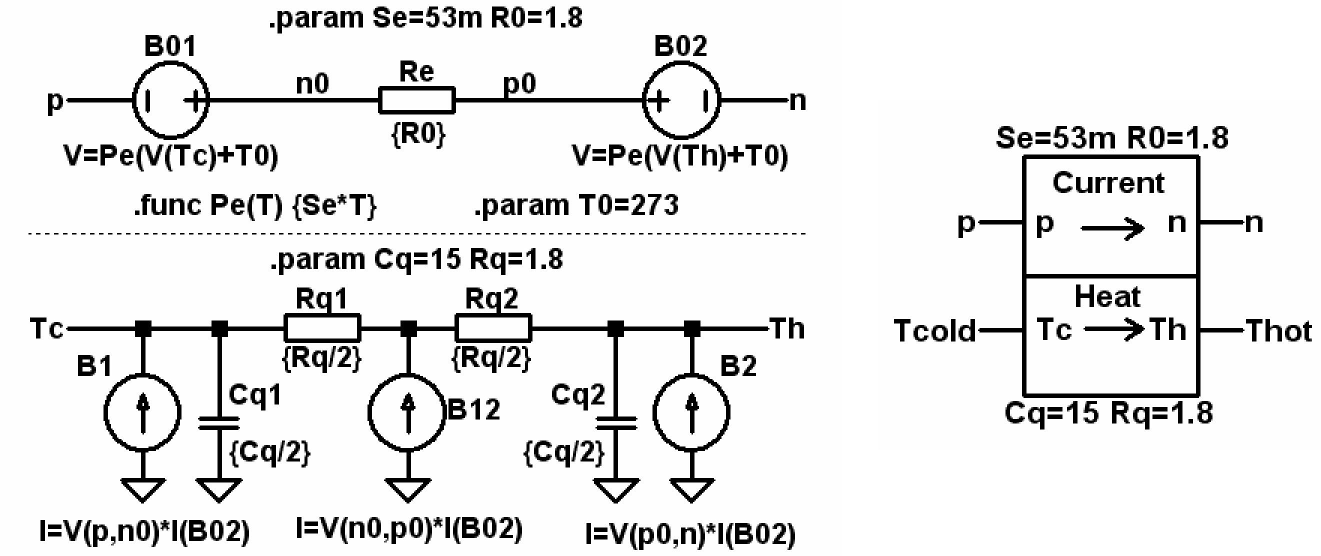
Peltier-Seebeck Thermoelectric Element
TEC1-12706

Kubov V.I. 2016



Model Symbol

Fig.1. Peltier-Seebeck model.

Model's parameters:

Electric part (top): Se – Seebeck coefficient; R0 – Resistance;
Heat part (bottom): Rq – Thermal Resistance; Cq – Thermal Capacity.

TEC1-12706 parameters: Se=53mV; R0=1.8Ω; Rq=1.8°K/W; Cq=15J/°K.

Note. The real parameters of TEC1-12706 maybe more worse relative to ideal parameters.
For example: Se=40mV; R0=6.0Ω; Rq=3.0°K/W.

Heat-Electricity analogy

Electricity		**Heat**
Voltage {V}		Temperature {°K}
Current {A}		Power {W}
Charge {Q}	→	Energy {J}
Resistance {Ω}		Resistance {°K/W}
Capacity {F}		Capacity {J/°K}

