Coaxial Filter Design

1.png

This sheet is used to design two coax filters that use semi-rigid RG402 coax cables shorted to ground. Equations are from Pozar "Microwave Engineering" or circuit Sage website. The conversion from ABCD to S21 is from Dean Frickley, MTT Feb 1994 "Conversion between S and ABCD valid for complex impedances"

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Two Coax Filter

$$Z_{coaxshort}(freq, freql) := \begin{pmatrix} 1 & 0 \\ -j\cdot\frac{1}{50}\cot\left(2\cdot\mathbf{p}\cdot\frac{freq}{8\cdot freql}\right) & 1 \end{pmatrix} \qquad Z_{capseries}(freq, cap) := \begin{pmatrix} 1 & \frac{1}{j\cdot 2\cdot\mathbf{p}\cdot freq\cdot cap\cdot ohm} \\ 0 & 1 \end{pmatrix}$$

$$R_{load} := 50\cdot ohm$$

$$nH := 10^{-9}H$$

$$Z_{2p}(freq, freql, cap1, cap2) := Z_{capseries}(freq, cap1)\cdot Z_{coaxshort}(freq, freql)\cdot Z_{capseries}(freq, cap2)\cdot Z_{coaxshort}(freq, freql)\cdot Z_{capseries}(freq, cap1)$$

$$logS21(f, fl, c1, c2) := 20\log\left[\left|\frac{2\left(\frac{R_{load}^2}{ohm^2}\right)^{0.5}}{Z_{2p}(f, fl, c1, c2)_{0,0}\cdot\frac{R_{load}}{ohm} + Z_{2p}(f, fl, c1, c2)_{0,1} + \frac{R_{load}^2}{ohm^2}\cdot Z_{2p}(f, fl, c1, c2)_{1,0} + Z_{2p}(f, fl, c1, c2)_{1,1}\cdot\frac{R_{load}}{ohm}}\right|, 10\right]$$

