Tuned Three Stage Coaxial Filter

This sheet is used to design **three** coax filters that use semi-rigid RG402 coax cables with capacitors at the bottom to tune.
Equations are derived from starting point 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"
There is no optimisation with this sheet

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http://www.sunshadow.co.uk/chris.htm

The filter is tuned using the capacitors

Where Z_{capgnd} is the impedance of the trimming cap to gnd
Z_{tlgnd} is the impedance to gnd of the coax 50 Ohm cable with the capacitor at the bottom end

$$Z_{capgnd}(freq, capL) := -j \cdot \frac{1}{2 \cdot \mathbf{p} \cdot freq \cdot capL \cdot ohm} \qquad Z_{tlgnd}(freq, freqL, capL) := 50 \cdot \frac{Z_{capgnd}(freq, capL) + j \cdot 50 \cdot \tan\left(2 \cdot \mathbf{p} \cdot \frac{freq}{8 \cdot freqL}\right)}{50 + j \cdot Z_{capgnd}(freq, capL) \cdot \tan\left(2 \cdot \mathbf{p} \cdot \frac{freq}{8 \cdot freqL}\right)}$$

$$Z_{coax}(freq, freqL, capL) := \begin{pmatrix} 1 & 0 \\ \frac{1}{Z_{tlgnd}(freq, freqL, capL)} & 1 \end{pmatrix}$$

This is the impedance of a 50 Ohm coax cable with capacitors at bottom

$$Z_{cap}(freq, cap) := \begin{pmatrix} 1 & \frac{1}{j \cdot 2 \cdot \mathbf{p} \cdot freq \cdot cap \cdot ohm} \\ 0 & 1 \end{pmatrix}$$

This is the impedance of a series capacitor

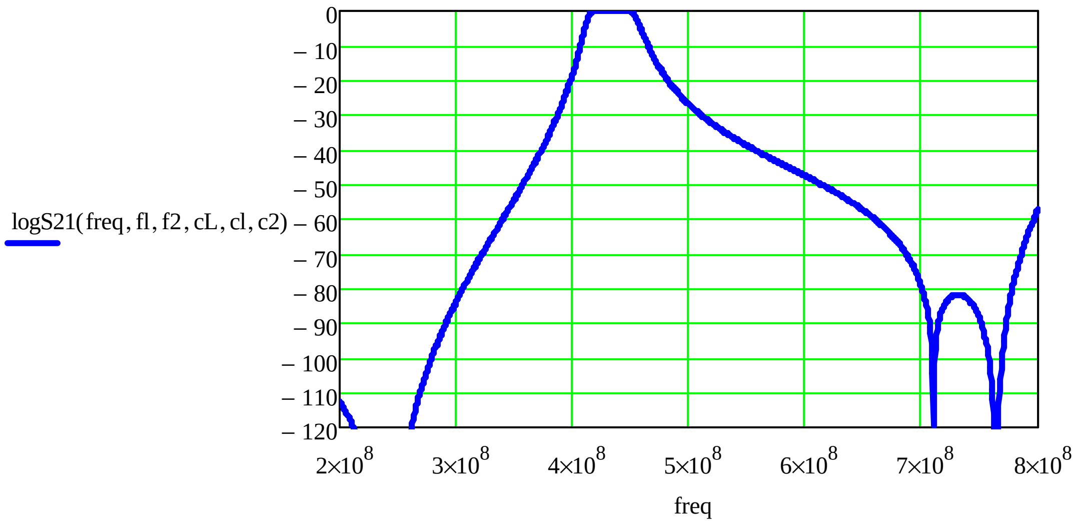
This makes ABCD matrix for three coax filter, f1 and f2 are the resonant lengths of the coax cable and S21 is calculated below

