1. \( A_s = \frac{300}{50} = 6 \) Looking at the curves for Butterworth (20dB) it appears that \( n = 2 \) should suffice.
The roots for \( n = 2 \) are 
\(-\alpha \pm j\beta = -0.7071 \pm j0.7071\)
\( Q_{bp} = \frac{500}{50} = 10 \)
Steps for a conjugate pole pair (to transform to 2 BPF sections)
\[ C = 1 = \alpha^2 + \beta^2 \]
\[ D = \frac{2\alpha}{Q_{bp}} = \frac{2(0.7071)}{10} = .14142 \]
\[ E = \frac{C}{Q_{bp}^2} + 4 = 4.01 \]
\[ G = \sqrt{E^2 - 4D^2} = 4.00001269 \]
\[ Q = \sqrt{E + G} = 14.15 \leftarrow Q \text{ for both resonant sections} \]
\[ M = \frac{Q}{\alpha Q} = \frac{0.7071(14.15)}{10} = 1.000626 \]
\[ \omega = M + \sqrt{M^2 - 1} = 1.036 \]
\[ f_{ra} = \frac{\omega}{2\pi} = 482.6 \text{ Hz} \leftarrow \text{Call this Section 1} \]
\[ f_{rb} = \omega f_0 = 578 \text{ Hz} \leftarrow \text{Call this Section 2} \]
Use

\[ T(s) = \frac{-sC/R_1}{s^2C^2 + 2sC/R_2 + 1/(R_1R_2)} \]

Comparing with

\[ T(s) = \frac{Hs}{s^2 + \frac{\omega_c}{Q}s + \omega_r^2} \]

we find

\[ R_2 = \frac{Q}{\pi f r C} \]
\[ R_1 = \frac{R_2}{4Q^2} \]

For section 1 we find

\[ R_2 = \frac{14.15}{\pi (482.6)(1.1 \times 10^{-6})} = 93.3 \text{k}\Omega \]
\[ R_1 = \frac{93.3 \text{k}\Omega}{4(14.15)^2} = 117 \text{k}\Omega \]

For section 2 we find

\[ R_2 = 87 \text{k}\Omega \]
\[ R_1 = 109 \Omega \]

The complete filter circuit becomes:

\[ \text{[Diagram]} \]

\[ \text{[Diagram]} \]
2. Looking at the curves for a Butterworth with $A_s = 3.33\sqrt{\pi}$ appears that a $n=2$ filter should be used. The roots for $n=2$ Butterworth are $-\alpha \pm j\beta = -0.7071 \pm j0.7071$

Start with $n=2$ LPF section

$n=2$ LPF section with $\omega_c = 1 \text{rps}$

\[ C_2 = \alpha = 0.7071 \text{F} \]

Transform to $n=2$ HPF section

\[ R_{1_{HP}} = \frac{C_1}{C_{1_{LP}}} = \frac{1.414}{0.7071} \]

\[ R_{2_{HP}} = \frac{1}{C_{2_{LP}}} = \frac{1}{0.7071} \]

Frequency and impedance scale

\[ FSF = 2\pi \times 10^3 \quad ZSF = \frac{C}{C'(FSF)} = \frac{1}{1 \times 10^{-3} \times (2\pi \times 10^3)} \]

Final circuit is: $\approx 1.6k$

\[ 1.13k \quad 1 \mu F \quad 1 \mu F \quad 2.25k \]
3. From this power derating curve we find \( \Theta_{jc} = \frac{200 - 25}{40} = 4.375 \frac{^\circ \text{C}}{\text{W}} \)

\( T_{max} = 200 \, ^\circ \text{C} \)

If \( \Theta_{cs} = 1 \frac{^\circ \text{C}}{\text{W}} \) and \( \Theta_{sa} = 4 \frac{^\circ \text{C}}{\text{W}} \)

then the maximum power that can be dissipated at \( T_A = 40 \, ^\circ \text{C} \) is

\[ P_{D_{max}} = \frac{200 - 40}{9.375} \approx 17.1 \, \text{W} \]

The heat sink temperature at \( P_{D_{max}} \) is \( T_s = 40 + 17.1(4) = 108.4 \, ^\circ \text{C} \)

\( (T_A = 40 \, ^\circ \text{C}) \)