production ramp up, as the supply line is established and parts are driven on an ongoing basis.
3. Validation tested in field. Several hundred thousand TEAs have been deployed in field and are operating properly in a wide variety of applications. Designers can find assurance that TEAs are robust through field data of legacy builds.
4. Product enhancements captured through market evolution. Laird Technologies receives feedback from the field on a continuous basis, so there is the added benefit of implementing Engineering Change Notices (ECNs) into the standard TEA product portfolio in order to cover a wide spectrum of application issues. This is a market evolution that has been ongoing for this TEA portfolio for more than two decades.

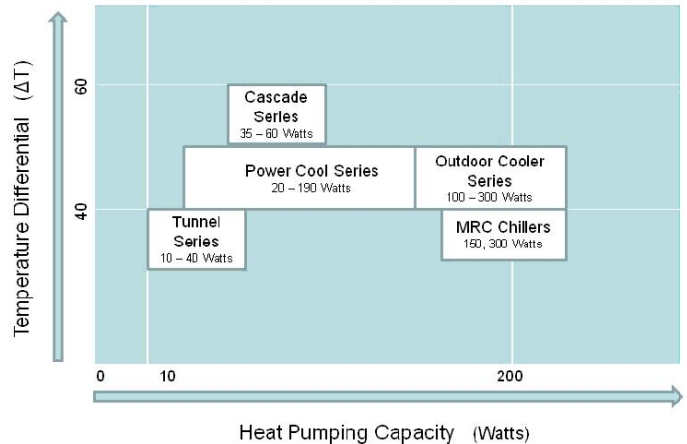
TEA Product Portfolio

Laird Technologies offers a wide product portfolio of TEAs that offer superior cooling performance, compact form factors, and minimal power consumption. There are five distinct TEA product families that were designed for a specific cooling capacity range, temperature differential range, or tight space constraint. The diagram to the right is a perceptual map of a cooling spectrum that can be used to guide designers to a particular product family that will have the desired attributes that the application requires.

Power Cool Series offers the widest selection of cooling capacities ranging from 20 to 190 Watts. The TEAs use impingement flow to dissipate heat on the hot side. The cold side heat transfer mechanism can absorb heat using convective (heat sink and fan), conductive (cold plate), or liquid (heat exchanger) means. This product series is offered in 12 or 24 VDC configurations. For 100 Watt systems and higher, 48 VDC is available. The Power Cool Series is designed for indoor use in the medical, analytical, and industrial markets.

Outdoor Cooler Series is designed for outdoor use to control the temperature of electronic cabinets. The product series has been designed to pass harsh environment demands such as earthquake resistance, salt fog, wind-driven rain, high temperature exposure and dust. The cooling capacity ranges from 100 to 300 Watts. This product series is offered in 12, 24, and 48 VDC configurations and is designed for outdoor use in the telecom and industrial markets.

Tunnel Series offers compact form factors and is specifically designed for cooling capacities ranging from 10 to 40 Watts. The TEA uses cross flow to dissipate heat on the hot side, which reduces the number of airflow paths required to operate. The cold side mechanism can transfer heat using convective (heat sink and fan) or conductive (cold plate) means. This product series is offered in 12 or 24 volt options and was designed for high end instrumentation with restricted air flow paths available due to tight geometric space constraints. The Tunnel Series is designed for indoor use and serves the medical, analytical, and industrial markets.



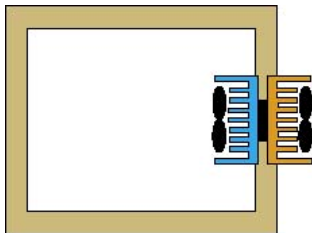
Cascade Series is a TEA that is specifically designed to reach colder temperatures than standard TEA product offerings. The TEMs are custom designed multistage cascades that achieve a high cooling capacity (Q_c) at high temperature differentials (ΔT). The cold side mechanism can transfer heat using convective (sink and fan) or conductive (cold plate) means. This product series is offered in 12 or 24 volt configurations and is designed for indoor use in lab instruments.

MRC Chillers are self contained re-circulating chillers that offer dependable, compact performance by controlling the temperature of a coolant in a liquid circuit. The coolant is re-circulated using a pump with high mean time between failures (MTBF). Heat from the coolant is absorbed by a heat exchanger and dissipated through high density heat sinks equipped with brand name fans. The TEMs are custom designed to achieve long life operation. The unit is regulated with an easy-to-use digital temperature controller and is housed inside an aesthetic sheet metal casing.

