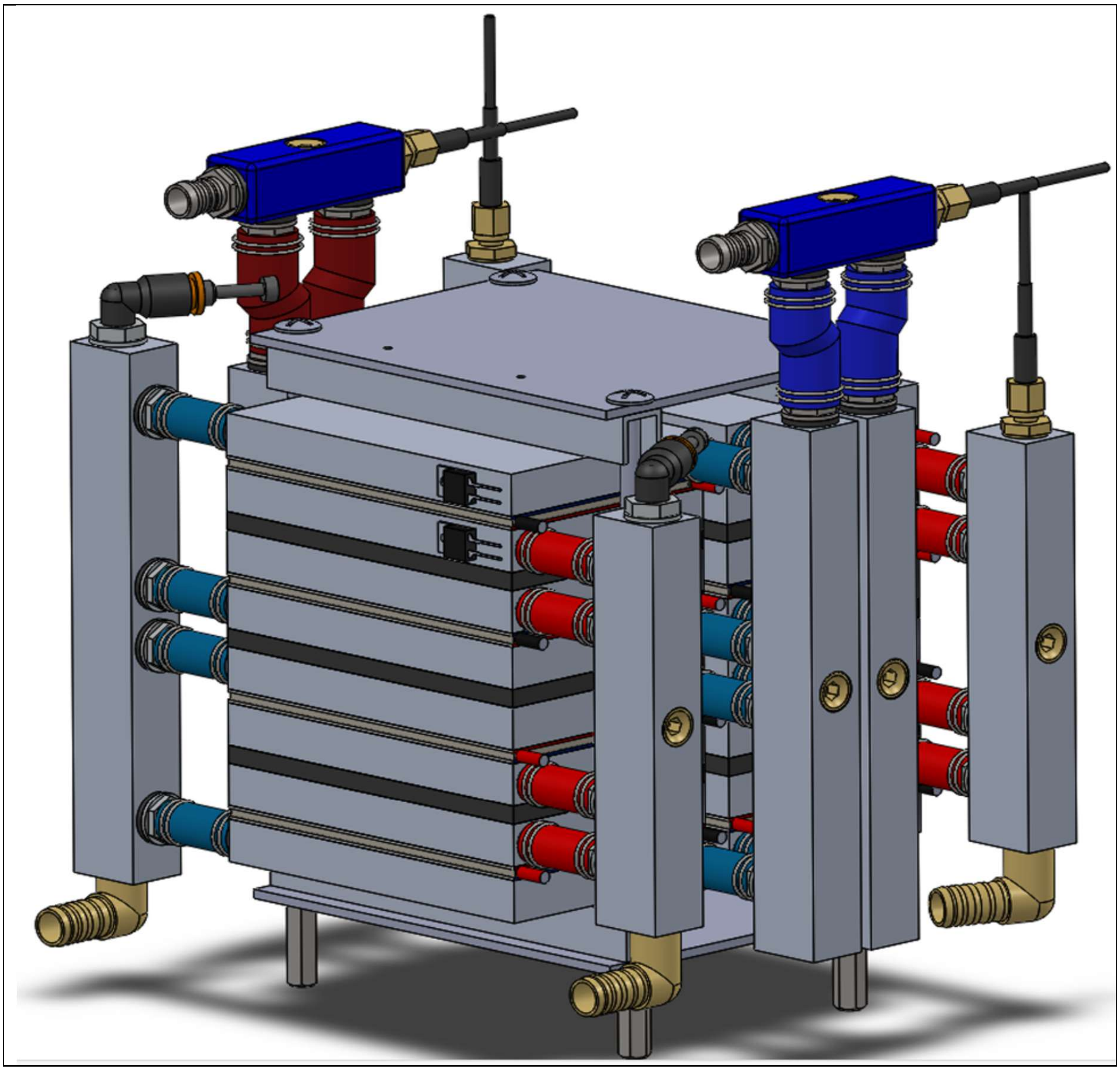
Hummingbird Series

Revised October 2024
Version 2.0

6kW Fluid to Fluid Thermoelectric Heat Pump

High capacity, high temperature, reversible heat engines.