$c1 := 2.0pF$

$c2 := 1.0pF$

$fl := 250MHz$

Given

$logS21(200MHz, fl, c1, c2) < -50.0$

$logS21(414MHz, fl, c1, c2) = -0.3$

$logS21(434MHz, fl, c1, c2) = -0.4$

$logS21(454MHz, fl, c1, c2) = -0.3$

$logS21(700MHz, fl, c1, c2) < -22.0$

$$\begin{pmatrix} flf \\ c1f \\ c2f \end{pmatrix} := Minerr(fl, c1, c2)$$

$logS21(200MHz, flf, c1f, c2f) = -64.8131$

$logS21(414MHz, flf, c1f, c2f) = -0.3$

$logS21(434MHz, flf, c1f, c2f) = -0.4$

$logS21(454MHz, flf, c1f, c2f) = -0.3$

$logS21(700MHz, flf, c1f, c2f) = -27.7572$

$flf = 270.6761\cdot MHz$

$c1f = 1.8864\cdot pF$

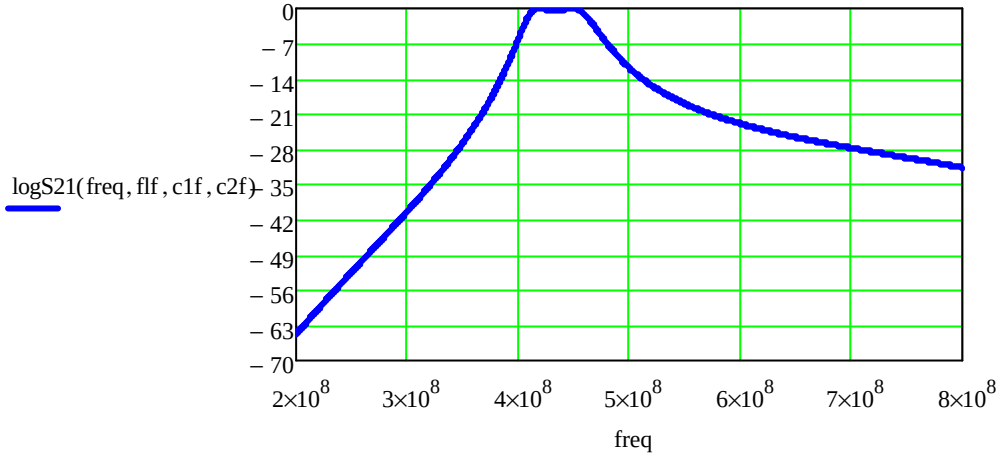
$c2f = 0.6186\cdot pF$

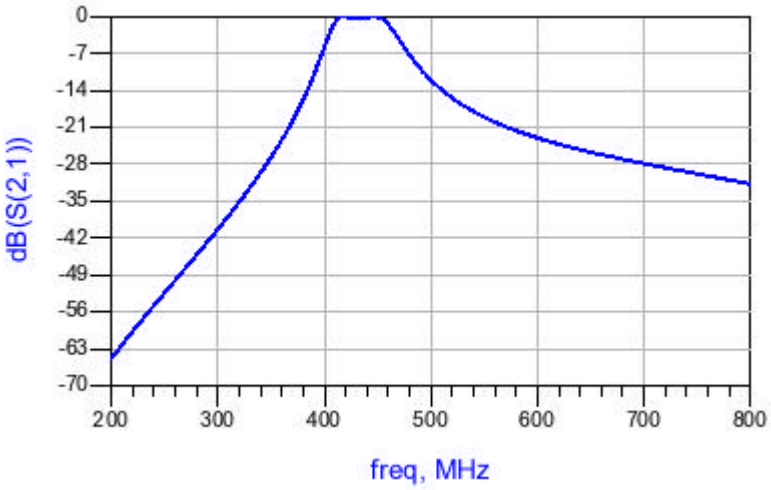
Now we can build the filter using RG402 semi rigid coax cable

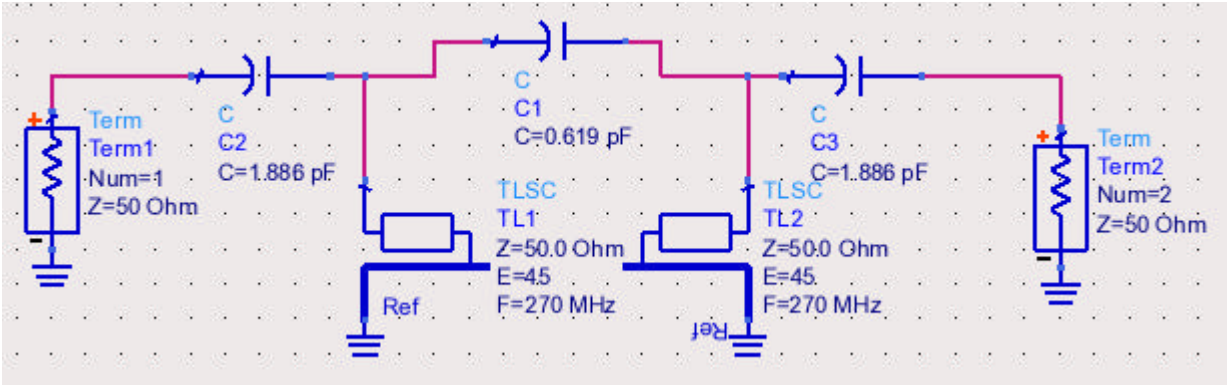
The simulations below use ideal transmission lines and we can see the calculations and siomulations agree very well. The transmission line is shortened bz 3mm to allow for connections.

$$inductorlength(freql) := \frac{300\cdot 10^6\cdot m\cdot s^{-1}}{freql\cdot 8\cdot\sqrt{2.1}} - 3mm$$

$inductorlength(flf) = 92.603\cdot mm$







Three Coax Filter

$$Z_{2p}(freq, fl1, fl2, cap1, cap2) := Z_{capseries}(freq, cap1) \cdot Z_{coaxshort}(freq, fl1) \cdot Z_{capseries}(freq, cap2) \cdot Z_{coaxshort}(freq, fl2) \cdot Z_{capseries}(freq, cap2) \cdot Z_{coaxshort}(freq, fl1) \cdot Z_{capseries}(freq, cap1)$$

$$logS21(f, fl1, fl2, c1, c2) := 20 \log\left[\left|\frac{2\left(\frac{R_{load}^{\,2}}{ohm^2}\right)^{0.5}}{Z_{2p}(f, fl1, fl2, c1, c2)_{0,0} \cdot \frac{R_{load}}{ohm} + Z_{2p}(f, fl1, fl2, c1, c2)_{0,1} + \frac{R_{load}^{\,2}}{ohm^2} \cdot Z_{2p}(f, fl1, fl2, c1, c2)_{1,0} + Z_{2p}(f, fl1, fl2, c1, c2)_{1,1} \cdot \frac{R_{load}}{ohm}}\right|, 10\right]$$

