Chapter: AFX 'V'ariable

this is the Best-of-AFX Phase-Filter Circuit Design

Non-Resonant Dual-Notch Phase-Filter-

****

********* Goals achieved in AFX-'V' :**
***** (1) Simpler design,**
***** (2) Simpler construction,**
***** (3) Simpler adjustment.**
***** (4) Enhanced Variability f(0)**

Continued Design features from AFX:

***** Improved design from building-block modules**
3 Filters are Q=3, 1 Filter Q=5,
all R(freq) aprox. Same.
Enables use of single control of four R(freq) stages.

***** Designed so that the High 'Q' Sharp Filter is also variable**
within the main band-pass.

***** Designed so that the Dual-Notches**
are < -60 dB and the Stop-Band < -100 dB .

Design choices:

***** Simple repetitive application of**
Modified *Deliyannis-Friend*-Multple-FeedBack design.

***** MFB topology was chosen because :**

***** (1) input vs output impedances match well,**
loading is naturally controlled.

***** (2) single resistor frequency control each stage.**

***** (3) frequency adjustments alters gain**
by only the square-root of the f(change) .

Just for reference:

Delyannis-Friend Multiple-Feed-Back design

MULTIPLE FEEDBACK BAND-PASS DESIGN EQUATIONS

$$\frac{-H\ \omega_0 s}{s^2 + \alpha\ \omega_0 s + \omega_0^2}$$

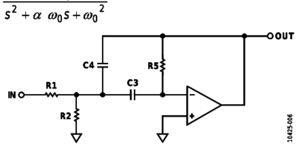


Figure 6.

$$\frac{V_O}{V_{IN}} = \frac{-s\frac{1}{R1C4}}{s^2 + s\frac{C3+C4}{C3C4R5} + \frac{1}{R5C3C4}\left(\frac{1}{R1} + \frac{1}{R2}\right)}$$

To design the filter, choose C3.