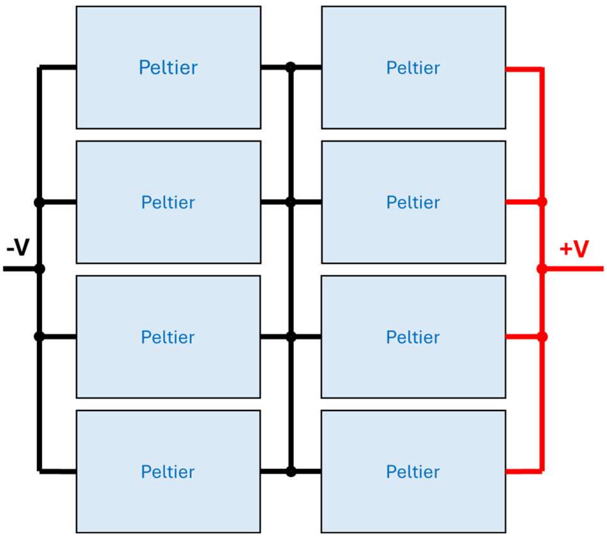


Overview.

The **Hummingbird™** Thermoelectric Heat Pumps (TeHPs) have been developed to service a wide range of thermal management applications using a common form-factor. They are intended for use as standard heat pump for heating or cooling applications using either a fixed-voltage supply or, if connected to the Peltech Optidrive® range of controllers, offer a wide and reversible heating / cooling capacity with controllable power usage and very high Coefficient of Performance. The heat engines will be available in a range of capacities to >20kW.

The TeHP utilises the Peltier effect to create a temperature difference between the opposing faces of the device in response to a DC current being passed through it. The magnitude of the temperature difference depends proportionally on the current, and the direction of the temperature gradient depends on the polarity of DC current. The amount of heat pumped by the Peltier elements depends on both the DC current passing through it and also the temperature difference between its faces.

The efficiency with which a Peltier element can pump heat is referred to as the Coefficient of Performance (CoP). This is expressed as the ratio of the electrical power applied (P_E) to the amount of heat absorbed on the cold face (Q_C): $CoP_{(Cooling)} = Q_C / P_E$, or $CoP_{(Heating)} = (Q_C + P_E) / P_E$ or $CoP_{(H)} = CoP_{(C)} + 1$. The CoP is strongly influenced by the temperature difference, ΔT, between the faces of the Peltier element and also by the current flowing through the device. The magnitude of the current that leads to the greatest temperature difference (ΔT_{MAX}) across the element is referred to as I_{MAX}, and the highest CoP for any given ΔT and operating current is expressed as a ratio of $I{:}I_{MAX}$. ΔT_{MAX} depends on the average temperature of Peltier elements (*i.e.*, the difference between the hot- and cold-side temperatures) and is usually measured for a hot side temperature of 27°C, 50°C or some other convenient value. ΔT_{MAX} is strongly temperature dependent whereas I_{MAX} is largely temperature independent. The Hummingbird TeHPs use anywhere between 8 and 48 Peltier modules running thermally in parallel and have a nominal maximum DC voltage of 48V and a ΔT_{MAX} in excess of 70°C @ T_{HOT} = 50°C. Other voltages are available in multiples of 12V DC or 24V DC, depending on the capacity.



Minimising the thermal resistances on each side of the Peltier element is particularly important if an efficient heat pump is to be realised, especially so on the side which rejects the additional electrical energy supplied to the device. For this reason, the TeHP uses fluid labyrinth heat exchangers on both sides of the Peltier element. The physical size of the heat exchangers is the same as Peltier element – this ensures that there are no thermal “short circuits” between the hot and cold sides. The data in the following tables and graphs specifies various related parameters, *e.g.*, fluid flow rates, that should be regarded as a minimum for the end-use application of the heat engine. The recommended coolant in the system is deionised water. For applications where either side may fall close to or below freezing point, glycol may be added at a ratio commensurate with the lowest anticipated temperature.