Given

$\text{logS21}(200\text{MHz}, fl1, fl2, c1, c2) < -65.0$

$\text{logS21}(414\text{MHz}, fl1, fl2, c1, c2) = -0.2$

$\text{logS21}(424\text{MHz}, fl1, fl2, c1, c2) > -0.6$

$\text{logS21}(434\text{MHz}, fl1, fl2, c1, c2) > -0.4$

$\text{logS21}(444\text{MHz}, fl1, fl2, c1, c2) > -0.6$

$\text{logS21}(454\text{MHz}, fl1, fl2, c1, c2) = -0.2$

$\text{logS21}(800\text{MHz}, fl1, fl2, c1, c2) < -50.0$

$fl2 := 260\text{MHz}$ $fl1 := 250\text{MHz}$

$c1 := 2.0\text{pF}$ $c2 := 1.0\text{pF}$

$$\begin{pmatrix} fl1f \\ fl2f \\ c1f \\ c2f \end{pmatrix} := \text{Minerr}(fl1, fl2, c1, c2)$$

$\text{logS21}(200\text{MHz}, fl1f, fl2f, c1f, c2f) = -90.1925$

$\text{logS21}(414\text{MHz}, fl1f, fl2f, c1f, c2f) = -0.2$

$\text{logS21}(434\text{MHz}, fl1f, fl2f, c1f, c2f) = -0.4$

$\text{logS21}(454\text{MHz}, fl1f, fl2f, c1f, c2f) = -0.2$

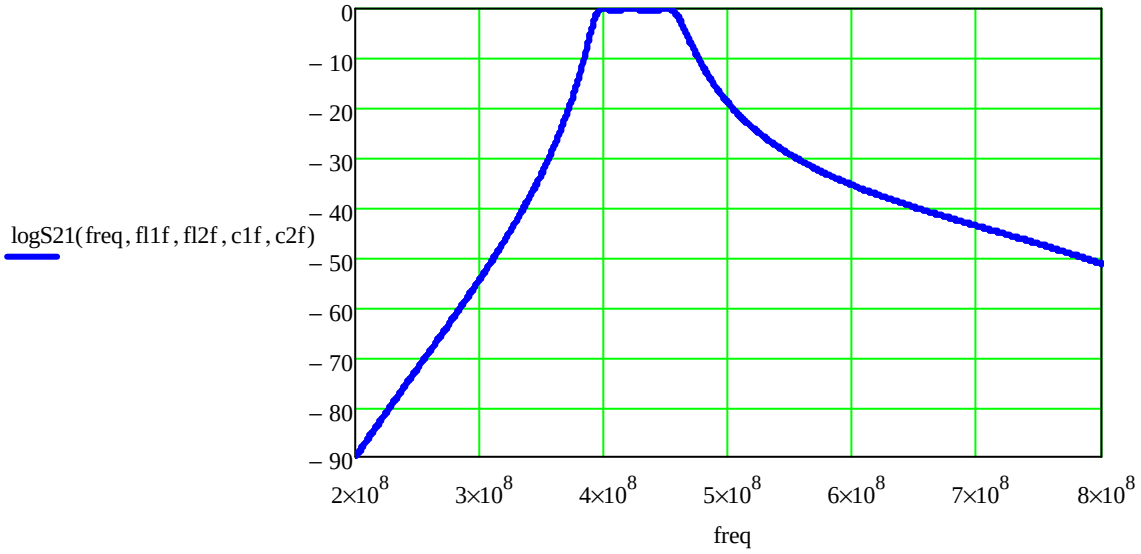
$\text{logS21}(700\text{MHz}, fl1f, fl2f, c1f, c2f) = -43.6445$