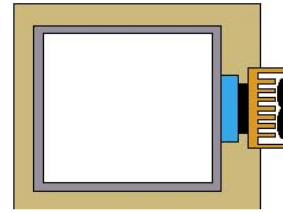
TEA Transfer Systems

TEMs are devices that pump heat from one side of a TEM to the other when DC power is applied. The absorption and dissipation of heat is conducted through heat exchangers. There are many different types of heat dissipation mechanisms that can be mounted onto a TEM or TEM Array to create a TEA. The most common means use convection or conduction to transfer heat from an active source to the dissipation heat mechanism. Heat transfer via a liquid circuit is less common and isolated in instances where active source requiring cooling cannot accommodate a localized heat exchanger due to geometric size constraints, noise, or lack of air exhaust to the ambient environment.

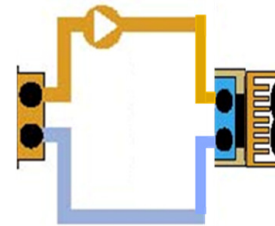
- Air-Air Assemblies (AA) offer dependable, compact performance by cooling objects via convection. Heat is absorbed on the cold side heat exchanger, then pumped by TEMs, through the hot side of the heat exchanger equipped with fans and dissipated to the ambient environment. The internal air circulation aids in keeping the temperature gradient within the enclosure to a minimum. This configuration is common in sample storage chambers for medical and analytical instruments, electronic enclosures, and compartment storage for food and beverages.



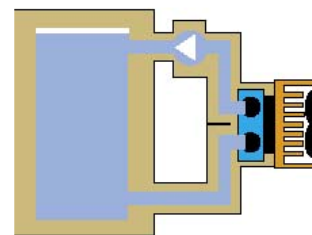
- Direct-Air Assemblies (DA) offer dependable, compact performance by cooling objects via conduction. Heat is absorbed through a cold plate and then pumped by TEMs through a hot side heat exchanger equipped with fans and is dissipated into the ambient environment. The internal cold plate allows the chamber to be completely sealed, which aids in containing bio-hazardous liquids and also saves space in small chambers that cannot accommodate a cold side heat sink and fan. This configuration is common in smaller sample storage chambers for medical and analytical instruments, spot cooling for laser diode packages, laser systems used in industrial, telecom and medical markets, and compartment storage for food and beverages applications.



- Liquid-Air Assemblies (LA) cool or heat liquids in a re-circulating liquid circuit. Heat is absorbed by an external liquid heat exchanger and moved through a liquid circuit via an external pump. The LA unit's liquid heat exchanger absorbs the heat and TEMs pump through to the hot side heat exchanger equipped with fans and dissipates the exhaust heat into the ambient environment. This product series is ideal for spot cooling where localization of a heat sink fan mechanism is not possible, such as medical imaging systems and laser systems in the industrial, semiconductor and medical markets.

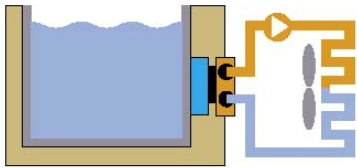


LA units can also be used in small re-circulating baths to maintain temperature of liquids. This is a suitable replacement to running tap water as cooling mechanism, which is common in the lab science and semiconductor markets.

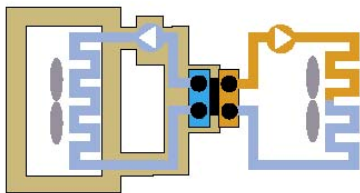


Since LA units require a pump to operate, many customers opt to incorporate a Re-Circulating Chiller into their system. This is a self contained unit that consists of an LA unit, pump, reservoir, power supply and temperature controller housed inside of a sheet metal casing. The temperature controller provides closed loop feedback control in order to maintain a specific outlet temperature of the liquid.

- Direct-Liquid Assemblies (DL) cool or heat devices or chambers. A cold plate absorbs heat from the object and is pumped by TEMs through a hot side liquid heat exchanger. The heat is then dissipated into the ambient environment. This product is ideal for spot cooling applications in the medical, industrial, and semiconductor markets or for maintaining temperature of a small bath in the lab science market. The advantage of this configuration is that there is more cooling capacity of the TEMs utilized because liquid heat exchangers are more efficient at dissipating heat than conventional heat sink fan mechanisms.



