20 to 60 m Bands Boredom Converter

I have a very nice JVC T-X2 AM/FM Tuner which I have had for some years now. The normal FM broadcast bands are all available digitally (I receive them on my Freeview, TV set top box) and of course nobody would want to listen to AM anymore – which is why the medium and long wave bands are now a virtual desert.

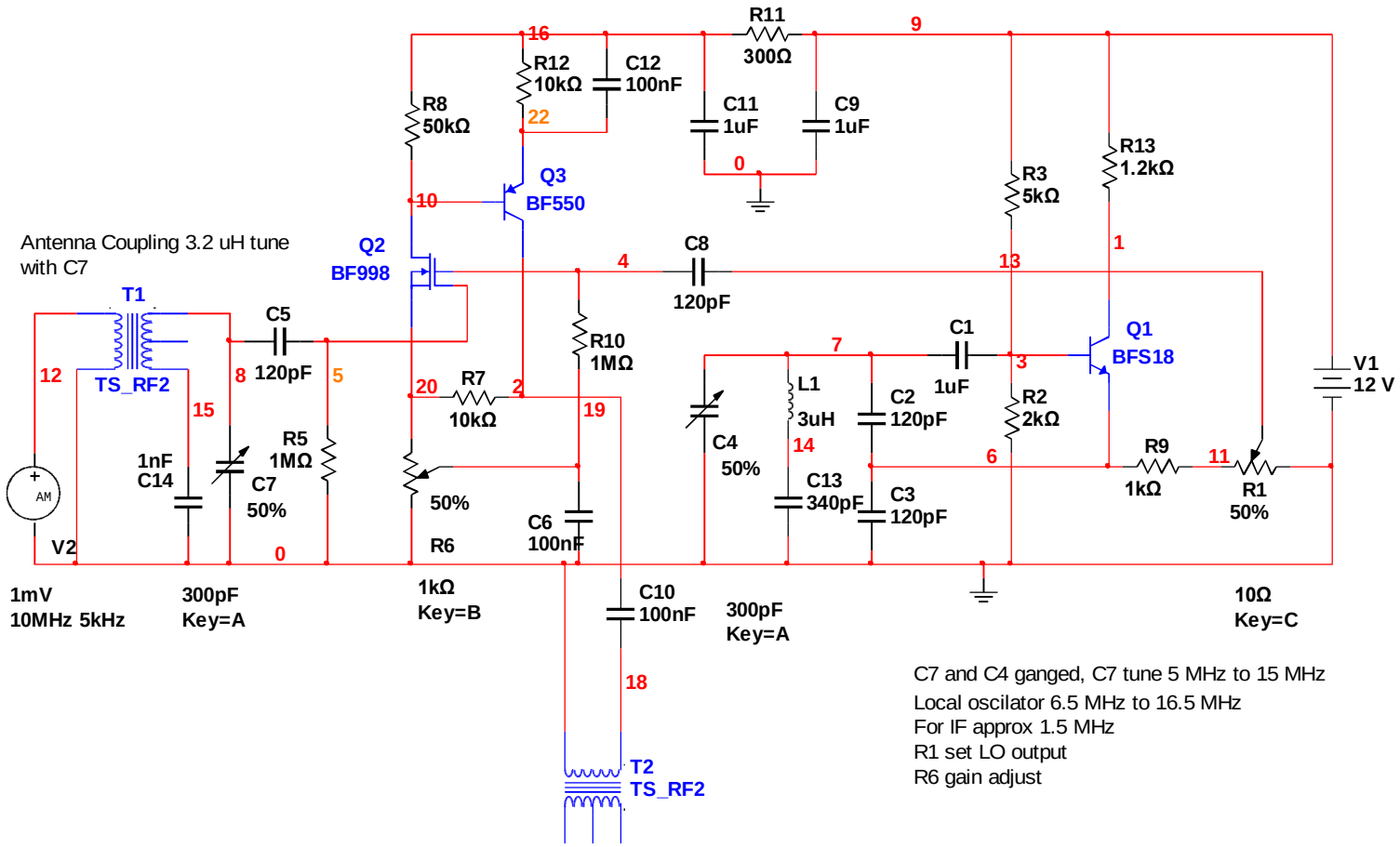
It seemed a great pity to throw out my JVC tuner, which is in perfect working order, and beautifully made. So what to use it for? I decided to design an amateur bands converter covering 20m to 60m (approx 5MHz to 15MHz). I intend to prototype it first as an external circuit, and then rebuild it on a small circuit board and install it in the tuner cabinet. I should then have a fairly decent duel conversion communications receiver – just for fun, and give the old tuner a new lease of life.

