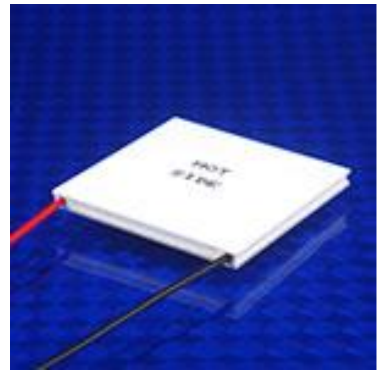
TXL-127-25Q



Thermoelectric Generator Module with high L/A ratio elements and 127 Thermoelectric Couples

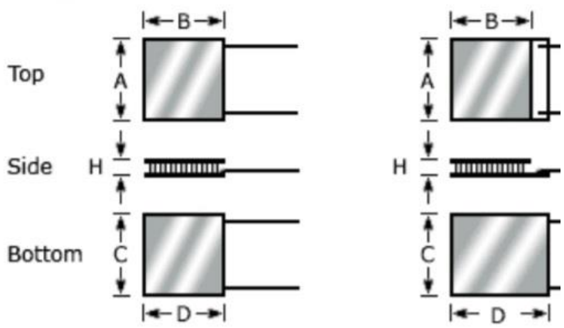
Internal Resistance: R_{int} = 4.9 Ω

Maximum Ratings --- Do Not Exceed
T Anywhere on Module   125 °C

Dimensions, Lapped

Bottom Plate				Top Plate			
A		B		C		D	
mm	in	mm	in	mm	in	mm	in
40.0	1.57	40.0	1.57	40.0	1.57	40.0	1.57

Weight (w/o leads)
21.3 grams



Design Guidelines: This module has been specifically designed for electrical power generation from the relatively low grade (low ΔT) heat sources found in the environment. Graphs for this specific module are shown on the next page, but the design formulas are common to all TE generation applications and should be used for tailoring the module to the application.

Open Circuit Voltage: This module uses bismuth telluride thermoelements having a temperature dependent Seebeck coefficient (thermopower) of S=200 μV/ºC at room temperature and increasing 0.4% per degree C with temperature rise. So the formula for the the no-load or open circuit voltage is

$$V_{OC} = N * (0.0002 * 1.004^{\Delta T}) * \Delta T \qquad (1)$$

where N is the total number of thermoelements (254, or twice the number of thermocouples), the term in parenthesis is the thermopower, and $\Delta T = T_H$ - 27ºC, where we assume a cold side temperature tied to a room temperature standard of 27ºC.

When a load is attached to the module, the output voltage that appears across that load, V_L, is less than V_{oc} and is a function of the load resistance R_L and the internal resistance R_{int} of the module. The output voltage, current and power may be calculated as

$$V_L = \frac{V_{OC}R_L}{(R_L+R_{int})}, \qquad I_L = \frac{V_L}{R_L}, \qquad P_L = \frac{V_{OC}^2 R_L}{(R_{int}+R_L)^2} \quad (2)$$