- Liquid-Liquid Assemblies (LL) cool or heat liquids as they pass through a heat exchanger. Heat is pumped by TEMs into the hot side heat exchanger. The liquid circuit is normally a re-circulating type that requires a pump and an additional liquid heat exchanger to dissipate heat into the ambient environment. This product is ideal for controlling the temperature of process fluids in a liquid circuit and utilizes available process water as a cooling mechanism commonly found in many semiconductor applications.



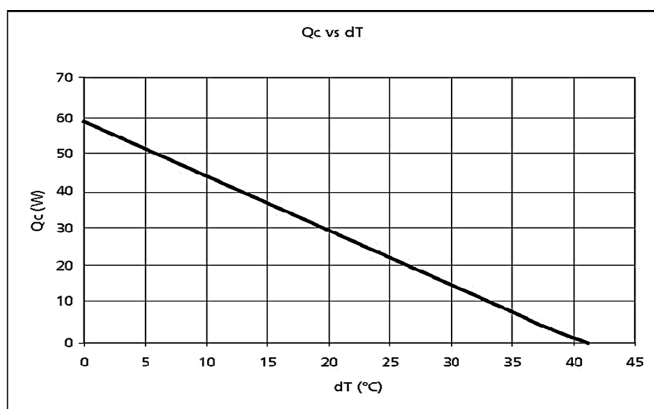
TEA Sizing

In order to bring the temperature down of an object or chamber, heat must be removed faster than it can be created. There are two primary attributes that the designer needs to determine to specify a TEA for their application. The first parameter is calculating the cooling capacity requirement. This is achieved by estimating the total heat load of the system, Q_t :

$$Q_t = Q_a + Q_p + Q_r$$

This consists of calculating the active heat load (Q_a), passive heat load (Q_p), and for outdoor applications, the radiant heat load (Q_r). The active heat load consists of the load from objects to be cooled, powered electronic devices, and dehumidification of air. Heat from active devices can simply be measured by input power to device. When the object being cooled is at a lower temperature than the ambient environment, heat from the ambient environment will naturally be drawn to the cold source in order to reach equilibrium in the surrounding environment. This is known as passive heat load. It is critical to minimize this parameter as thermal shorts in system level design, will require TEAs to pump more thermal energy in order to keep source control temperature. As a result, the TEA will be less efficient. Therefore, insulating the chamber walls or objects to be cooled as much as geometric constraints will allow is required to maximize the efficiency of the TEA. For outdoor applications, the radiant (solar) heat load must also be considered, which is infrared heat generated from the sun. Solar shields are commonly used to reduce the affects of solar heat load.

Performance Curve



The second primary parameter is defining the temperature differential:

$$\Delta T = T_a - T_c$$

This is defined as the difference between the temperature in the ambient environment (T_a) and the desired control temperature of the application (T_c). T_a is generally chosen to be the worst case ambient that the application will be exposed to. As the temperature differential increases, more thermal energy is required to achieve a colder control temperature so the cooling capacity (Q_c) will go down. Reference the performance chart on the right as an example. This is the performance curve of an AA-060 assembly that measures the heat pumping capacity of the TEA against temperature differential. The performance curve is based on an ambient temperature of 32°C. The cooling capacity of an AA-060 at $\Delta T = 5^\circ\text{C}$ is 50 Watts and lowers to 30 Watts at a $\Delta T = 20^\circ\text{C}$.

Once the total heat load and temperature differential have been defined, the designer can now specify a TEA to meet the cooling parameters of an application by referencing the performance charts of each unit. Since Q_t is a difficult parameter to calculate due to the necessity to characterize all heat loads and losses, Laird Technologies recommends incorporating a 20% safety factor into the Q_t value. The benefit of this is that there is extra cooling capacity which accelerates the cool down cycle, and with closed loop feedback control, the TEA can run at a percentage of maximum power input to minimize efficiency losses.