The circuit is shown below. It consists of a conventional three impedance oscillator (BFS18), designed to oscillate between 6.5MHz and 16.5MHz, thus giving an IF of approximatly1.5 MHz at the top end of the medium wave band – I will adjust this to an appropriate empty frequency.

The local oscillator is RC coupled to an RF/Mixer stage consisting of a duel gate FET (BF998) and PNP bi-plolar (BF550) pair (I can hear my old friend Keith Alexander sighing – he hates duel gate FET's). The stage is designed to give about 10db gain and the 2nd gate is used to inject the LO signal, which I have always thought rather neat. The BF550 is designed to provide DC feedback to stabilize the FET operating point – always a problem with FET's because of the large variation in pinch off voltage and drain source saturation current.

It simulates quite well using Multisim, we shall see how it performs in practice. Initially I shall probably use an ancient duel gang variable capacitor I have kicking around and then covert it to varicap diodes and a ten turn pot for tuning, later. The coils will be wound on miniature toroidal cores. I have incorporated some presets to adjust the LO level and RF gain.


JVC



C7 and C4 ganged, C7 tune 5 MHz to 15 MHz
Local oscilator 6.5 MHz to 16.5 MHz
For IF approx 1.5 MHz
R1 set LO output
R6 gain adjust

part of JVC Tuner AM ferrite rod antenna

Phils Boredom 60m to 20m bands converter for JVC T-X2 Tuner

Padding Capacitor Action

One of the problems with Mixer - local oscillator combinations (as found in Superhets) is maintaining a constant IF frequency whilst tuning the local oscillator and tuned circuit of the mixer.

Traditionally this is done by incorporating trimmer and padding capacitors. The former in parallel with the tuning device, and the latter in series with the coil.

Inductance's, Tank and LO ...

$$LT := 3.2 \cdot 10^{-6}$$

$$LO := 3.2 \cdot 10^{-6}$$

Trim and padding capacitors ...

$$Ctrim1 := 33 \cdot 10^{-12}$$

$$Ctrim2 := 25 \cdot 10^{-12}$$

$$Cpad2 := 320 \cdot 10^{-12}$$

$$Cpad1 := 1900 \cdot 10^{-12}$$

Tank Tune ...

$$ftank(CT) := \frac{1}{2 \cdot \pi \cdot \left[LO \cdot \left[(CT + Ctrim1) \cdot \frac{Cpad1}{(CT + Ctrim1) + Cpad1} \right] \right]^{0.5}}$$