Then

$$k = 2\ \pi\ F_0\ C3$$

$$C4 = C3$$

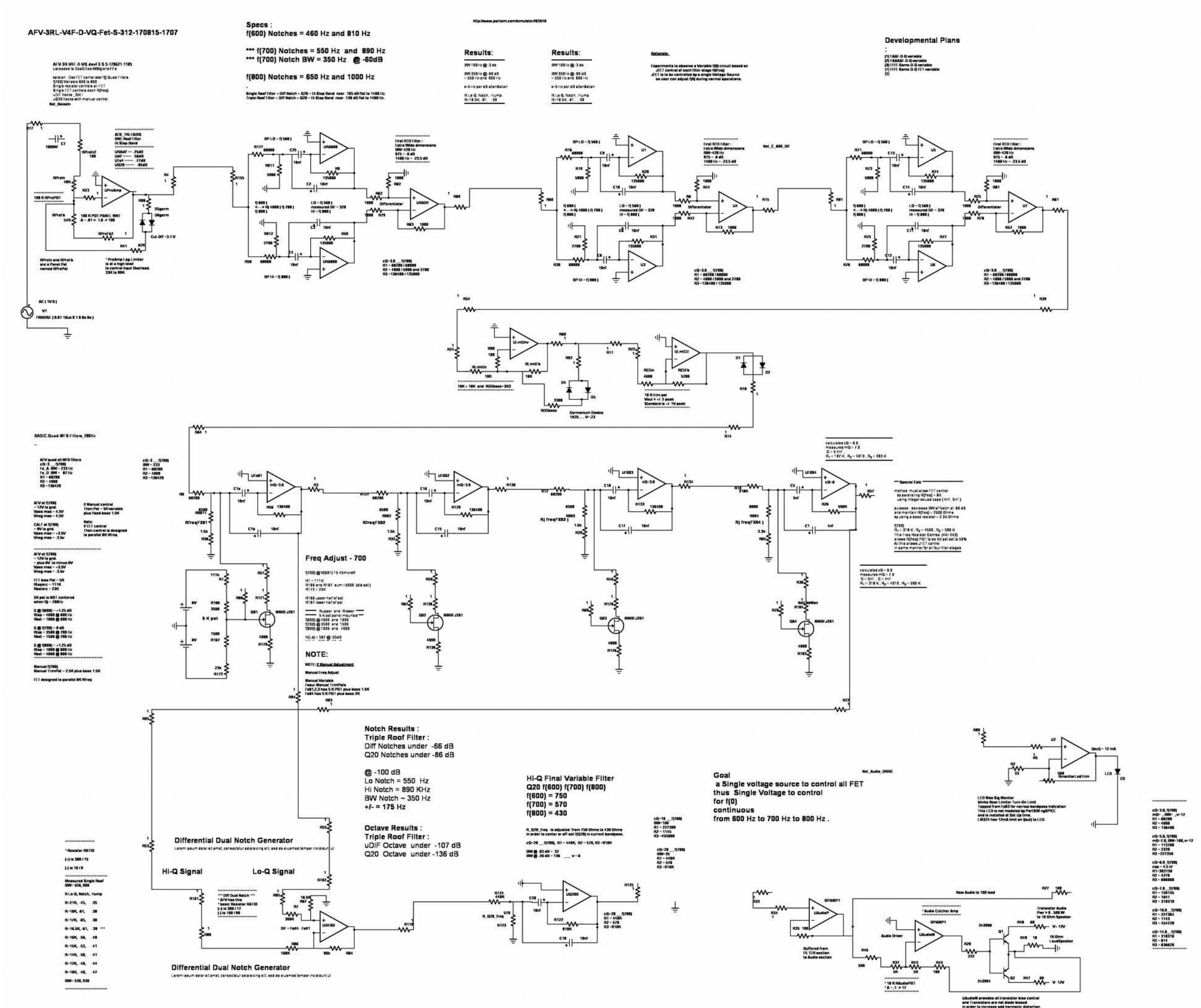
$$R1 = \frac{1}{H\ k}$$

$$R2 = \frac{1}{(2Q - H)k}$$

$$R5 = \frac{2Q}{k}$$

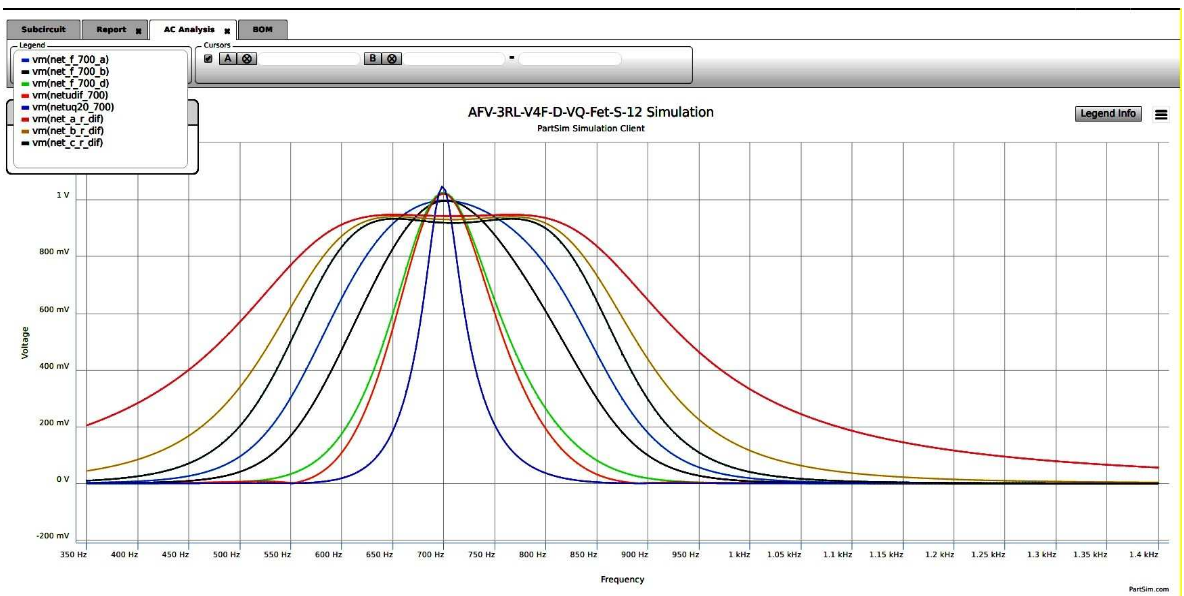
Delyannis-Friend Multiple-Feed-Back design