Thermoelectric Cooler

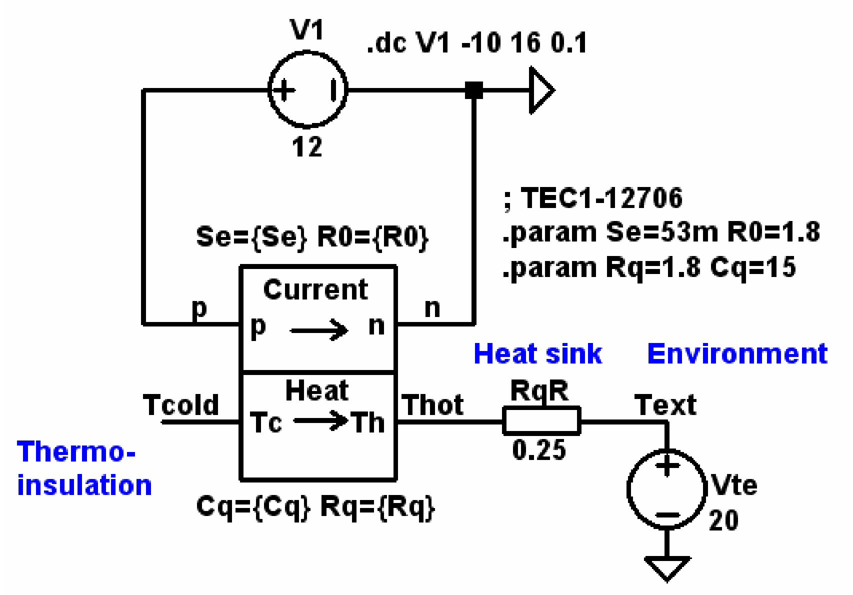
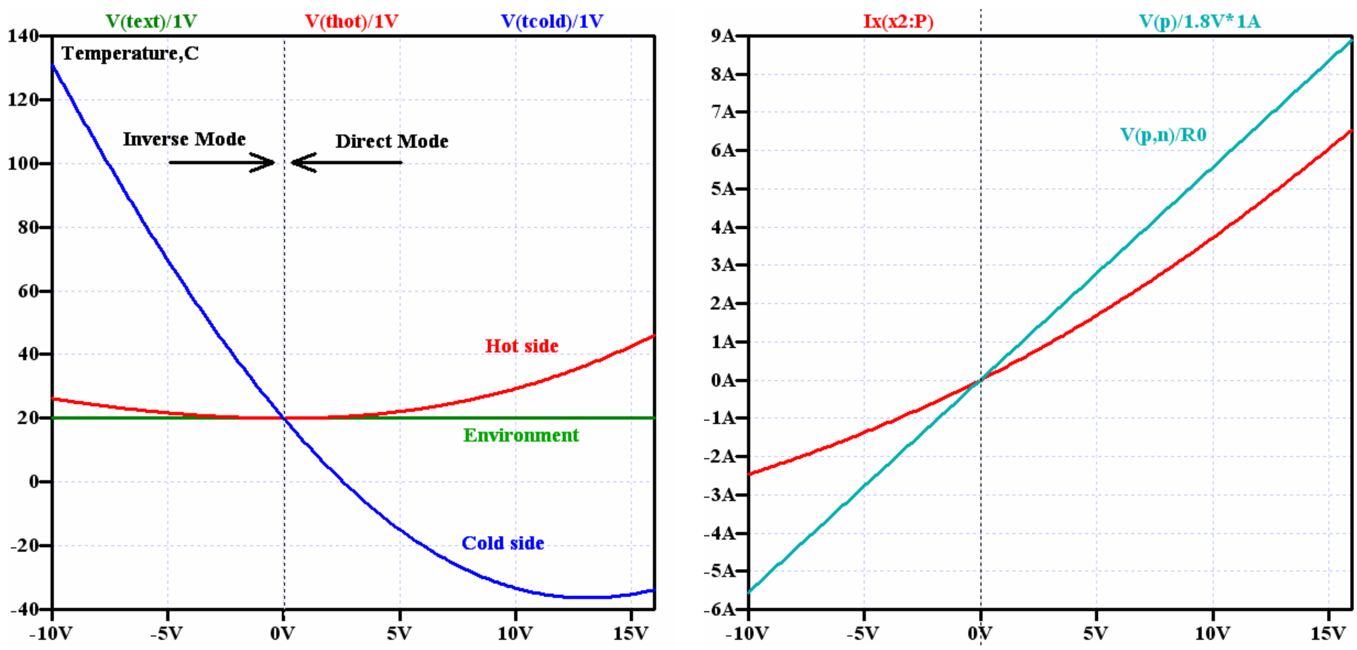


Fig.2.Thermoelectric Cooler.

V1- DC power supply.
The Cold side is heat-insulated. The Hot side is located on Heat sink.
RqR – Heat Sink (CPU cooler). Vte – Environment Temperature {°C}.



a) Temperature versus Voltage b) Current versus Voltage

Fig.3. TEC1-12706 characteristics. Thermoelectric Cooler Mode.

Thermoelectric Generator

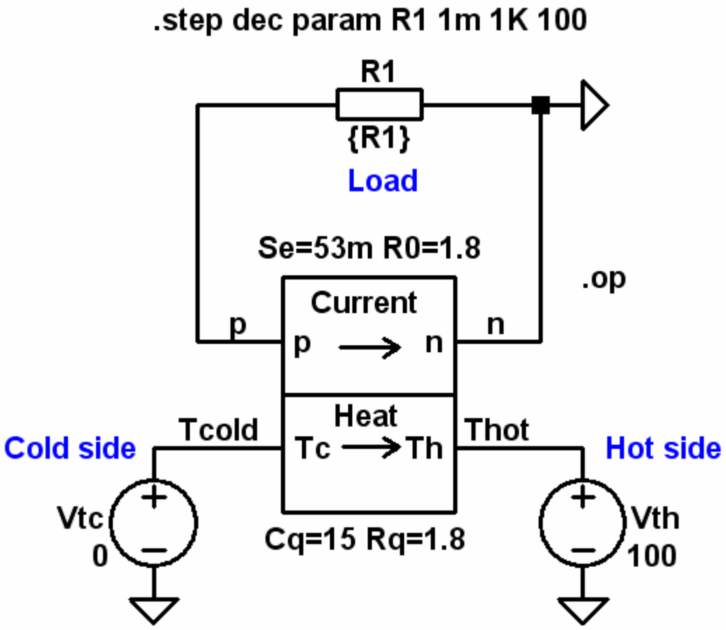


Fig.4.Thermoelectric Generator.