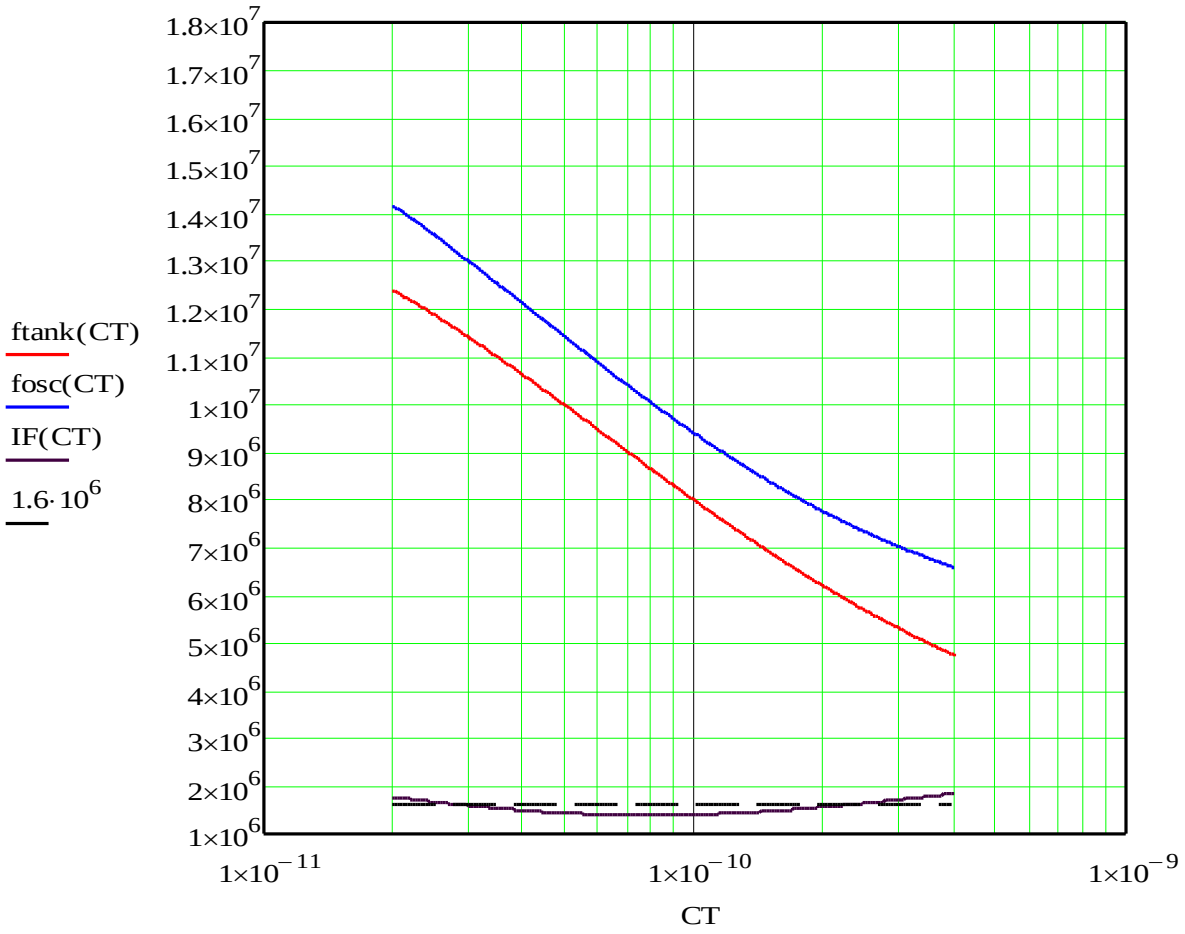
LO Tune ...

$$fosc(CT) := \frac{1}{2 \cdot \pi \cdot \left[LO \cdot \left[(CT + Ctrim2) \cdot \frac{Cpad2}{(CT + Ctrim2) + Cpad2} \right] \right]^{0.5}}$$