$c1f = 2.211 \cdot \text{pF}$

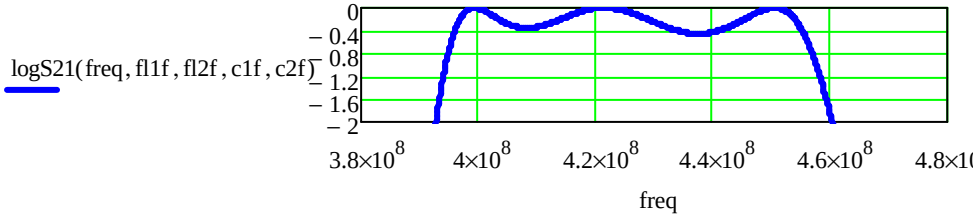
$c2f = 0.6737 \cdot \text{pF}$

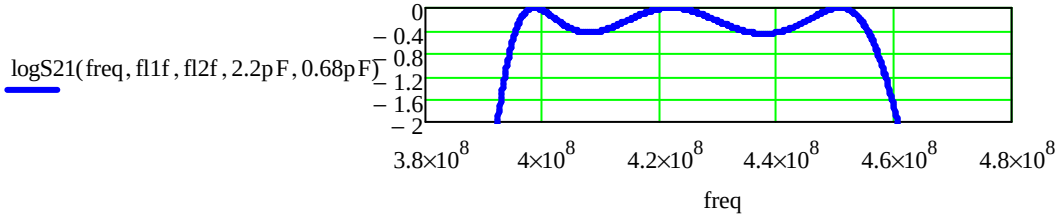
$fl1f = 270.6974 \cdot \text{MHz}$

$fl2f = 239.0721 \cdot \text{MHz}$



This is the close in plot with capacitors from the box

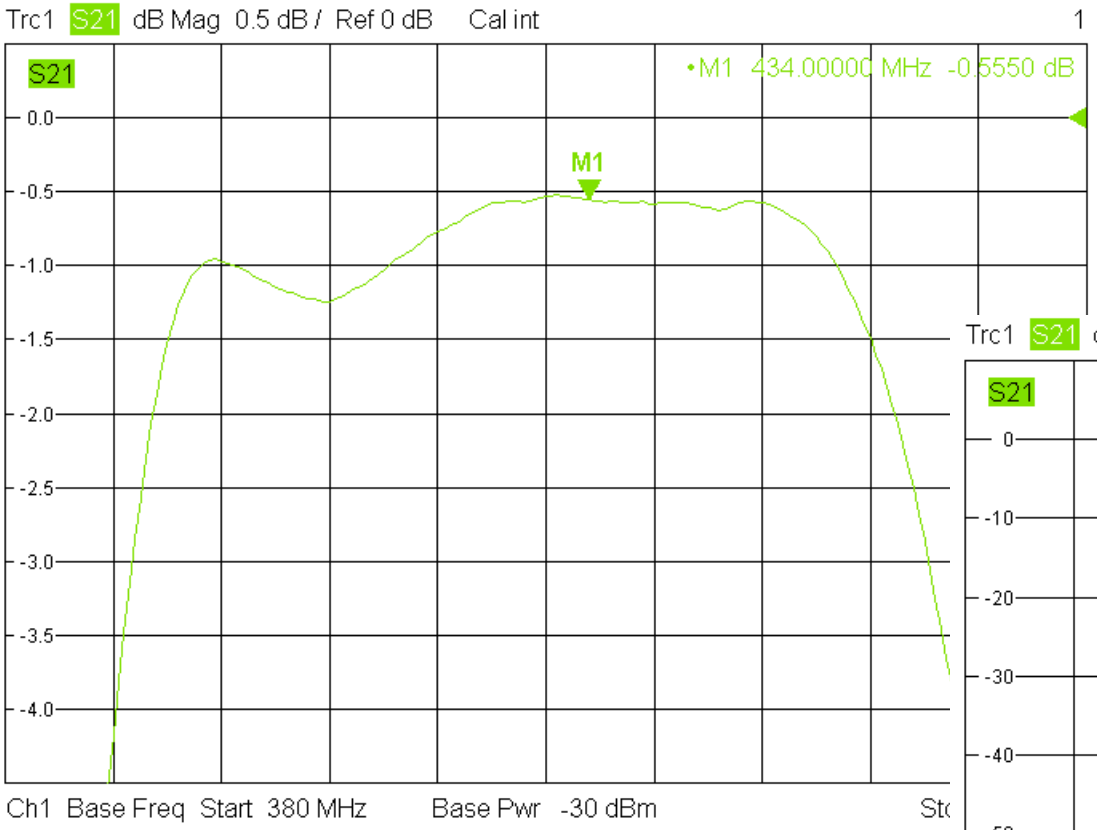




Now we can build the filter using RG402 semi rigid coax cable
The transmission line is shortened bz 3mm to allow for connections.

inductorlength(fl1f) = 92.5955·mm

inductorlength(fl2f) = 105.2412·mm



A reasonable match when it is built