Vtc – Cold side Temerature. Vth – Hot side Temperature. R1 – Electric Load Resistance.

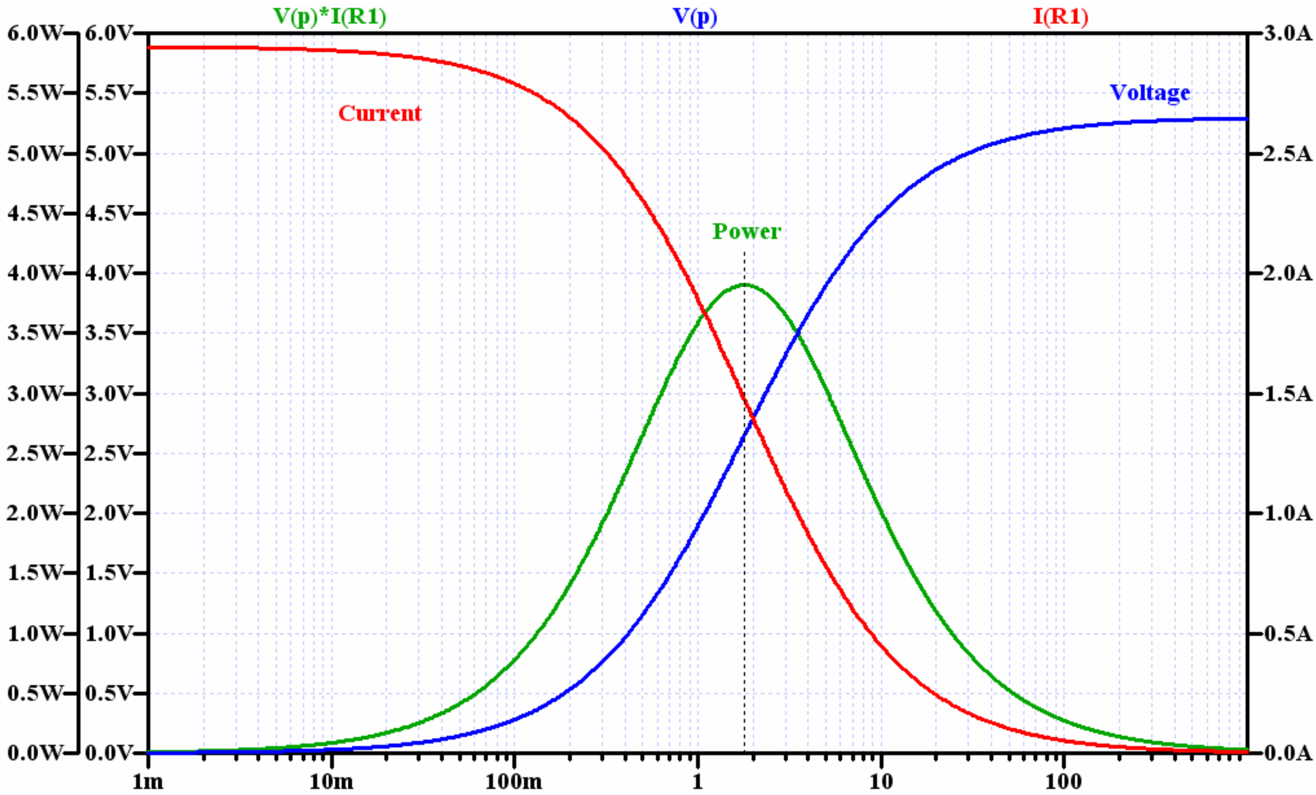


Fig.5. Voltage, Current, Power versus Load Resistance. Thermoelectric Generator Mode. ΔT=100°C.

ΔT=100°C: Voc=5.3V; Isc=2.9A; Pmax=3.8W; R1(Pmax)=1.8Ω.