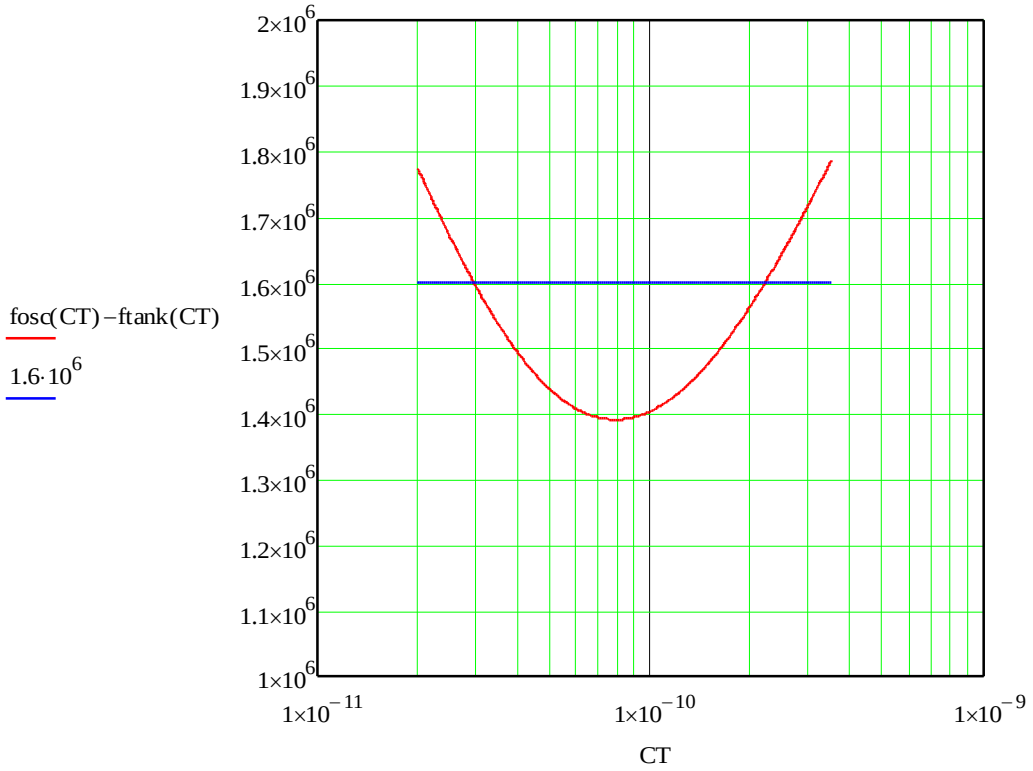
IF Frequency ....

$$IF(CT) := fosc(CT) - ftank(CT)$$

Plot Results, Frequency against tuning capacitor, LO blue, mixer red, IF black ....

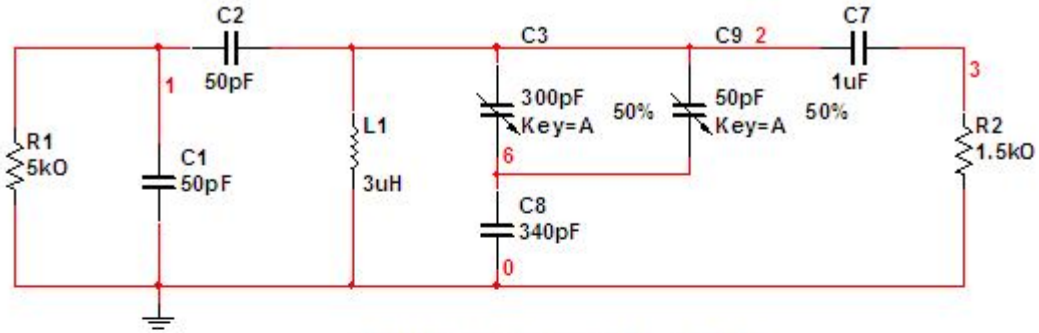


IF frequency in greater detail. Its nominally 1.6 MHz +/- 200 KHz

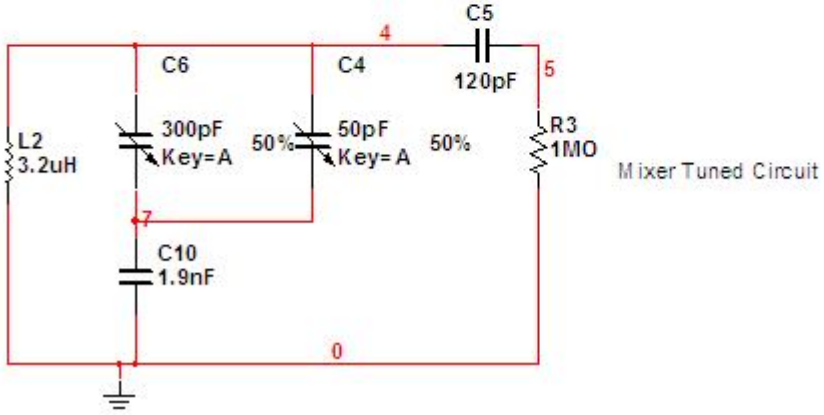


Analysis of Boredom Converter

Local oscillator Section (input across R1, output across R2) ...