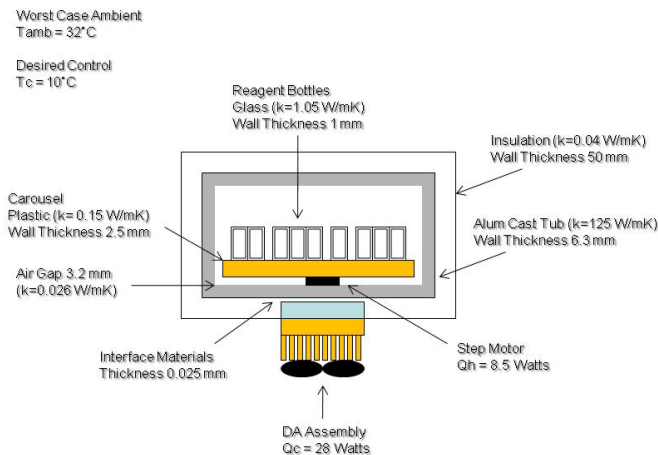
Thermal Model Analysis

For designers with access to thermal modeling software, this is a preferred option to validate the performance of TEA in an application. This can be run in 3-D or 2-D models to estimate if the desired control temperature will be reached based on the expected cooling capacity of a TEA at a specific temperature differential.

Below is an example of cooling reagents in a sample storage compartment for a clinical diagnostic application. The reagent samples need to be maintained at 10°C in a worst case ambient environment of 32°C. A 2-D thermal analysis was conducted to validate if a DA-060 would be suitable to reach a control temperature requirement of 10°C. All thermal resistances from components between the control source (reagents) to the DA assembly were identified by specifying the thermal conductivity and thickness of each material. Then a thermal resistance path was defined by stacking up each material's thermal resistance to the DA assembly. The cooling capacity of the DA assembly, $Q_c = 28$ Watts, was estimated at the desired temperature differential of 22°C. The Q_c value was obtained by referencing the performance curve on the datasheet. Then a thermal model was run using thermal analysis software to confirm if the DA-060 could cool reagents inside the bottles to temperatures lower than 10°C. Note the active heat source generated by the stepper motor to operate the carousel. This heat is an active heat load that will need to be removed by the TEA.

Running a simple 2D thermal analysis model can save time with selecting a TEA prior to actually purchasing it for trial and conducting validation testing. Consult with one of Laird Technologies' thermal design engineers for specific questions on how to run a thermal model, or have Laird Technologies run a thermal analysis of the application to confirm sizing of the TEA.

Laird Technologies is uniquely positioned in the market place to offer a wide spectrum of standard TEA solutions. Cooling capacities are offered in a wide range of increments, from 10 to 200 Watts, to keep form factors compact for each cooling capacity increment. If the designer specifies a standard TEA early in the concept stage of development, then the engineer can usually rearrange the system level housing to accommodate the standard geometric shape of a TEA. This is beneficial for both standardization and optimization of performance against power consumption. As a result, the designer does not have to spend time designing and validating a custom thermoelectric solution.



Product Nomenclature

Laird Technologies' TEA product nomenclature can be defined as follows:



Each suffix is associated with a specific attribute:



Heat transfer mechanisms

The cold side heat exchanger can be one of three options:

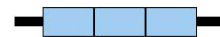
- A = Air, Convective Cooling
- D = Direct, Conduction Cooling
- L = Liquid Cooling

The warm side is used to remove heat by one of two methods:

- A = Air Heat Exchanger
- L = Liquid Heat Exchanger

Air heat exchangers are on the hot side of the TEA and are the most common heat transfer mechanisms due to the potential issues of having fluids near electronics. However, liquid heat exchangers are ideal where geometric constraints at the control source cannot accommodate an air heat exchanger or when additional heat dissipation is required, which cannot be achieved by an air heat exchanger due to size constraints.

Heat exchangers have been designed to maximize heat dissipation while minimizing the volumetric footprint. Heat exchangers are machined from high grade aluminum to create extrusions with excellent heat transfer properties. All heat exchangers are anodized to provide superior protection against outside contaminants and minimize corrosion. Modifications to standard extrusions or custom heat exchanger configurations are available, however MOQ applies.



Cooling Power, Qc

This is the maximum amount of cooling capacity expected out of the TEA unit at a temperature differential of zero under no load conditions. Each TEA has been designed and tested using a custom designed TEM or TEM Array to maximize cooling power and efficiency.

Each unit has a specification datasheet, which contains a performance chart showing the heat pumping capacity obtained based on desired temperature differential requirements.

By reversing the power applied to the TEA, the unit will heat instead of cool. Heat output can be estimated through the Carnot principle, where $Q_h = Q_c + \text{Power input}$. Caution should be used when using TEAs in heating mode as the cold side heat exchanger was designed for primarily cooling with tight form factor, resulting in the cold side heat sink being smaller than hot side heat sink. Exceeding the heat dissipation of the cold side heat exchanger will result in excess heat that will revert back to the TEMs and potentially damage them if the temperature exceeds the operational limit of the TEM. In most instances, this can be prevented by controlling the TEA with a temperature controller and adding a thermostat over-temp switch to the cold side of the heat sink. Consult with a Laird Technologies engineer on options to protect TEM in heating mode.