The Hummingbird series uses the Peltier elements configured in an array similar to shown above. This gives a degree of fault-tolerance and helps equalise the operating points of the elements in the array. *Note that each graph indicates if the data are for an individual element or the whole array.*

Thermoelectric Heat Pumps

Application areas.

The Hummingbird heat pumps are ideally suited for the following application areas:

- Fridges, Freezers, Tumble Dryers.
- Hot water tank, hot tub & swimming pool heaters.
- MVHR units.
- Air-conn and air heaters (fixed & stand-alone).
- Recuperators.
- Energy recyclers (e.g. grey water).
- Traditional Air, Ground & Water source heat pumps.
- Micro heat pumps – e.g. water & drinks coolers.
- EV cabin heating, cooling & battery thermal management.
- Pre-heaters for hot water systems.
- Off-grid DC systems.

Differences to conventional heat pumps.

There are a number of unique features of a TeHP that differ from conventional heat pumps:

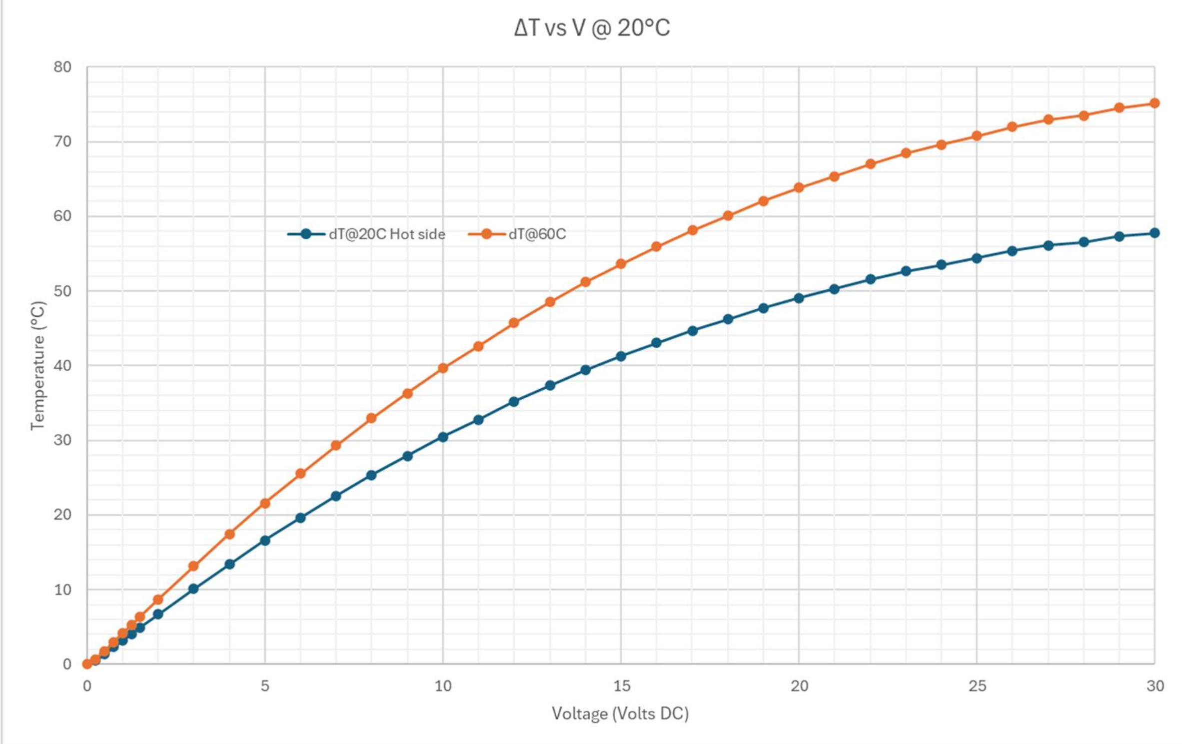
- Bi-directional heat transport.
- No refrigerants / gases.
- High Coefficient of Performance.
- Low starting current.
- Ideally suited to off-grid / battery DC systems.
- Low cost.
- Physically robust.
- No vibration.
- Infinitely variable modulation of output from 0% to 100%+ of rated capacity.
- Unlimited stop / start.
- Quiet, compact and lightweight (< 3kg / kW).
- High temperature range (< -30°C → > 80°C).
- Reliable (MTTF > 300K hours / 30 years continuous use)
- Fault-tolerant Peltier element array.
- Scalable output to many kW.