Oscillator section - output R1 - input R2



Mixer Tuned Circuit

.

.. Mixer Section (input across L2, output R3
Local Oscillator components …

$C1 := 50 \cdot 10^{-12}$

$C2 := 50 \cdot 10^{-12}$

$C3 := 150 \cdot 10^{-12}$

$C8 := 900 \cdot 10^{-12}$

$L1 := 1.5 \cdot 10^{-6}$

$R1 := 1000$

$R2 := 5000$

$C7 := 1 \cdot 10^{-6}$

$Cpad2 := C8$

$Ctrim2 := 20 \cdot 10^{-12}$

Mixer Components ...

$L2 := 3.2 \cdot 10^{-6}$

$C5 := 50 \cdot 10^{-12}$

$R3 := 1 \cdot 10^{5}$

$C6 := 150 \cdot 10^{-12}$

$C4 := 25 \cdot 10^{-12}$

$Ctrim1 := C4$

$Rsource := 50$

$Cpad1 := 1900 \cdot 10^{-12}$

Define Reactance, Oscillator ....

$$XC1(f) := \frac{-i}{2 \cdot \pi \cdot f \cdot C1}$$

$$XC2(f) := \frac{-i}{2 \cdot \pi \cdot f \cdot C2}$$

$XL1(f) := 2 \cdot \pi \cdot f \cdot L1 \cdot i$

$$XC7(f) := \frac{-i}{2 \cdot \pi \cdot f \cdot C7}$$

$$XTune2(f, C) := \left[\frac{\left[\left(\frac{-i}{2\cdot\pi\cdot f\cdot C\cdot 10^{-12}} \right) \cdot \left(\frac{-i}{2\cdot\pi\cdot f\cdot Ctrim2} \right) \right]}{\left(\frac{-i}{2\cdot\pi\cdot f\cdot Ctrim2} \right) + \left(\frac{-i}{2\cdot\pi\cdot f\cdot C\cdot 10^{-12}} \right)} \right] + \frac{-i}{2\cdot\pi\cdot f\cdot Cpad2}$$

Define Reactance Mixer ...

$$XL2(f) := 2\cdot\pi\cdot f\cdot L2\cdot i$$

$$XC5(f) := \frac{-i}{2\cdot\pi\cdot f\cdot C5}$$

$$XTune1(f, C) := \left[\frac{\left[\left(\frac{-i}{2\cdot\pi\cdot f\cdot C\cdot 10^{-12}} \right) \cdot \left(\frac{-i}{2\cdot\pi\cdot f\cdot Ctrim1} \right) \right]}{\left(\frac{-i}{2\cdot\pi\cdot f\cdot Ctrim1} \right) + \left(\frac{-i}{2\cdot\pi\cdot f\cdot C\cdot 10^{-12}} \right)} \right] + \frac{-i}{2\cdot\pi\cdot f\cdot Cpad1}$$

Define Oscillator Transfer Matrices ...

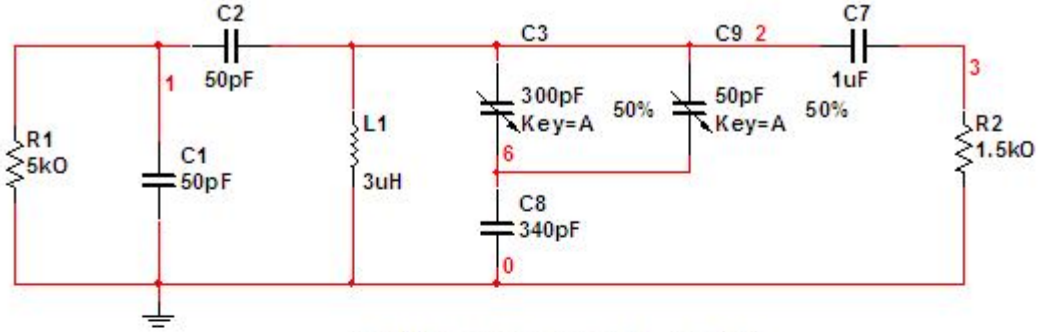
$$T1LO := \begin{pmatrix} 1 & 0 \\ \frac{1}{R1} & 1 \end{pmatrix}$$

