Heat Load Calculations

- I started trying to make a spreadsheet that could model the heat load with varying parameters of the mechanical design
- There were certain assumptions made, and loading modes that were ignored for simplicity, but may be significant, and I wanted to include these.

Convection

- All calculations of heat flow until now have used the assumption of an infinite heat bath at T_{amb}
- There is a limit due to the lousy conductivity of air to the amount of heat that can be supplied through a given area, known as *h* the convective heat transfer coefficient.
- For free convection in air, this ranges from 1 to 30 $W/m^2/K$.
- This constrains the heat flow, and allows the determination of the temperature of the edge of the board, and the “warm” side of the fiber connector.

The Cookie

- Assuming the cookie is 15mm x 15mm and 10mm thick.
- Assuming Q=kA/L*(T_h-T_c) and using T_h=T_{amb} would yield 0.33W/m/K*225E-6m^2/0.01m(25-(-15))=0.297W
- However, given Q=hA(T_{amb}-T_h), and a high *h* of 30W/m^2/K would require a dT of 0.297/30/225E-6=44K --TOO LARGE
- Instead use the equations to calculate T_h, the temp of the *hot* side of the cookie and then determine Q
- kA/L*(T_h-T_c)= hA(T_{amb} - T_h)
- T_h =(h* T_{amb} +k/L* T_c)/(k/L+h)
- For this example, T_h =4C, and Q=0.14W, not 0.297
- If h is lower, this value is reduced further.

The Board

- Assuming a board is 40mm x 40mm and 1.52mm thick.
- A brute force calculation assuming k=0.62W/m/K and a 15mm x 15mm APD at –15 at the center yields power of 0.25W
- Approximating the area of the board as a circle of circumference π*L with thickness of 1.52mm given $Q=hA(T_{amb}-T_h)$, and a high *h* of 30W/m^2/K would require a dT of 0.25/30/(3.14*40*1.52E-6)=44K --TOO LARGE
- Instead use the equations to calculate T_h, the temp of the *hot* side of the board and then determine Q
- $kA/L*(T_h-T_c)= hA(T_{amb} - T_h)$
- $T_h =(h* T_{amb} +2k/L* T_c)/(2k/L+h)$
- For this example, T_h =5C, and Q=0.12W, not 0.25
- If h is lower, this value is reduced further.

What Else?

- Convection and Radiation between the board and the heat sink in areas that are not covered with the APD
  - The area of the hot plate and board are (40mm x 40mm – 15mm x 15mm)=0.0014m^2
  - The convection loss heats the air and the air heats the board, this is 30*0.0014*15=0.63W!
  - Radiation loss is 5.67E-8*0.0014*(288^4-258^4)=0.2W