Dynamic Thermoelectric Characteristics

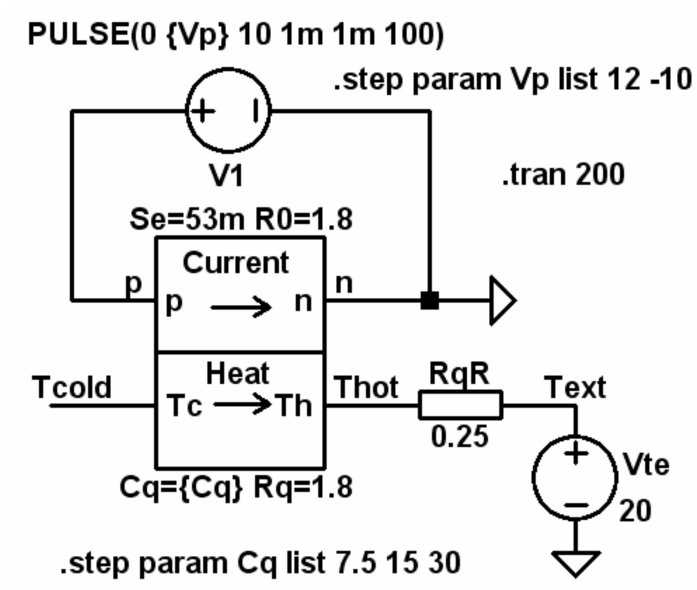


Fig.6. Dynamic Thermoelectric Characteristics.

V1 – Pulse Current Power Supply (+12V – Direct Mode; -10V – Reverse Mode).
Cq – Element Heat Capacity (List: 7.5, 15, 30 {J/°K}).
The Cold side is heat-insulated. The Hot side is located on Heat sink.
RqR – Heat Sink (CPU cooler). Vte – Environment Temperature {°C}.