$$T2LO(f) := \begin{pmatrix} 1 & 0 \\ \frac{1}{XC1(f)} & 1 \end{pmatrix}$$

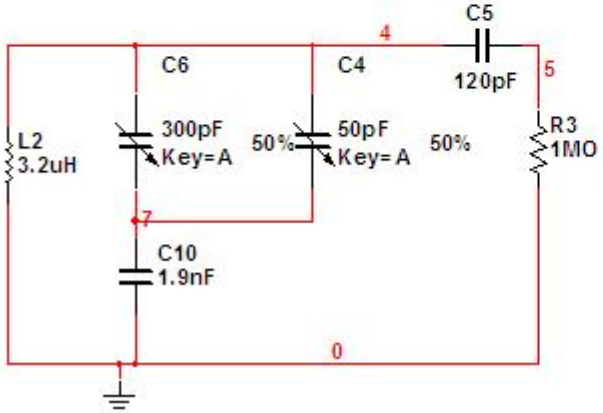
$$T3LO(f) := \begin{pmatrix} 1 & XC2(f) \\ 0 & 1 \end{pmatrix}$$

$$T4LO(f) := \begin{pmatrix} 1 & 0 \\ \frac{1}{XL1(f)} & 1 \end{pmatrix}$$

$$T5LO(f, C) := \begin{pmatrix} 1 & 0 \\ \frac{1}{XTune2(f, C)} & 1 \end{pmatrix}$$



Oscillator section - output R1 - input R2



Mixer Tuned Circuit

$$T6LO(f) := \begin{pmatrix} 1 & XC7(f) \\ 0 & 1 \end{pmatrix}$$

$$T7LO := \begin{pmatrix} 1 & 0 \\ \frac{1}{R2} & 1 \end{pmatrix}$$

Overall Oscillator Transfer matrix ...

$$TLO(f, C) := T1LO \cdot T2LO(f) \cdot T3LO(f)\ T4LO(f) \cdot T5LO(f, C)\ T6LO(f) \cdot T7LO$$

Oscillator Transfer function ...

$$TFLO(f, C) := \frac{1}{TLO(f, C)_{0,0}}$$

Define Mixer Transfer matrices ...

$$TM1(f) := \begin{pmatrix} 1 & 0 \\ \frac{1}{XL2(f)} & 1 \end{pmatrix}$$

$$TM2(f, C) := \begin{pmatrix} 1 & 0 \\ \frac{1}{XTune1(f, C)} & 1 \end{pmatrix}$$

