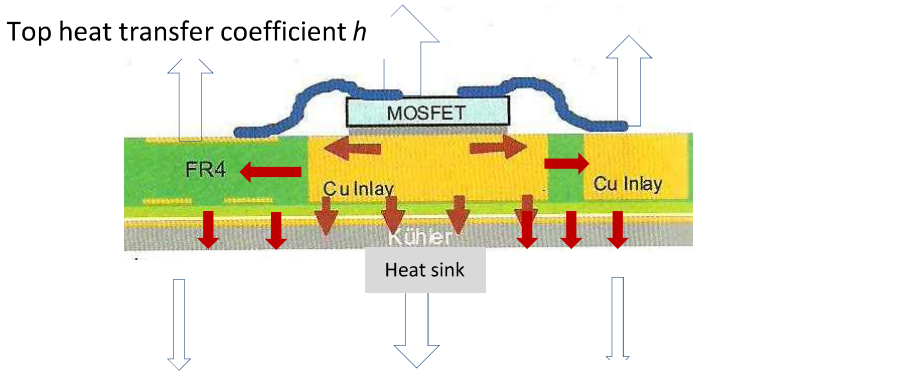
Basic Knowledge I.

Good to know:

- Heat Q is a form of energy [Joule]
- No difference in T -> no heat flow -> no cooling
- FR4 is not a good heat conductor, but much better than not a heat conductor.
- Without FR4 no component would survive. Although heat spreading is low in FR4, it is essential.
- Heat flux $\dot{Q}$ [J/s=W] does not flow in wires like electricity, but anywhere in space.
- Power is also a form of heat flux. All portions of flux emerging from a component must sum up to power loss.
- 1D-thermal resistances R_{th} are always problematic. Heat doesn‘t flow in wires like electricity.
- Ohm‘s law of thermics $\Delta T=R_{th}\ \dot{Q}$ should be handled with care
- 3D treatment is necessary for realistic results
- Cooling is not done by heat sinks, but by cold air.



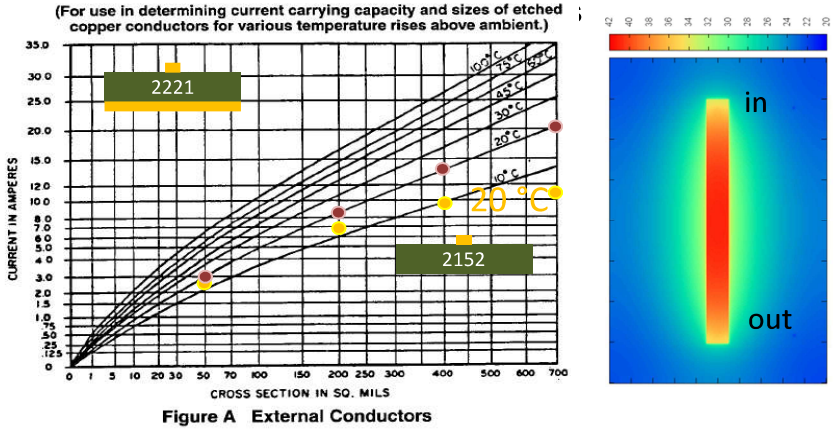
Temperature and Heat

- Heat flows, temperature doesn‘t .
- Heat flows from warm to cold (only).
- Temperature T is the result of heating and cooling conditions.
- Same power could make different temperatures.
- An effective flow of heat results in an overall low temperature, vice versa.
- Heat is flowing better in metals than in plastics and better over large areas.
- Final destination of heat is the ambient air.
- The transition to ambient air is a large hurdle. h will be an input value.

Basic Knowledge II.

Good to know:

- Connector pins or pads are supports of current or potential
- Electric current can be modelled by a pair of pin/pads with
  - U_1 and U_2 (or 0V, resp.),
  - +I and 0V,
  - +I and -I.
- In a net (trace) the sum of currents must be zero or it must be terminated by a voltage sink.
- $V=U_{in}-U_{out}$ is the DC voltage drop. Differences in U drive I.
- Resistance R is $R=V/I$
- Resistance of a straight trace $R_{trace}=\rho_{el}$ *length/cross-section
- Copper: R_{trace} =0.0175 *length(m)/cross-section(mm²)*T-dep term
- For long straight traces heating and cooling are proportional to length (length cancels). Not for short traces.
-



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Temperature and Current

- Flow of DC current I is from high level of *potential* U to low level U.
- Voltage V is the difference of potential values between two points.
- Current is heating up metals (Joule).
- Joule power: $P = R*I^2$ (= $V*I$).
- Resistance R grows with length.
- R grows with shrinking cross-section.
- For our simulations we use the current density [A/mm²] from $-\sigma\nabla U$.
- FR4 is an electric insulator.
- Copper traces are heat spreaders and heat sinks.