Also note for unique applications that require greater temperature differential than what can be achieved using single stage TEMs, Laird Technologies offers TEAs with multistage TEMs. This increases the amount of Q_c achieved at a given temperature differential.



Voltage

TEAs are intended for DC operation only. All standard assemblies are designed to run on either 12 or 24 VDC operation. For assemblies with 100 Watts of capacity or greater, Laird Technologies has a selection of TEAs that run on 48 VDC. Laird Technologies also has a few models available at the lower cooling capacity spectrum that can run on 5 VDC. Consult with a Laird Technologies engineer for unique input voltage requirements.

Input voltage for the standard fans should be within $\pm 10\%$ of nominal voltage of the TEA, and within 5% maximum ripple to maintain proper function and optimal service life. Switched PWM voltage from the TEA unit rating is not recommended to power fans. So for example, a TEA operating at 48 VDC should not have PWM running at 50% to drive 24 VDC fans.

Input voltage for the TEMs can be reversed to use TEAs in heating mode. However, regulation should not exceed the ability of the cold side heat exchanger to dissipate heat. Otherwise, the temperature of the TEM can elevate to exceed its operational temperature limit, which is 80°C. For switched PWM voltage, a PWM frequency above 5 kHz is recommended to prevent thermal cycling. Thermostatic control on/off cycling should be kept to five minutes or higher. Lowering the parameter on either condition could degrade the TEM and shorten service life expectations of the TEA.



Fans

Laird Technologies only purchases brand name fans from reputable suppliers that put a premium on performance and reliability. The fan is the only moving part in a TEA, so there is a correlation between the service life of the fan and the service life of the TEA. All standard fans use brushless motors with ball bearings. Expected service life at 25°C is 50,000 hours (L10). For outdoor environments, Laird Technologies also offers fans with IP55 rating for protection against dust and moisture (low pressure jets). For high reliable applications in the medical, telecom, and semiconductor markets, Laird Technologies also offers high performance fans with a service life of 100,000 hours (L10). Custom fan configurations are available to accommodate specific noise, environmental, or reliability requirements; however, MOQ applies.



Temperature Control

Temperature control is provided by one of two control methods: Open Loop (manual) and Closed Loop (automatic). In the Open Loop method, an operator adjusts the output of a power supply to achieve and maintain a steady temperature. All standard TEAs are supplied without a temperature controller, and can be used in an Open Loop condition that is driven directly from a power supply.

In the Closed Loop method, an electronic controller runs an algorithm that utilizes feedback data from temperature sensors within the system to vary the output of the power supply to control the temperature. Laird Technologies offers three types of controllers: Single Directional Thermostatic, Bi-Directional Thermostatic, and Proportional Integral Derivative (PID) (Programmable).

A Single Directional Thermostatic Controller can operate in Heating or Cooling mode, but not in both. Controllers with a single directional output are used to maintain a constant temperature within a system surrounded by a relatively constant ambient temperature. Take for example the cooling or heating of a sample storage compartment in a room temperature laboratory environment using thermostatic (on/off) control. The thermostatic controllers operate by turning on the TEA in order to cool or heat to a set temperature point. The set point tolerance is defined by a hysteresis range. Once the set point is achieved, the controller shuts off the TEA. When the control temperature changes to outside the hysteresis range, the controller turns on power to the TEA and restarts the cooling or heating mode process. This cycle continues until the controller is shut down. Thermostatic control is often used in climate control and refrigeration, where a narrow temperature swing can be tolerated. Laird Technologies offers two standard single directional thermostatic temperature controllers, QC-50 and QE-50.

A Bi-Directional Thermostatic Controller operates in the same manner as a Single Directional Controller, except output can operate in both Heating and Cooling mode. Controllers with a bi-directional output are used for maintaining a constant temperature within a system surrounded by an ambient environment with large temperature fluctuations, i.e., back-up battery storage, climate control in an outdoor environment. Laird Technologies offers two standard Bi-Directional Thermostatic Controllers, LE-80 and LK-81.