$$TM3(f) := \begin{pmatrix} 1 & XC5(f) \\ 0 & 1 \end{pmatrix}$$

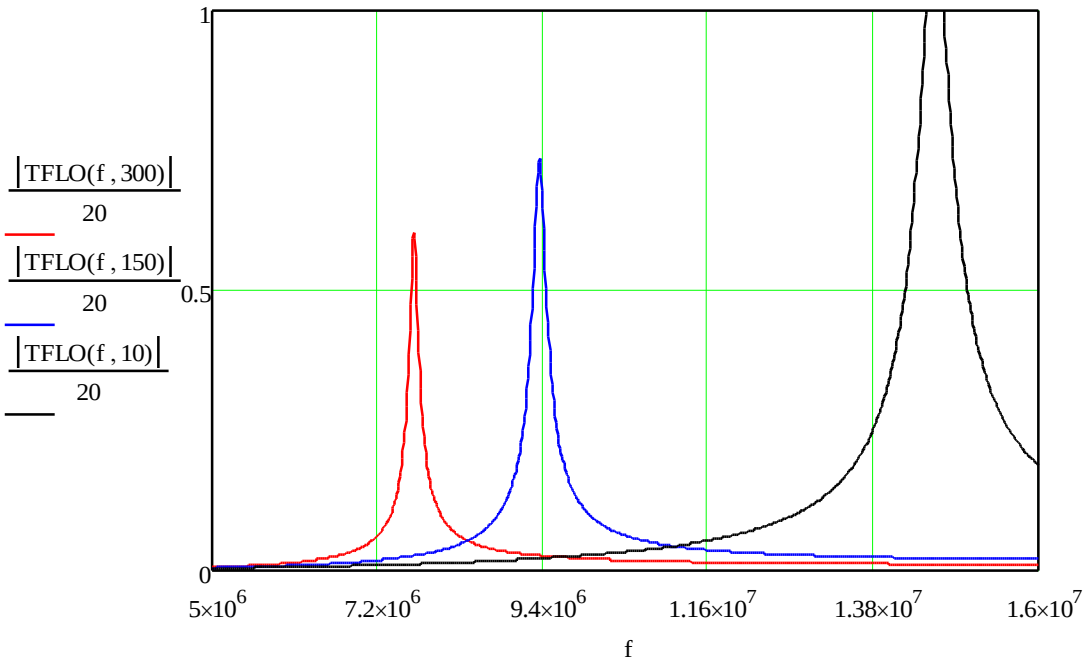
$$TM4 := \begin{pmatrix} 1 & 0 \\ \frac{1}{R3} & 1 \end{pmatrix}$$

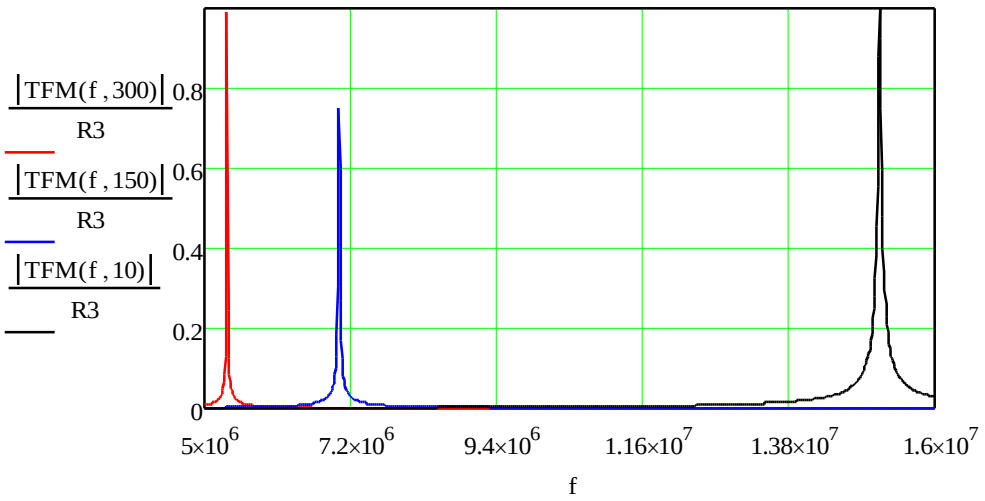
Overall Mixer Transfer matrix ...