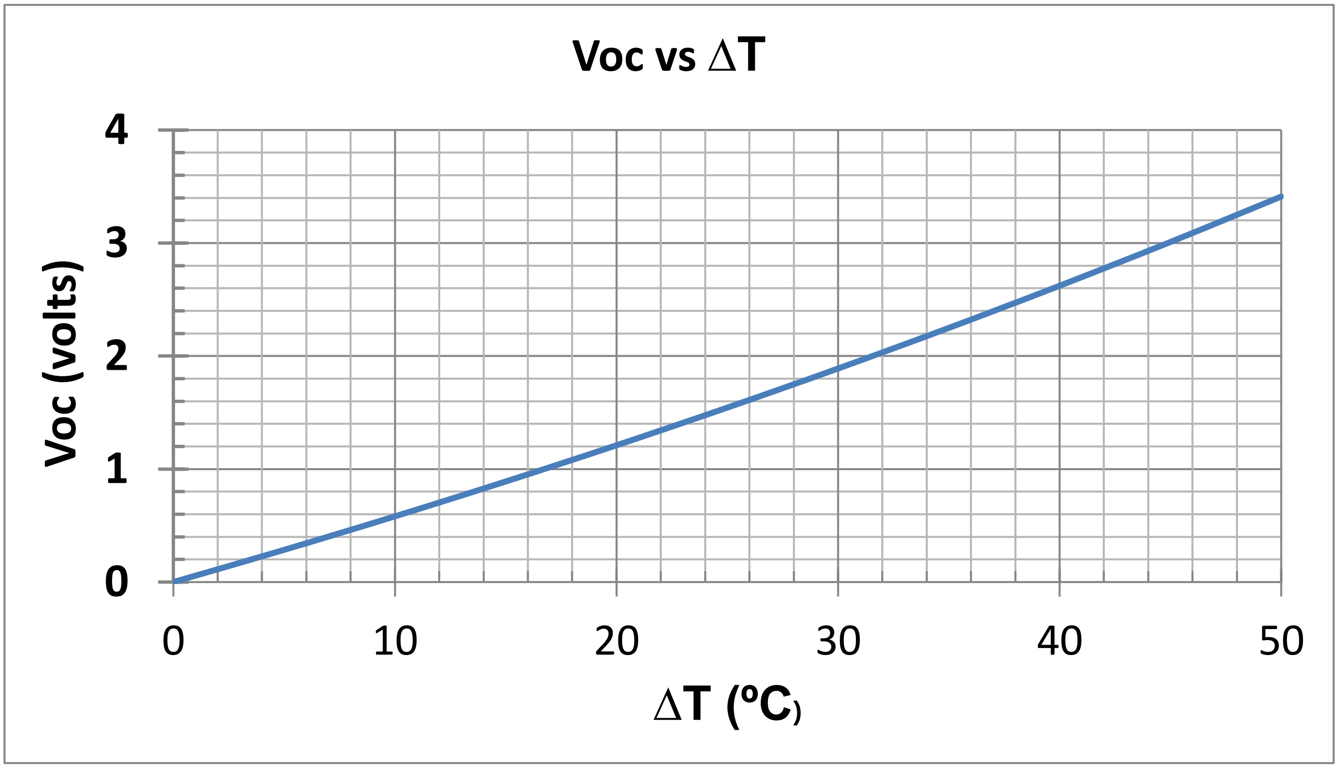


Figure 1 – Open Circuit (No Load) Voltage vs ΔT for the TXL-127-25Q

Figure 1 depicts the open circuit voltage as a function of the temperature difference across the module, assuming the cold side temperature is held to a constant 27ºC.

Impedance Matching: When a load is added to the output of the module it always causes a decrease in the output voltage relative to the open circuit or no-load voltage. This can be seen from the V_L calculation in equation (2). So, it might seem that having high valued electrical loads is desirable from the standpoint of having high values of output voltage. This is not necessarily so, since the power delivered to the load is also a function of the value of load resistance. There is a well-known result from circuit theory that the maximum power is delivered to an electrical load when that load is chosen to match the input impedance of the generator. This is known as "Impedance Matching". A plot of the power output as a function of the maximum possible power that can be delivered to a load is shown in Figure 2. This is a general plot that applies to any arbitrary electrical generator.