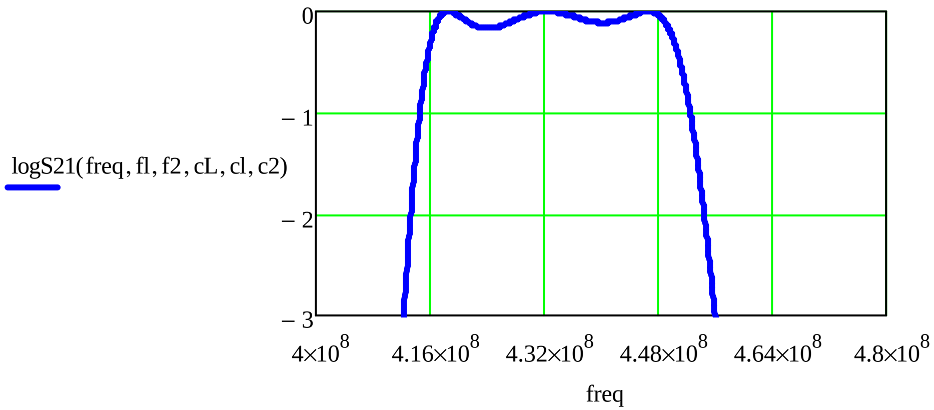
$$Z_{2p}(freq, f1, f2, capL, cap1, cap2) := Z_{cap}(freq, cap1) \cdot Z_{coax}(freq, f1, capL) \cdot Z_{cap}(freq, cap2) \cdot Z_{coax}(freq, f2, capL) \cdot Z_{cap}(freq, cap2) \cdot Z_{coax}(freq, f1, capL) \cdot Z_{cap}(freq, cap1)$$

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

$$logS21(f,f1,f2,cL,c1,c2) := 20\log\left[\left|\frac{2\left(\frac{R_{load}^{2}}{ohm^{2}}\right)^{0.5}}{Z_{2p}(f,f1,f2,cL,c1,c2)_{0,0}\cdot\frac{R_{load}}{ohm}+Z_{2p}(f,f1,f2,cL,c1,c2)_{0,1}+\frac{R_{load}^{2}}{ohm^{2}}\cdot Z_{2p}(f,f1,f2,cL,c1,c2)_{1,0}+Z_{2p}(f,f1,f2,cL,c1,c2)_{1,1}\cdot\frac{R_{load}}{ohm}}\right|,10\right]$$

$cl := 2.7pF$ $c2 := 0.82pF$ $fl := 152MHz$ $f2 := 140MHz$ $cL := 4pF$



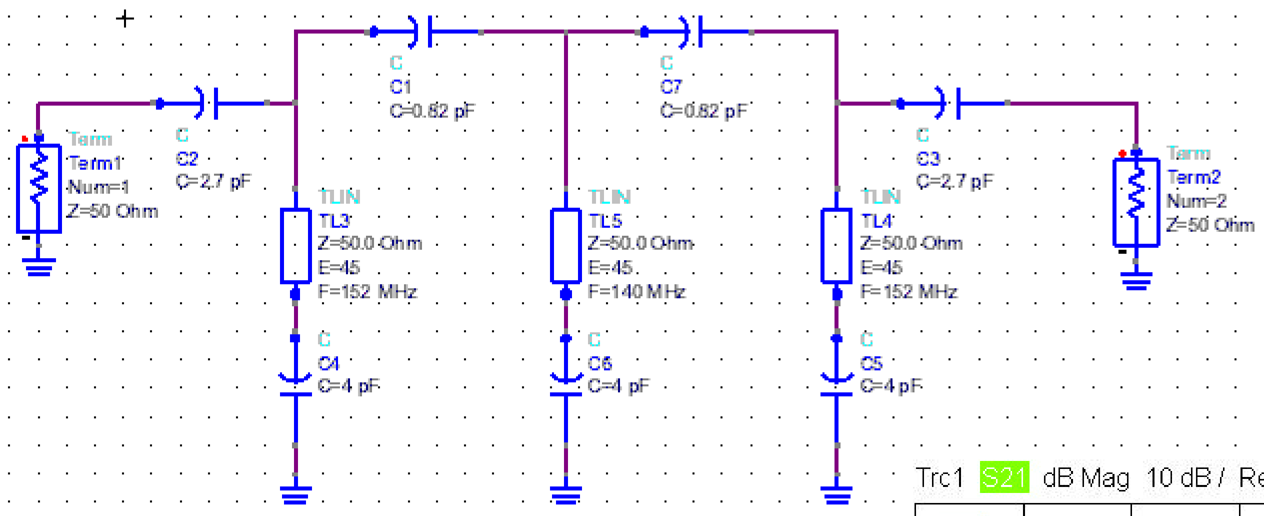


Now we can build the filter using RG402 semi rigid coax cable, this equation gets the length

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

$inductorlength(fl) = 167.2464\cdot mm$

$inductorlength(f2) = 181.839\cdot mm$



This is the actual response of filter, marker is at 434MHz, rather good, but the filter is quite large. At least it can be trimmed as cutting the coax cables is not so easy!!!