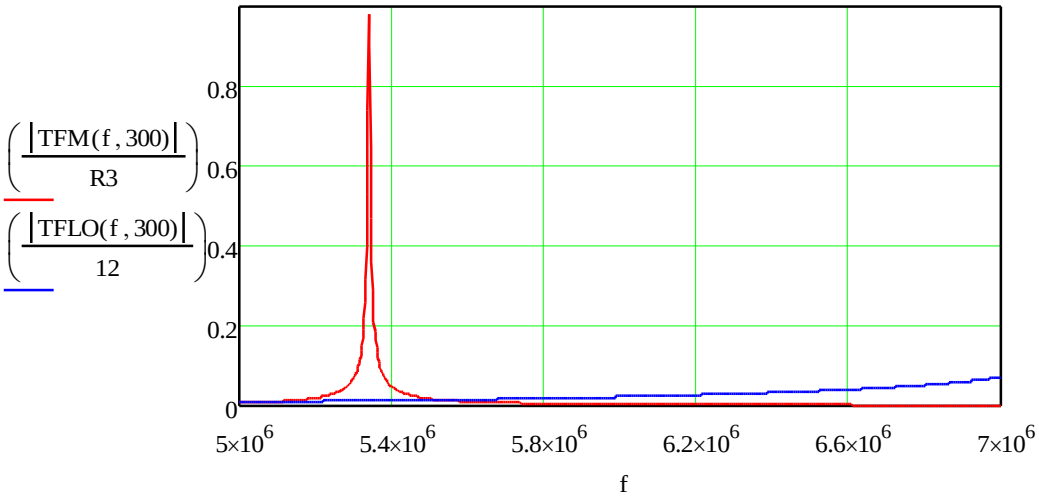
$$TM(f, C) := TM1(f) \cdot TM2(f, C) \cdot TM3(f) \cdot TM4$$

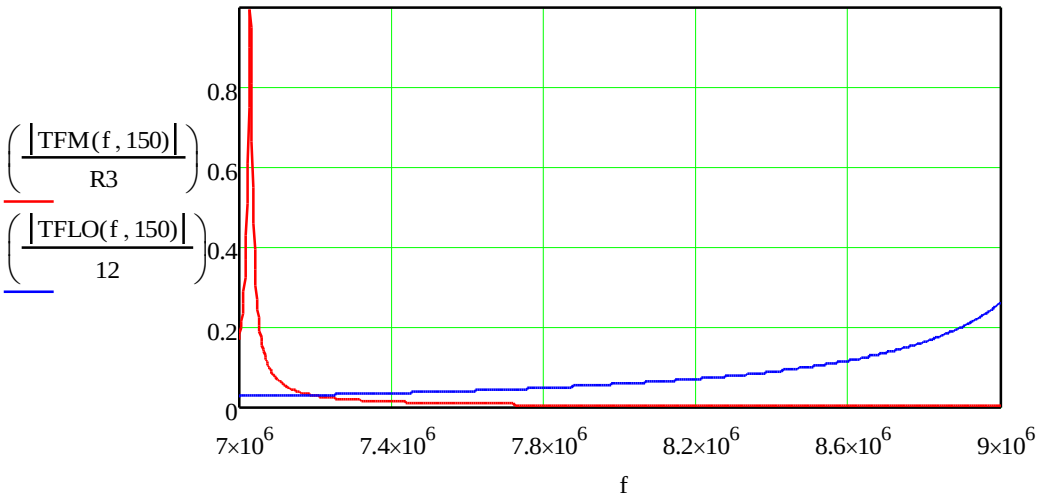
Mixer Tank Transfer Impedance ...

$$TFM(f, C) := \frac{1}{TM(f, C)_{1,0}}$$


|TFLO(f , 300)| / 20
|TFLO(f , 150)| / 20
|TFLO(f , 10)| / 20
1
0.5
0
5×10^6
7.2×10^6
9.4×10^6
1.16×10^7
1.38×10^7
1.6×10^7
f


|TFM(f , 300)| / R3
|TFM(f , 150)| / R3
|TFM(f , 10)| / R3
0.8
0.6
0.4
0.2
0
5×10^6
7.2×10^6
9.4×10^6
1.16×10^7
1.38×10^7
1.6×10^7
f


(|TFM(f , 300)| / R3)
(|TFLO(f , 300)| / 12)
0.8
0.6
0.4
0.2
0
5×10^6
5.4×10^6
5.8×10^6
6.2×10^6
6.6×10^6
7×10^6
f


$\left(\frac{|TFM(f,150)|}{R3}\right)$
$\left(\frac{|TFLO(f,150)|}{12}\right)$
0.8
0.6
0.4
0.2
0
7×10^6
7.4×10^6
7.8×10^6
8.2×10^6
8.6×10^6
9×10^6
f