Ancillaries

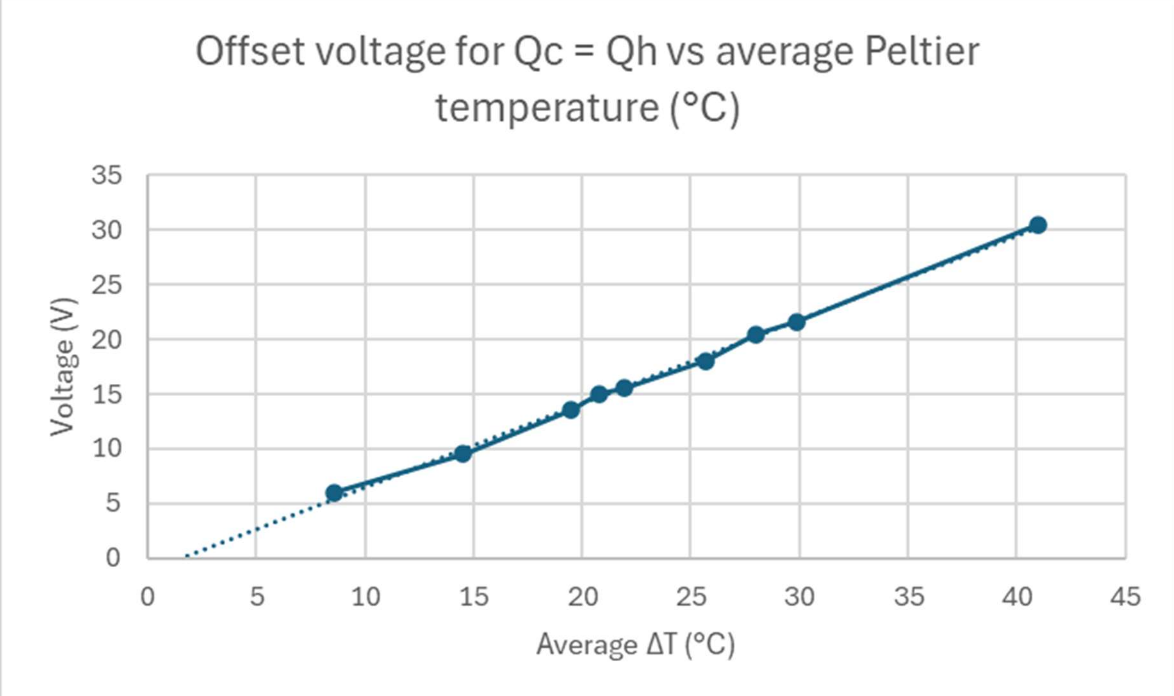
Each unit is supplied with the following additional parts:

- 4 x DS18B20 digital temperature sensors (Hot & Cold side Inlet & Outlet).
- 2x 8mm swivel 90° push-fit pipe connectors for filling points.
- 4x M6 x 30mm standoff / mounting points.
- 2x 80°C normally closed auto-reset thermal cutouts (hot side & cold side). Reset at 65°C.
- Electrical connection block.
- 4x 13mm I.D. hot & cold side inlet ports.
- 2x 13mm I.D. hot & cold side outlet ports.
- Pre-plumbed manifolds with high temperature red & blue silicone hoses.