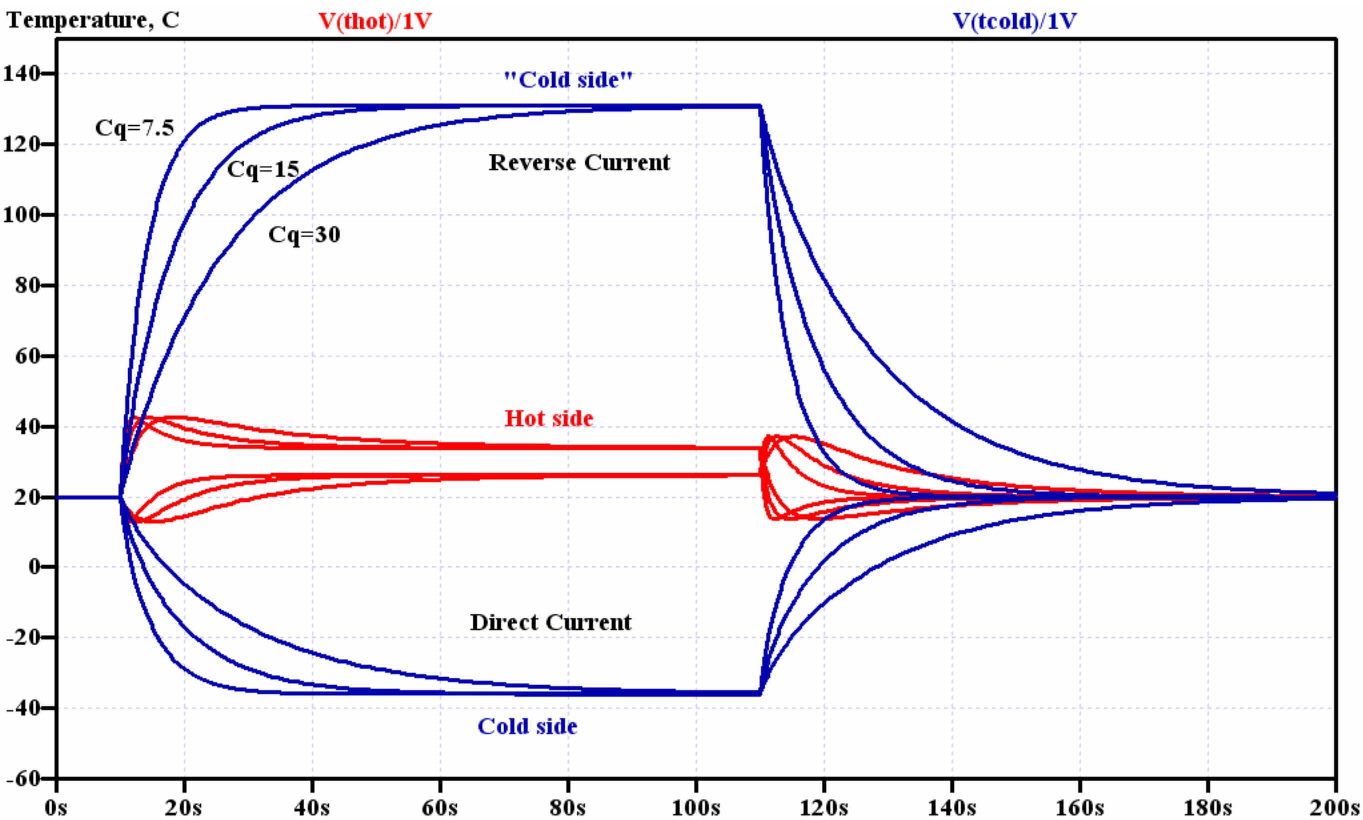


Fig.7. Temperatures versus Time. Voltage On/Off. Direct/Reverse Mode.

When Voltage source is switched to 0V, the Element goes to Generator mode (Short Circuit Mode).
The value of Heat Capacity Cq=15J/°K is most suitable (but not undoubted).

Note. The Heat Time Constant for Open Circuit Mode is greater relative to Short Circuit Mode.
Electric Current produces additional "Heat sink".

Thermoelectric Cooler with natural Cooling

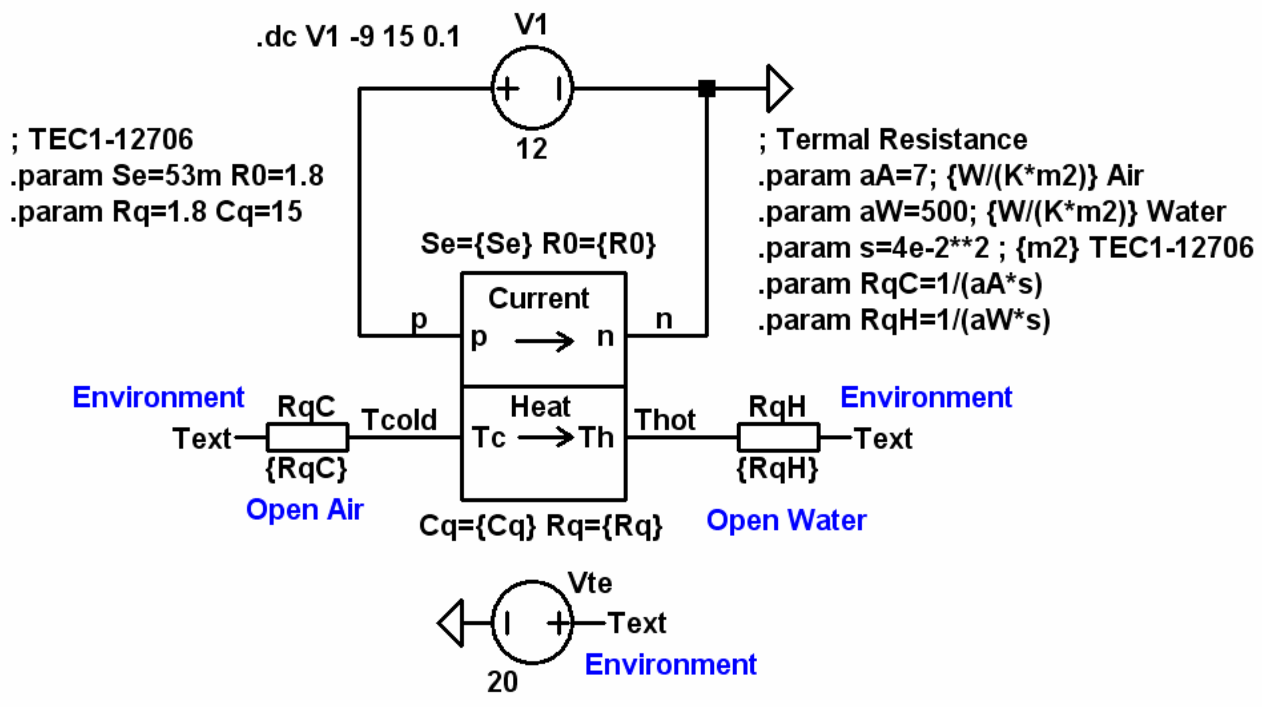


Fig.8.Thermoelectric Cooler with natural Cooling.

V1- DC power supply.