Proportional Controllers use proportional regulation to maintain a constant temperature with no swing in the control temperature. This is often accomplished by using a PID algorithm to determine the output value and a Pulse Width Modulation (PWM) output to handle the physical control. When using a controller with a PWM output, a capacitor can be placed (electrically) across the output to filter the voltage to the TEM. Proportional Controllers are often used in heating and cooling systems where the temperature must stay constant (with no change) regardless of the change in ambient temperature. Liquid chiller systems used in medical imaging systems are a perfect example of where the temperature of the detector head needs to be stable, while the ambient temperature in the room can fluctuate throughout the work day. Laird Technologies offers one standard programmable controller, PR-59.

Regardless of the controller used, the easiest feedback parameter to detect and measure is temperature. The sensors most commonly used by temperature controllers are thermocouples, thermistors, and RTDs. Depending on the system; one or more temperature sensors may be used for the purpose of control. The temperature sensor feedback is compared by the controller to a set point or another temperature to determine the power supply output. The temperature feedback sensor(s) Laird Technologies uses are thermistors, and one is provided with each controller. Reference the datasheet for specifications.

Temperature controllers can accommodate more advanced options to trip alarms; control fan speeds, and interface remotely with a PC or UI. But these are beyond the scope of this handbook. However, some basic questions to consider for temperature controller designs are:

1. What alarms/indicators are required for UI?
2. Does the controller need to interface with a PC?
3. Does the TEM controller provide fan control?
4. Does the temperature set point need to be changed by the end user?

Other design conditions may exist and should be considered during system level design. Laird Technologies has the ability to customize and design temperature controllers to meet unique application requirements. Consult with a Laird Technologies engineer on customized solutions relating to specific design criteria.

Note: All standard AA, DA and LA TEAs with power input greater than 48 Watts feature an Over-Heating-Thermostat (OHT) for protection in case of poor ventilation on the hot side. The OHT is set to cut off at a heat sink temperature of $75^{\circ}\text{C} \pm 4^{\circ}\text{C}$.

TEA Installation Guideline

General

Reducing the passive heat load is critical to yield the highest efficiency out of a TEA system and maximize service life. It is important to insulate the device requiring cooling or insulate the walls of an enclosure with as much insulation material as permissible without interfering with nearby electronics or system level obstructions. Proper insulation of the enclosure or device can result in sizing a smaller TEA and power supply, which will also reduce total system costs.

Air heat exchangers require air exchange, so it is important to run them in a chamber that is sealed from the outside environment. If the dew point is reached, then moisture in the air will condense onto the cold side heat exchanger. Access to outside air exchange can accelerate the moisture condensation rate and cause large amounts of moisture to accumulate on cold surfaces of the TEA, and potentially degrade operation life over time if the system is not designed to drain condensation properly.

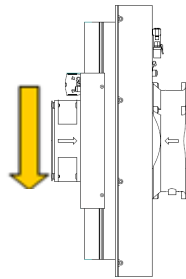
For TEAs with air heat exchangers on the hot side, it is important to have good ventilation to transport exhaust heat away from the system. A minimum of one fan thickness is recommended from the wall surface to the exterior face of the fan to allow air to enter into the fan and transport the exhaust through the ducted shroud.

For TEAs mounted inside the system level instrument, separation of the cold side air inlet from the hot side air outlet is recommended to maximize cooling power and efficiency. Air flow paths are required to direct the cold side air of the control source, and the exhaust inlet air to the outside ambient environment. Air ducts can be created with sheet metal ducting or flexible hosing with a large outside diameter. Consult with a Laird Technologies engineer for assistance with ducting requirements.

Air-Air (AA) Assemblies

All AA assemblies are designed as through-mount. A cut out on the enclosure wall will be required to accommodate the cold side heat exchanger. Reference the datasheet of a particular model for mounting hole locations and cold side heat exchanger dimensions. The cut out should be 2 to 3 mms larger than the cold side heat exchanger.

The enclosure should be sealed from the outside environment by maintaining good compression between the AA assembly and enclosure wall. Mounting holes along the centerline are through-hole, and can accommodate either an M4 or M5 machine screw, dependant on the unit model. Larger models also have threaded M4 counter bores along the perimeter of the hot side heat exchanger. These should be used in addition to the centerline mounting holes to assure sufficient compression is maintained along gasket the perimeter. External tooth lock washers, split ring lock washers, or captive machine screws are recommended to prevent AA assemblies from loosening over time from the enclosure wall.