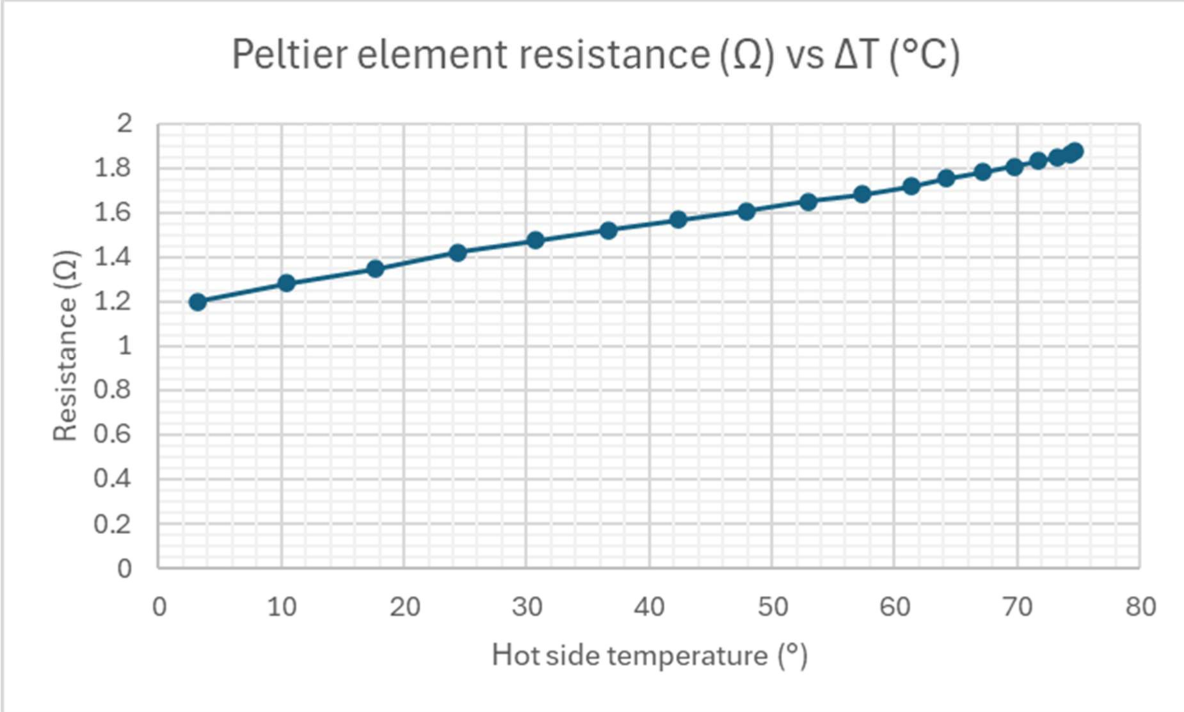
The following graphs summarise the main parameters of the 6kW Hummingbird heat engine.