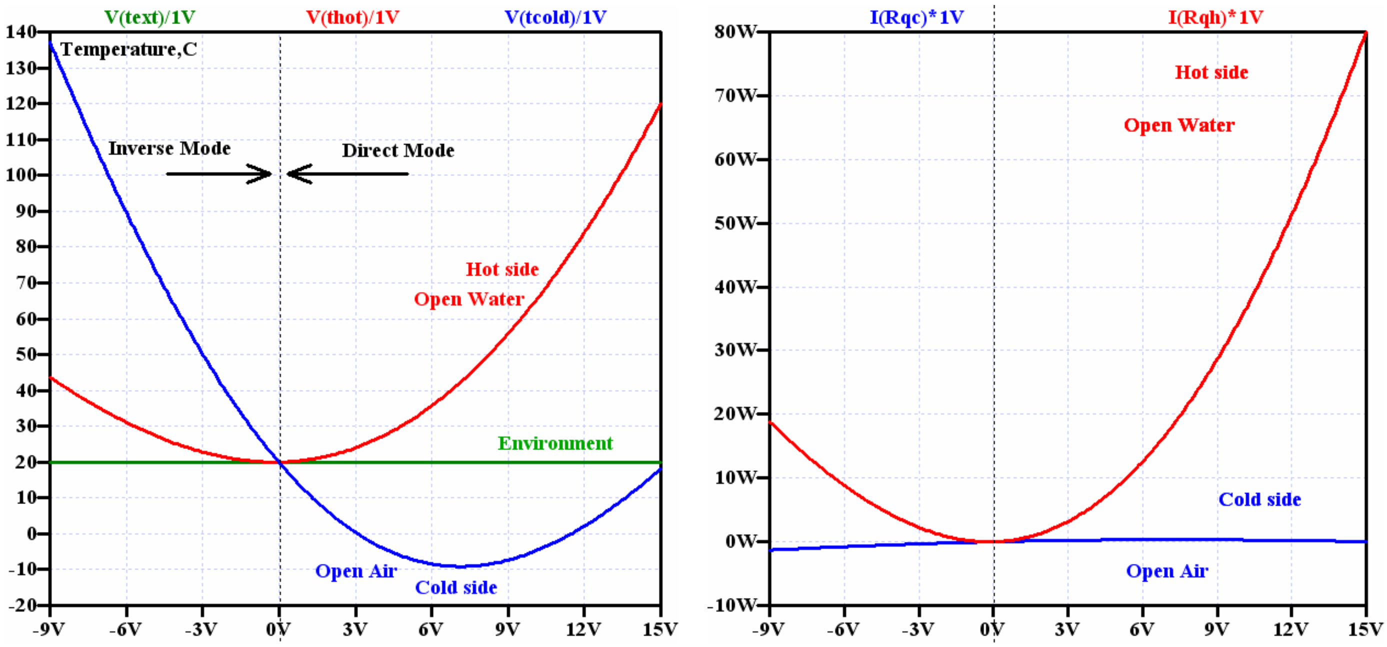
The Cold side is natural cooling by Open Air. The Hot side is natural cooling by Open Water.

Thermal Resistance for natural Cooling is $\Re_{C,H} = 1/\left(\alpha_{C,H} \cdot S_{C,H}\right)$.

Heat conductivity: $\alpha_C = \alpha_{Air} = 7\mathrm{W/(K \cdot m^2)}$ – open Air; $\alpha_H = \alpha_{Water} = 500\mathrm{W/(K \cdot m^2)}$ – open Water.

Radiator size $S = l^2$. Here l = 40mm for TEC1-12706.

Vte – Environment Temperature {°C}.



a) Temperature versus Voltage b) Heating Power versus Voltage

Fig.9. TEC1-12706 characteristics. Thermoelectric Cooler Mode with natural Cooling.