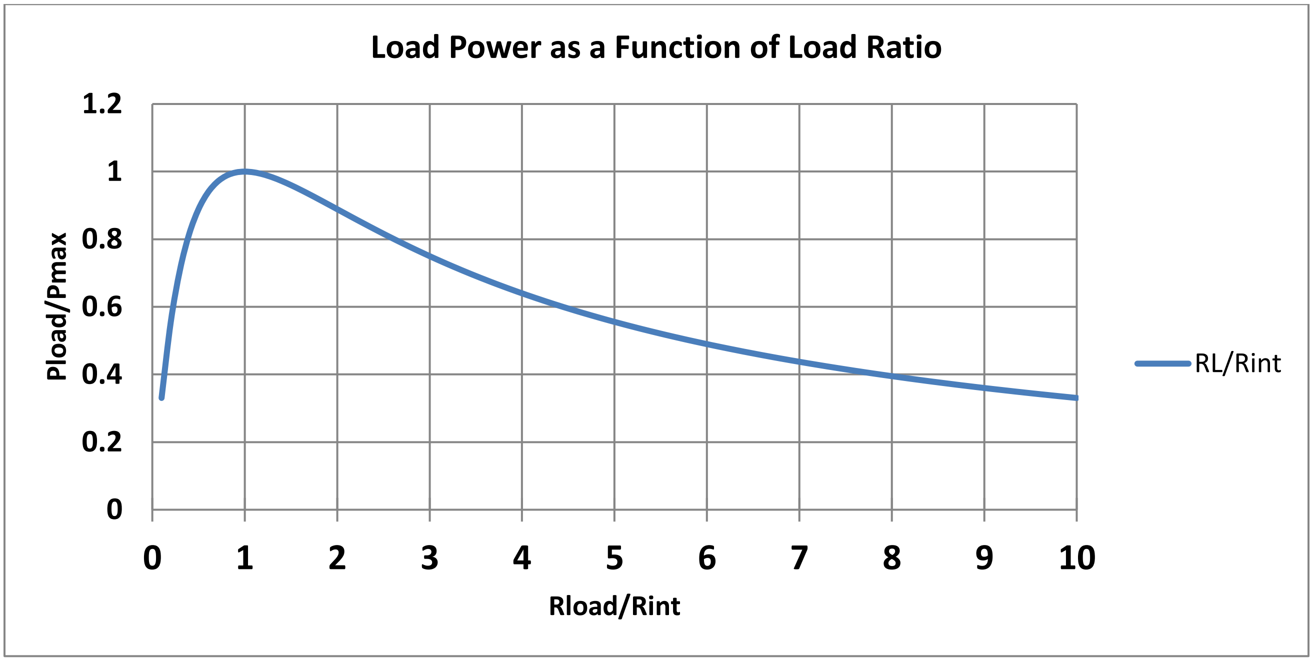


Figure 2 – Output Power as a Function of Load Resistance

Output power is not necessarily the only item of interest in a thermoelectric generation application. Sometimes it is desirable to use a load resistance that is higher than the maximum power load in order to have higher, more useable, output voltages. A plot of output voltage as a function of ΔT for three different choices of load resistance is shown in Figure 3.