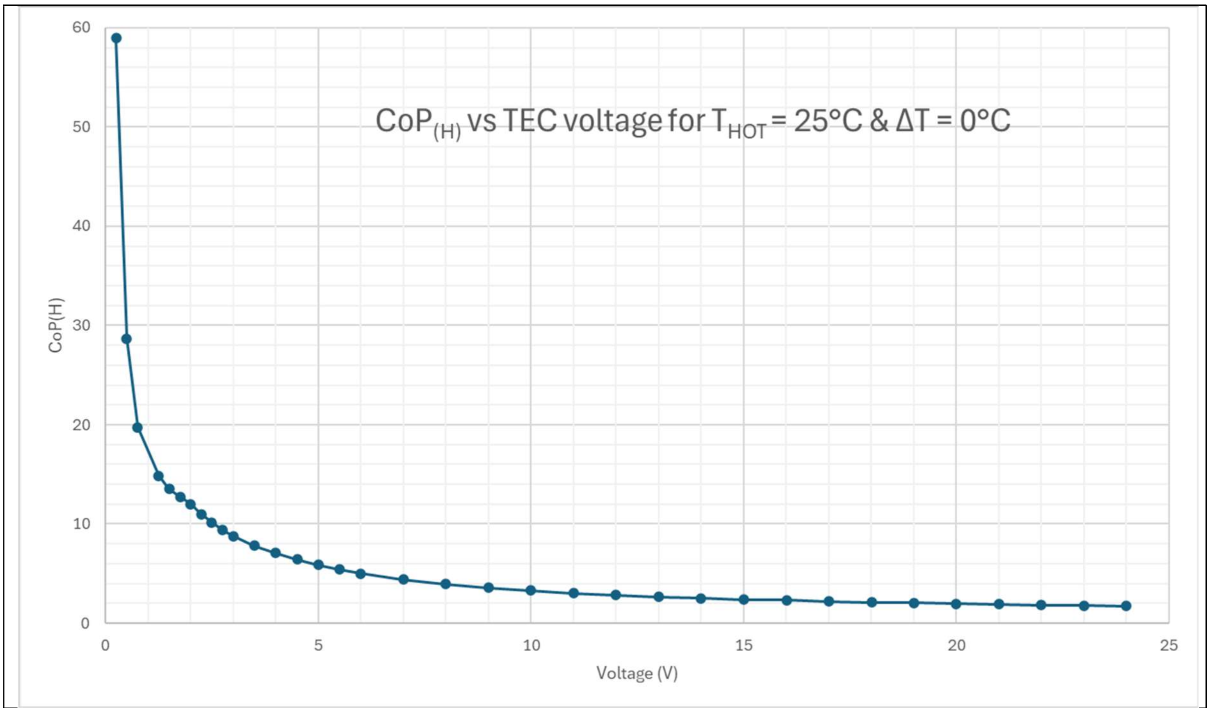
Temperature vs voltage for T_{HOT} = 20°C and for T_{HOT} = 60°C. *Peltier element.*



Voltage offset vs ΔT. The voltage required for a given ΔT to establish a heat flow Q_C *Array*