Heat Pump

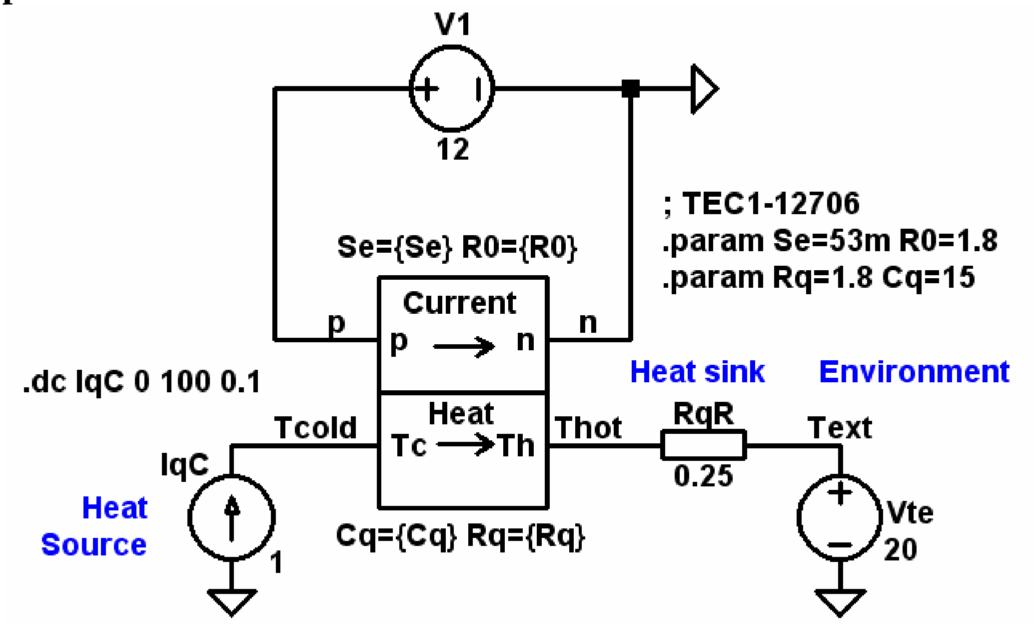


Fig.10.Thermoelectric Heat Pump.

V1- DC power supply V1=12V.
IqC – Heat Power {W} Source on the Cold side.
RqR – Heat Sink (CPU cooler). Vte – Environment Temperature {°C}.

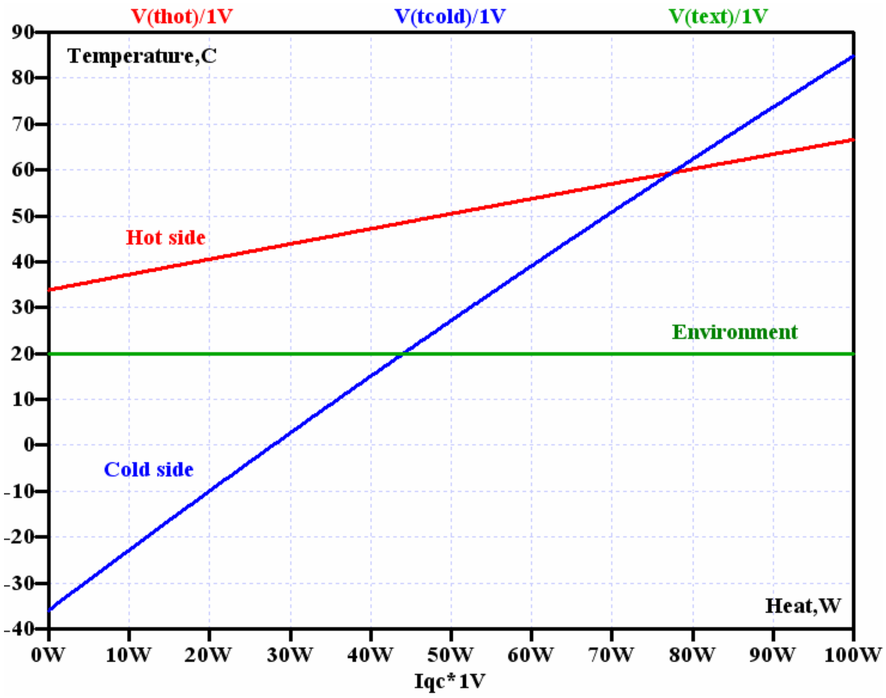


Fig.11. Temperatures of Cold and Hot sides versus Heat Power.