If the design permits, and if the application will reach dew point, an AA assembly should be mounted in a vertical direction to allow for gravity to run off condensation that has accumulated on cold side heat sink. If the enclosure cannot accommodate an AA assembly in vertical orientation, then the unit should be installed at a 15 degree angle in horizontal orientation to allow for condensation to run off the cold side heat sink. Otherwise, moisture will sit on the cold side of the heat sink and potentially penetrate into the TEMs over time.

For electronic cabinets with thin un-insulated walls, proper exhaust from the hot side of the AA assembly is needed to prevent exhaust from warming up the cabinet wall. Similarly, the cold side should not be mounted close to the mating enclosure of the wall. Otherwise, heat pumped by the TEA will be absorbing passive heat from the exterior of the enclosure.

For insulated cabinets, it is recommended to make insulation as thick as possible without interfering with the electronics in the enclosure in order to minimize the passive heat load. The TEA will operate more efficiently, as it is removing only the active heat load and solar heat load in outdoor environments. Also note that racks that come in contact with the enclosure wall can act as a cold bridge. Insulating cold bridges to minimize thermal shorts is recommended in order to make the TEA operate more efficiently.

Direct-Air (DA) and Direct-Liquid (DL) Assemblies

DA and DL assemblies are mounted directly onto the active device or chamber wall. To ensure optimal performance, Laird Technologies recommends that the flatness of the mating surface should not exceed 0.05 mm over 100 mms.

Cold plates have threaded holes to accommodate M3, M4 or M5 machines screws. Reference the datasheet of a particular model for the threaded hole size. All threaded holes on the cold plate should be used to assure good contact between the cold plate and mating surface. Use of external tooth lock washers or split ring lock washers, or use of captive machine screws is recommended to prevent DA or DL assemblies from loosening over time.

TEAs are designed to structurally support themselves, but should not be used as structural support for system level designs. Using TEAs as structural support can cause excessive shear stresses to occur on TEMs and degrade the life of TEA. Similarly, objects mounted to the cold block should be limited in weight and size. Consult with a Laird Technologies engineer to review application attributes and to make sure the TEA can sufficiently support the object prior to installation.

All DA and DL assemblies come with high-performance thermal grease that is used as an interface material between the cold plate and mating surface. Prior to applying the interface material, Laird Technologies recommends cleaning both mating surfaces with degreaser, such as acetone or alcohol, and allow time to dry. Apply a thin continuous film of grease onto the cold plate and mating mounting surface. After the thermal grease relaxes, the operator should re-torque the mounting machine screws of the DA or DL units again to ensure that good thermal contact has been maintained.

When cooling a liquid container or tank with a thin walled housing, the surface area can be much larger than that of a cold plate. Additional heat spreading maybe required to aid in heat transfer. Laird Technologies recommends using three 5 mm sheets of aluminum (or equivalent) that is larger than the cold plate to ensure good thermal transfer between the tank and TEA.

Not all cold plates used in standard DA and DL units will be insulated. This is done to accommodate the wide range of mating surfaces the DA and DL units can come in contact with. It is recommended to insulate all exposed cold plate surfaces in order to minimize condensation and maximize the efficiency of the TEA. Laird Technologies recommends using polyethylene (LDPE) insulating material as a gasket.

Liquid-Air (LA) and Liquid-Liquid (LL) Assemblies

Mounting holes along the centerline are through hole and can accommodate either an M4 or M5 machine screw dependant on unit model. Larger models also have threaded M4 counter bores along the perimeter of the hot side heat exchanger. External tooth lock washers, split ring lock washers, or captive machine screws are recommended to prevent LA or LL assemblies from loosening over time from the system wall.

The recommended fluid to use in-line with an LA or LL unit is distilled water. This is due to water's high heat transfer coefficient and distillation process that removes aggressive minerals that can attack the liquid heat exchanger over time. Tap water is not recommended because the water is unfiltered and contains mineral ions that can attack the heat exchanger core and bacteria that can reduce the flow rate over time. Glycol is commonly mixed with water to lower the freezing point and in high mixture ratios, inhibits algae growth. Laird Technologies recommends fluid in the liquid circuit to be distilled water with a minimum of 30% glycol.