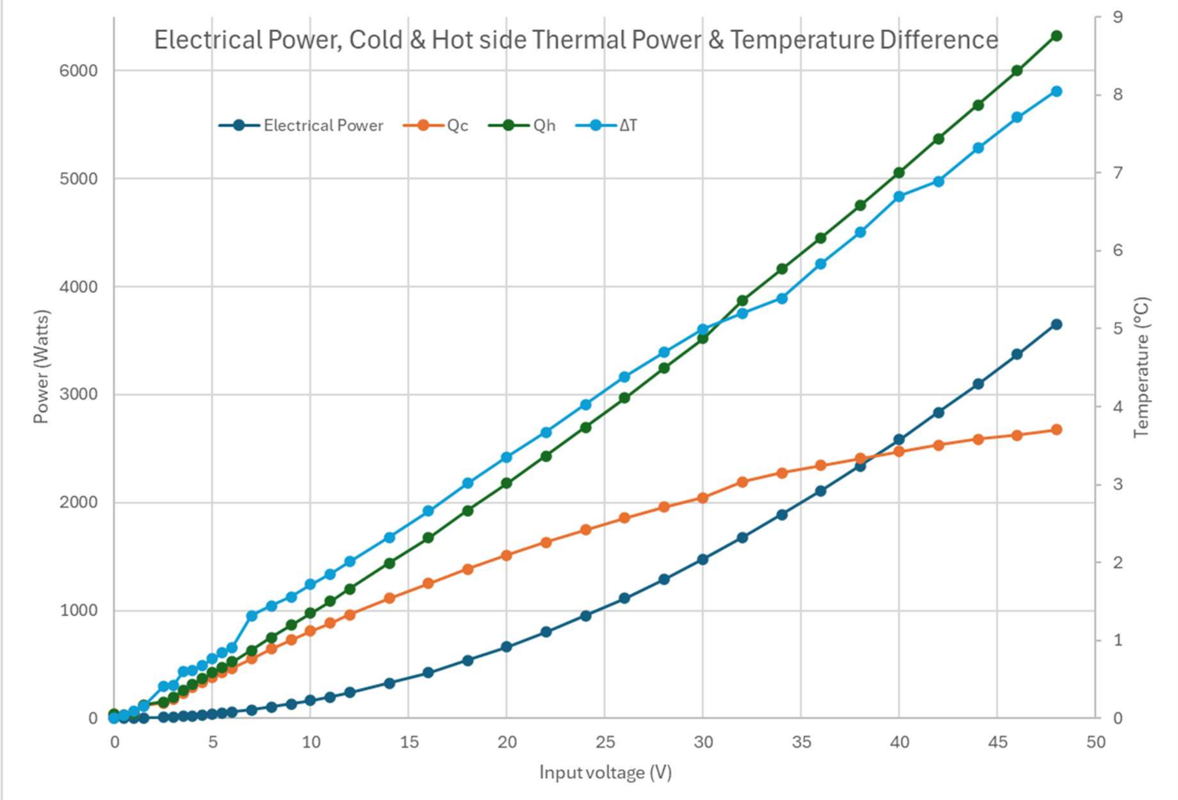


Variation of individual Peltier electrical resistance with hot side temperature. *Element*



Coefficient of Performance (heating) vs Peltier voltage for T_{HOT} = 25°C and ΔT = 0°C. *Element*

Thermoelectric Heat Pumps



Thermal & Power characteristics for 6kW Hummingbird. *Array*

Summary tables.

Parameter	Value	Condition
Rated Output Power	> 6kW	T_{HOT}=20°C / I_{IN} = 80A / ΔT=0°C
Maximum voltage(4)	48V DC	T_{HOT}=20°C
Maximum current(7)	80A	T_{HOT}=20°C / V_{IN} = 48V DC
Peak CoP	> 60	See graph
ΔT_{MAX}	> 55°C / > 70°C	T_{HOT}=20°C / T_{HOT}=60°C
Operating temperature range(1)	-30°C → 80°C	At rated output power
Operating pressure range	0.5 → 2.5 Bar	Relative to atmospheric
# Peltier devices(2)	8	6kW unit
# Temperature sensors(3)	4	Type DS18B20
Fluid connect internal diameters	13mm	All ports
Minimum flow rates (hot & cold sides)(6)	12 L/min	DI water / no glycol
Electrical connector cross-section	16mm^2	Copper cables with lugs
Peltier array resistance	0.6Ω	At 20°C. (See graph)
Mass of assembly	10.5 kg	Measured with no fluid
Physical size (W x D x H)(5)	170 x 245 x 300mm	Includes cable bend radius

Precautions and notes.

1. During operation at or below the dew point of where the TeHP is in use, condensate or ice will form on the exposed surfaces of the heat exchangers, pipes and manifolds.

2. The clamps securing the stacks of heat exchangers and Peltier devices are pre-torqued and then secured to the mounting stand-offs. Attempting to disassemble the stack will permanently damage it.
3. Temperature sensors data is at https://www.analog.com/en/products/ds18b20.html
4. The parasitic Seebeck voltage produced by the heat engine ΔT is approximately 110mV /°C.
5. The assembly is intended to be mounted vertically to enable air to be easily expelled.
6. Inclusion of glycol will require increased fluid flow rate to retain thermal performance.
7. Maximum current @ 48V DC is > 80A at < 20C and < 80A at > 20C.