Thermal paste interlayer

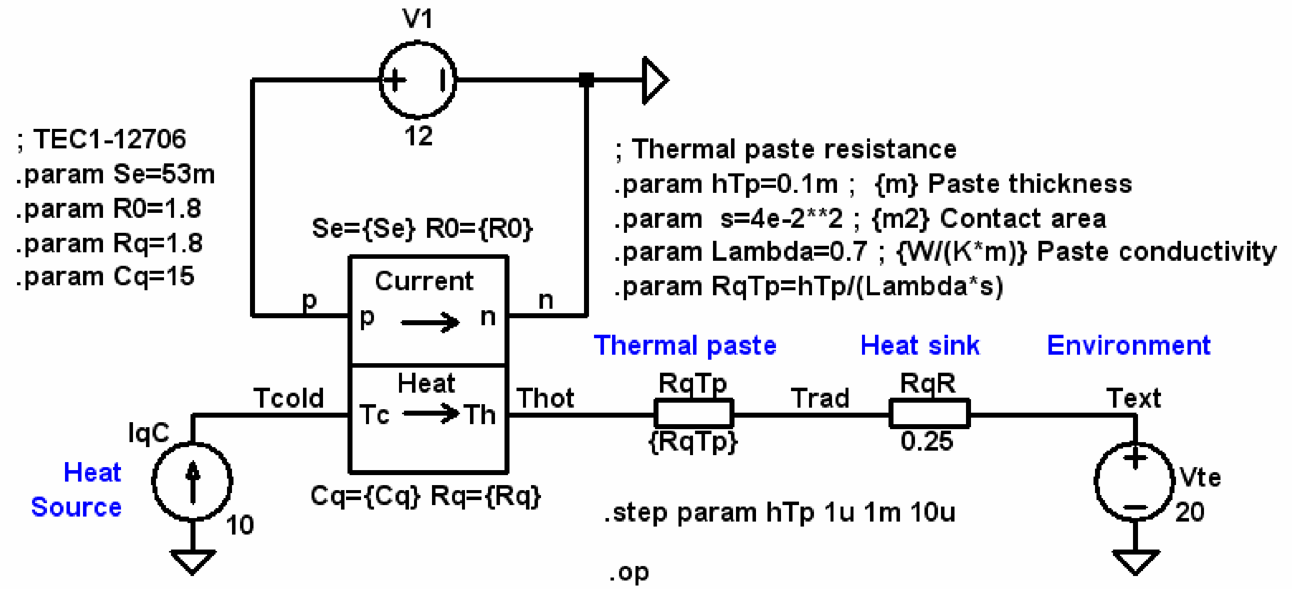


Fig.12.Thermoelectric Heat Pump.

V1- DC power supply. V1=12V.
IqC – Heat Power {W} Source on the Cold side. IqC=10W.
RqR – Heat Sink (CPU cooler).
RqTp – Thermal paste Resistance. Thermal Resistance for thin interlayer is $\Re = h/(\lambda \cdot S)$.
Heat conductivity for common Thermal paste is: λ=0.7W/(K·m) .
Radiator size $S = l^2$. Here l = 40mm for TEC1-12706.
Vte – Environment Temperature {°C}.

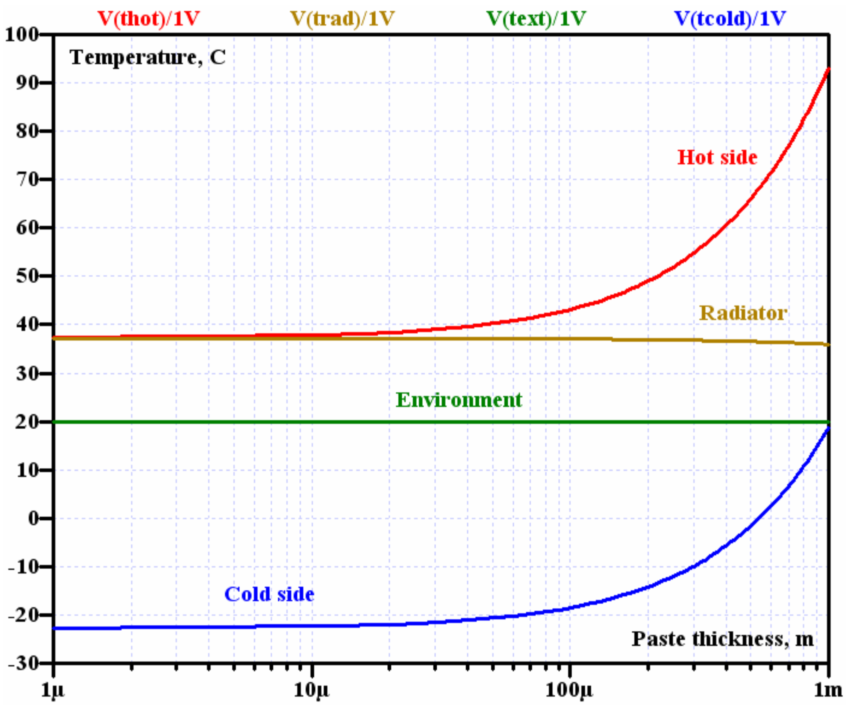


Fig.13. Temperatures of Cold and Hot sides versus Thermal paste Thickness.

The Thermal paste interlayer thickness greater than 0.1mm is unacceptable.

Heat conductivity examples for some materials {W/(K·m)}:
Cooper – 380; Aluminum – 210; Thermal paste (common) – 0.7; Water – 0.6; Air – 0.03.

References

1. Kubov V.I., Dymytrov Y.Y., Kubova R.M. LTspice-model of Thermoelectric Peltier-Seebeck Element. 2016 IEEE 36th International Conference on Electronics and Nanotechnology ELNANO. Conference proceedings. pp.47-51.
2. Kubov V.I., Dymytrov Y.Y., Kubova R.M. LTspice-model of Thermoelectric Peltier-Seebeck Element. Presentation. PeltierELNANO2016.pps. http://dx.doi.org/10.13140/RG.2.1.1372.2002