14th Order Chebyshev Lowpass Filter 3dB ripple
(Distributed)

\[ Q_1 = 3.5182, \quad Q_2 = 0.7728, \quad Q_3 = 4.6386, \quad Q_4 = 0.8039, \quad Q_5 = 4.6386, \quad Q_6 = 0.7728, \quad Q_7 = 3.5182, \quad Q_8 = 1 \]

Choose configuration w/ even # of series components

\[ R_0 = L_1 = L_2 = L_3 = L_4 \]

Transform to distributed filter:

\[ \frac{Z_3}{Z_2} = \frac{Z_2}{Z_1} = \frac{Z_1}{Z_0} = \frac{Z_0}{Z_{in}} = \frac{Z_{in}}{Z_{out}} = \frac{Z_{out}}{Z_{in}} \]

all \( Z \) in series @ \( Q = 1 \)

\[ \frac{Z_{in}}{Z_{out}} = \frac{Q}{Q_Z} \]

Add Unit Elements (UEs) at ends of filter
Let's use $Z_{ue} = Z_0 = 1$ and $\lambda/8$ length at $Z_e = 1$

Using Kuroda's identity, convert $\lambda$ to shunt components:

\[ N = 1 + \frac{Z_e}{Z_{2e}} \]

\[ Z_2 = \frac{Z_1}{Z_{2e}} \]

Look at right side: $Z_1 = Z_{01}$, $Z_2 = Z_{ue} = 1$

\[ N = 1 + \frac{Z_e}{Z_{2e}} = 1 + \frac{1}{Z_{2e}} = 1 + \frac{1}{\frac{35.82}{Z_{2e}}} = 1 + \frac{35.82}{Z_{2e}} = 1.2842 \]

So:

\[ Z_{ue} = 1 \]

\[ Z_{51} = Z_{01} (1.2842) = 4.5181 \]

\[ \frac{1}{NZ_{2e}} = 0.7787 \]

\[ Z = 1.2986 \]

Since symmetric, the equivalent distributor pitch is:

\[ Z_{51} = 4.5181 \]

\[ Z_{e} = 1.2986 \]

\[ Z_{2e} = 1.2986 \]

\[ Z_{2e} = 1.2986 \]
Add another pair of UEs at the filter ends.

Using Kundu’s identities:

\[ \frac{Z}{N} \]

Group (a) \[ \text{let } Z_2 = 1.2986 \text{ and } Z_1 = 1 \text{ the } N = 1 + \frac{Z_2}{Z_1} = 2.2986 \]

End \[ \frac{Z}{N} = \frac{1}{2.2986} = 0.4350 \]

So

\[ Z = 1.2986 \]

\[ Z_5 = Z_2 N = 1.2986 - 0.564 \]

\[ 2.2986 \]
Repeat procedure using Kuroda's Identity

for \( Z_3 \) and \( Z = 1.2940 \rightarrow \text{group (b)} \)

for group (b) \( Z_2 = 1.2940, \quad Z_3 = Z_3' = 4.5181 \)

so \( N = 1 + \frac{Z_3'}{Z_2} = 1.2864 \)

and \( Z_1 N = 4.5181 \times 3.5122 \)

1.2864

and \( Z_1 = \frac{1.2860 - 1.0059}{N} = 0.2829 \)

so the distributed cut is:

\[
\begin{array}{cccccccc}
0.4350 & 3.5122 & 4.6386 & 4.6386 & 3.5122 & 0.4350 \\
\end{array}
\]

add another pair of UEs at either ends:

\[
\begin{array}{cccccccc}
0.4350 & 3.5122 & 4.6386 & 4.6386 & 3.5122 & 0.4350 \\
\end{array}
\]
repeat procedure using Karote's identities.

Let group (a) \[ 0.4350 = z_1 \wedge z_2 = 6 \]

group (b) \[ z_1 = 3.5 \wedge z_2 = 5 \]

group (c) \[ z_1 = 4.4316 \wedge z_5 \]

Karote's Identity.

\[ N = 1 + \frac{z_2}{z_1} \]

group (a): Let \[ z_1 = 0.4350 \wedge z_2 = 1 \]

\[ N = 1 + \frac{z_2}{z_1} = 3.2989 \]

[Diagram of network with labels and calculations]

\[ \frac{z_{53}}{N_2} = 1.435 \]
Group (b): Let $Z_1 = 3.5122$ and $Z_2 = 2.82 = 0.5649$

\[ N = 1 + \frac{Z_2}{\bar{Z}_1} = 1.1608 \]

\[ \frac{Z_2}{\bar{Z}_1} = N \bar{Z}_1 \]

\[ Z = N \bar{Z}_1 = 0.6557 \]

\[ = 4.0770 \]

Group (c): Let $Z_1 = 4.6386$ and $Z_2 = 2.46 = 1.0059$

\[ N = 1 + \frac{Z_2}{\bar{Z}_1} = 1.2169 \]

\[ \frac{Z_2}{\bar{Z}_1} = N \bar{Z}_1 \]

\[ Z = N \bar{Z}_1 = 1.2248 \]
So the final configuration is:

\[ \frac{Z_1}{Z_2} = 3.2989 \Rightarrow Z_1 = Z_0 Z_n \]

\[ = (50)(3.2989) = 165 \Omega \]

if \( R_f = 50 \) \( \Omega \)