Optidrive™ controllers

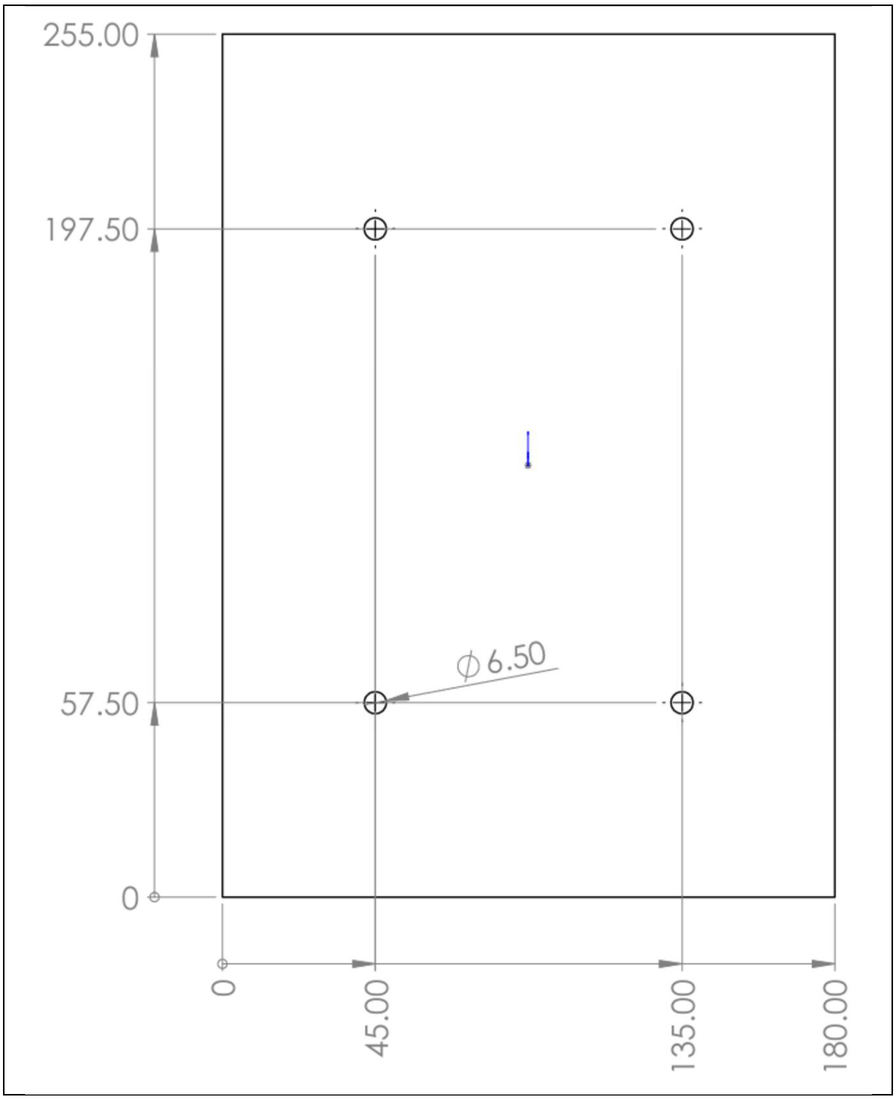
All Optidrive controllers have a variable Peltier element output drive. The modulation range of the controller is from 0% to 105% of rated output. An intuitive touch screen interface is used to control the various functions of the unit and this permits setpoint adjustment, On/Off control, Heating / Cooling etc. The controller can interface directly to the temperature sensors and thermal cutouts built into the Hummingbird series of TeHPs.

When used with the Optidrive controller, the Hummingbird series products are able to achieve a very high operating efficiency at part load due to the variable electrical power delivered to the Peltier elements in the heat engine.

If an Optidrive controller is required please contact Sales@TEConversion.com.

Mechanical Drawings

Mounting position for 6kW Hummingbird. All dimensions in mm.



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