The liquid heat exchanger used in the LA and LL units is made from aluminum. The heat exchanger is anodized to protect it from oxidation. However, mating the liquid heat exchanger in-line with dissimilar metals such as nickel, copper, bronze or brass can aggressively attack the heat exchanger due to galvanic corrosion. Overtime, this will cause the heat exchanger to oxidize. If mating components of dissimilar metals are unavoidable, than Laird Technologies recommends adding an inhibitor solution into distilled water instead of glycol in order to passivate the aluminum heat exchanger. The inhibitor will also inhibit algae growth. Consult with a Laird Technologies engineer for proper selection of the inhibitor.

For LA and LL units, an external pump is required to circulate the fluid in the circuit. Pumps generate heat into the liquid circuit, which is counterproductive for the removal of heat conducted by the LA and LL units. It is important to select a pump that is efficient and dissipates a low amount of heat into the liquid circuit, as this will make the LA or LL units operate more efficiently.

All standard liquid heat exchangers come with turbulators in order to maximize heat transfer performance. They are designed to cause turbulent flow as the fluid passes through the heat exchanger. The recommended liquid flow rate on the inlet of the heat exchanger is two liters per minute or higher. Lower liquid flow rates are permissible, but will reduce the cooling power of the LA or LL assembly. For applications that use a pump with low pressure drop, the turbulators can be removed in order to increase the flow rate.

To accommodate the wide possibilities of mounting an LA or LL unit, the liquid heat exchanger is not fully insulated as a standard product offering. The user must insulate the liquid heat exchanger in order to protect against condensation and also to minimize thermal leakage due to the passive heat load from the ambient environment. Tubing in the liquid circuit should also be insulated in order to minimize thermal losses. This will make the LA and LL units operate more efficiently. Laird Technologies recommends using polyethylene (LDPE) insulating material.

Inlet and outlet ports on liquid heat exchangers are threaded 1/8" BP/RP. As an accessory, Laird Technologies offers adaptors to accommodate 4 mm, 6 mm, and 8 mm ID tubing. This is required in order to operate LA and LL units in-line with the liquid circuit.

Expected Life and Reliability

TEAs are inherently reliable devices due to their solid-state construction and lack of moving parts. Laird Technologies has designed TEA systems for specific applications to last 40K, 80K and even up to 120K hours in the field. The quality of components used in TEA selection is important in order to maximize the life of the TEA. Laird Technologies has a premium supply base that has been built and qualified for over two decades with sourced components such as fans, heat exchangers, and gasket material. Laird Technologies also has developed proprietary assembly processes, TEMs, and interface materials to assure world class process control and high thermal transfer in order to optimize efficiency and also to create a robust design. For extreme cases where thermal or power cycling requirements are high or the application is operating in a high temperature environment, consult with a Laird Technologies engineer, as this will require a specially designed TEA to operate in either condition.

Estimating the useful life of a TEA is dependent upon the specific application attributes that induce thermal stresses onto the TEM array and fans. Drive circuit design can also contribute to the useful life of the TEA. Some examples of unique variables that can induce thermal stress to TEAs are the size of heat load, ambient temperature, desired control temperature and frequency of thermal cycling between set points or power cycling between on/off cycles. What makes it even more difficult to ascertain is that all these parameters can fluctuate throughout the useful life of the product.

To obtain an estimate on the expected life of a TEA for a specific application, the designer can conduct an accelerated life test by simulating the application attributes imposed on the TEA on a sample production lot. The accelerated life test should consist of simulating the thermal heat load, ambient temperature conditions, control set points and drive circuit controlling the temperature profile over a set frequency. To estimate the MTBF, the designer can run TEAs in the application continuously as exposed to a nominal condition environment, but increase the sample lot size in order to cut down on the number of test hours required in order to obtain the MTBF. All application conditions will need to be simulated for each TEA in the test in order to assure that a reliable estimate has been obtained. Consult a Laird Technologies engineer to assist with setting up an accelerated life test to estimate for the expected life or reliability of the TEA meant for the application requirements.

Specific markets such as telecom or military have set industry standards that TEAs must pass. If the designer does not have the time and resources to conduct validation testing of the TEA by simulating the application attributes and running the test for an extended duration, then consult with Laird Technologies engineer. Laird Technologies has conducted countless tests with thermoelectric products in order to adhere to Telcorida and MIL standards, and can provide data on power cycling, thermal cycling, and high temperature storage testing of specific TEAs and TEMs. This can be used as an estimate for obtaining the life expectancy of a TEA, but should not supersede actual reliability testing under simulated conditions for the specific application requirements.



global solutions: local support™

Americas: +1.888.246.9050

Europe: +46.31.704.67.57

Asia: +86.755.2714.1166

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