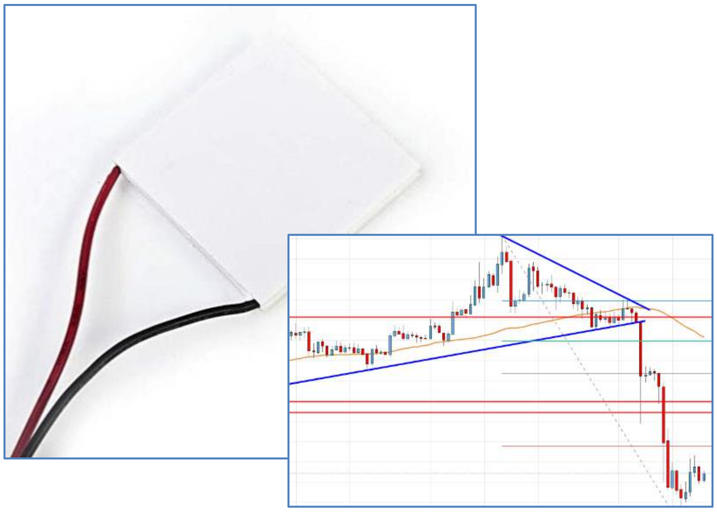


APPLICATION NOTE AN-018

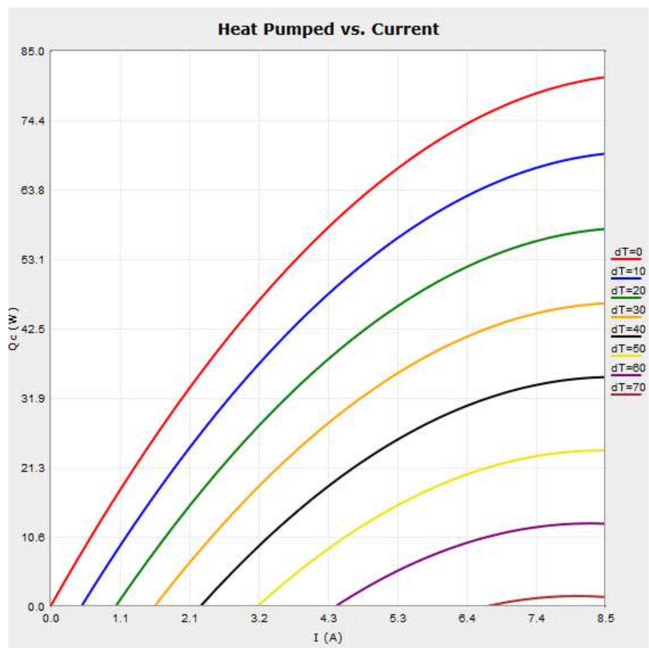
How to Choose the Current Limit for a TEC

October 10, 2019, Rev B

When setting up your temperature controller, what should you set the TEC current limit to? The TEC itself has a current limit specification, but for several reasons, it’s often better to use a current limit lower than the capability of the TEC.

Performance

Many TECs come with a performance curve similar to the chart shown here. This is a typical curve, where the efficiency of the TEC rolls off at the higher currents. Considering this chart, compared to the lower portion of the graph, there is only minor gains in cooling performance between above about 6A, or 75% of the rated current.



Increased Delta T

Operating at higher currents will produce more heat, creating a larger temperature delta (dT) across the TEC due to the increased temperature of the heat sink. As the dT increases, the performance of the TEC decreases. Operating at a lower current will lower the dT, but also lowers the heat pumping action, so there is a balance between current and dT.

Speed

Sometimes speed is the most important characteristic of the system… getting from one temperature to another as quickly as possible. Current certainly plays a major role in that, although as was illustrated above, increasing current may not actually lead to higher pumping capacity, which is what defines speed. However, by improving the performance of the heat sink to lower dT, it’s possible to operate the TEC to higher currents and reduce speed. Also, when heating, thermal pumping efficiency is less important, as it doesn’t matter if you are not pumping heat as quickly. In fact, when heating, you really don’t want to pump any heat at all, as that actually works against you, so higher currents will typically speed the heating process. However, as is discussed below, the higher currents will impact lifetime performance.

Lifetime Performance

TECs will fail. The question is how quickly? There are three major influencers on TEC lifetime: current, thermal cycling, and temperature. If your application requires thermal cycling, it's hard to avoid that, so you typically don't have a lot of control over this input. Likewise with temperature… your application will dictate the operating temperature needed. Current is the main variable that you can control. Lowering the current does a few things: it lowers the dT, which can an indirect impact on the temperature of the TEC; it reduces the speed of material migration between the P-N junctions of the TEC; and it reduces the stress on the joints and connections inside the TEC. Running at or near the maximum current is more likely to stress the weakest point of the TEC and cause a sudden failure when that element breaks. As you reduce the current, you are more likely to see a gradual reduction in the cooling efficiency of the TEC over time (instead of the sudden failure). Operating at 50-65% of the TEC's rated current provides a good trade-off over lifetime and operating performance. In a static (non-cycling environment), a TEC that is not overstress should operate for years. Lifetimes of cycling TECs can vary greatly… hard cycling (high currents, wide temperatures) can cause them to fail in months.

Heat and Energy

While not as critical, a lower current limit will lower the electrical power used and the waste heat generated by the TEC. In a single system application there is little concern, but in larger applications with many channels of control operating over longer periods of time, costs due to electrical power consumption and the heat load on the HVAC can add up.

Heat Sink Performance

Your heat sink performance is indirectly related to selecting a current limit, but a better performing heat sink will allow higher current operation. A good heat sink reduces dT, which improves heat pumping performance, allowing you to reach temperatures more quickly with less power. Even a good heat sink can be overpowered by a large TEC, so it may be that the heat sink itself can only support a current well below the maximum allowed by the TEC. Therefore, within the allowances of your application (size, weight, cost, etc.), use the highest performing heat sink possible.

Selecting a Current Limit

Given everything detailed above, the question of the ideal current limit has not really been answered, although values in the 50-75% range were suggested.

At Arroyo, we typically recommend starting with a current limit of about 2/3 (66%) of the rated current of the TEC, and adjusting up or down as needed or allowed by the application. This limit provides good lifetime performance, good heat pumping efficiency, and typically will not overload most heat sink designs.

If your application can tolerate a lower current limit, do so… you don't need to over-do it, but you might find that while your TEC is rated at 8.5A, you only need 2A to achieve your application requirements, lower the limit to 2 to 3A. Lowering the current limit will increase the life and performance of the TEC, so reduce it where possible and reasonable.

Conversely, you might find that 65% is too low… that you're not getting the speed you need, or the thermal capacity you need. Increase the current limit (but not above the maximum current allowed by the TEC), but take into consideration the elements discussed above.