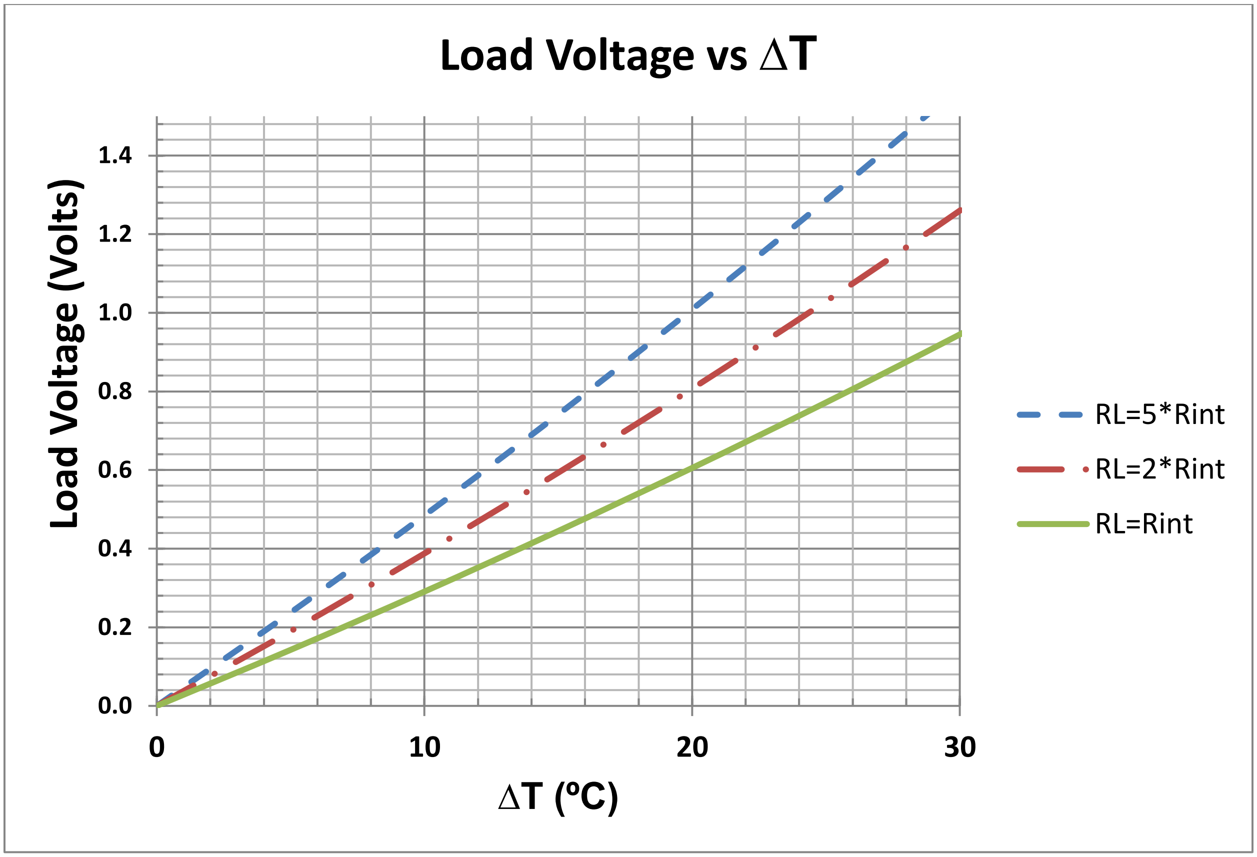


Figure 3 – Load Voltage as a Function of ΔT for Three Different Values of Load Resistance for the TXL-127-25Q (Rint = 4.9 Ω)

Figure 4 depicts the power delivered to the load as a function of ΔT for three different values of load resistance. In contrast to load voltage, where higher values of load resistance yield higher voltages, when considering power, the highest value occurs when $R_L=R_{int}$ (which is 4.9 Ω for the TXL-127-25Q). It is interesting to note that the power delivered to the load increases as the square of the load voltage. Since the generated voltage is approximately proportional to the temperature gradient across the module, this means that the best way to increase power generation from a given thermoelectric module is to increase the ΔT. However, it is more complicated than that.

Thermoelectric generation involves the coupling between thermal and electrical circuits. An interesting theoretical result is that the maximum power that can be extracted thermoelectrically from two thermal reservoirs occurs when the drop (ΔT) across the active thermoelectric elements is matched by the drops in the parasitic thermal resistances between the reservoirs. This is a thermal impedance match condition.

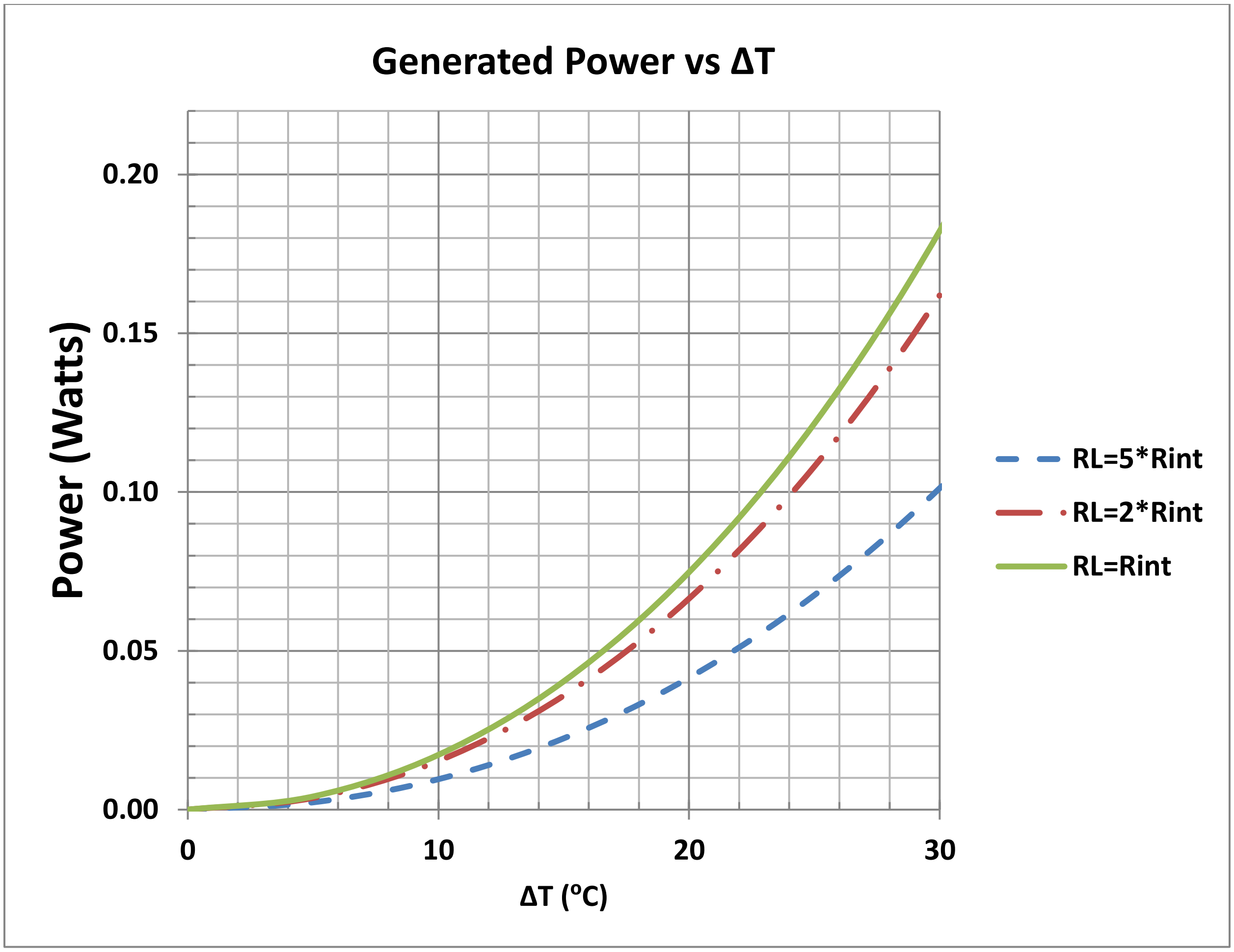


Figure 4 – Load Power as a Function of ΔT for Three Different Load Resistances Using a TXL-127-25Q Module

Obtaining More Power: The TXL-127-25Q has been specifically designed for energy capture from the low levels of heat found in the environment which are almost always under 30ºC. For higher ΔT, equations (1) and (2) can be used to calculate output power, taking care to never exceed the maximum temperature ratings. Output power can also be increased by adding modules in electrical series (for more output voltage) or electrical parallel (for more output current).

When ΔT is Very Low: many applications result in very low generated voltages that are not directly usable. In these cases, it may be necessary to use a voltage boost circuit. TXL Group offers a variety of voltage regulation circuits that can transform voltages as low as 40 mV and boost them to a higher, more usable voltage. For more information and general design guidance, go to http://www.txlgroup.com