Circuit : "**AFX-V-3RL-v4F-D-vQ-Fet**"

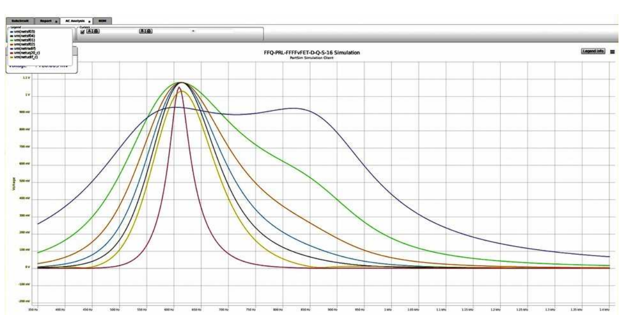


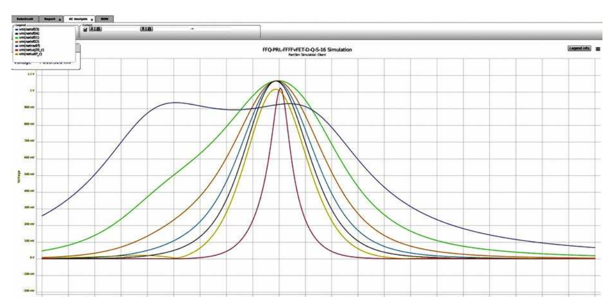
Bode Plot: **AFV-3RL-v4F-D-vQ-Fet**

Roofing Filter Output is (red), very wide
which contains the variability of the central f() signal



****** Below : shown adjusted 600Hz , 700Hz , 800Hz**
******* Notice that the peak amplitudes of the final signals**
stay within 0.3 dB of the f(700) signal.





variability of the central f() signal

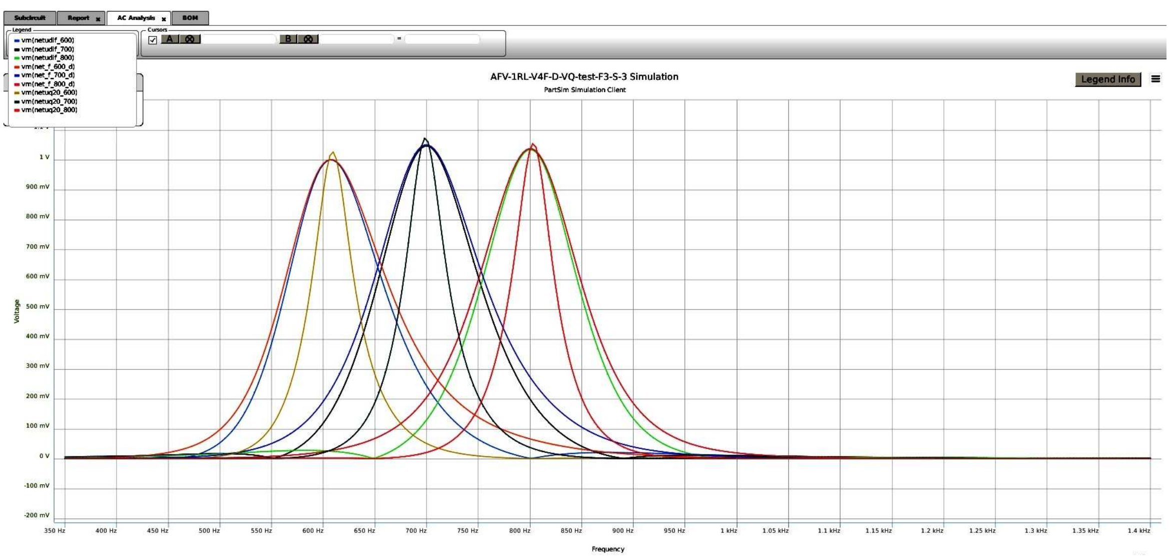
Notice that the 600 --- 800 waveforms
have good central Band-Pass shapes.

Bode Plot: advanced AFV circuit utilizes

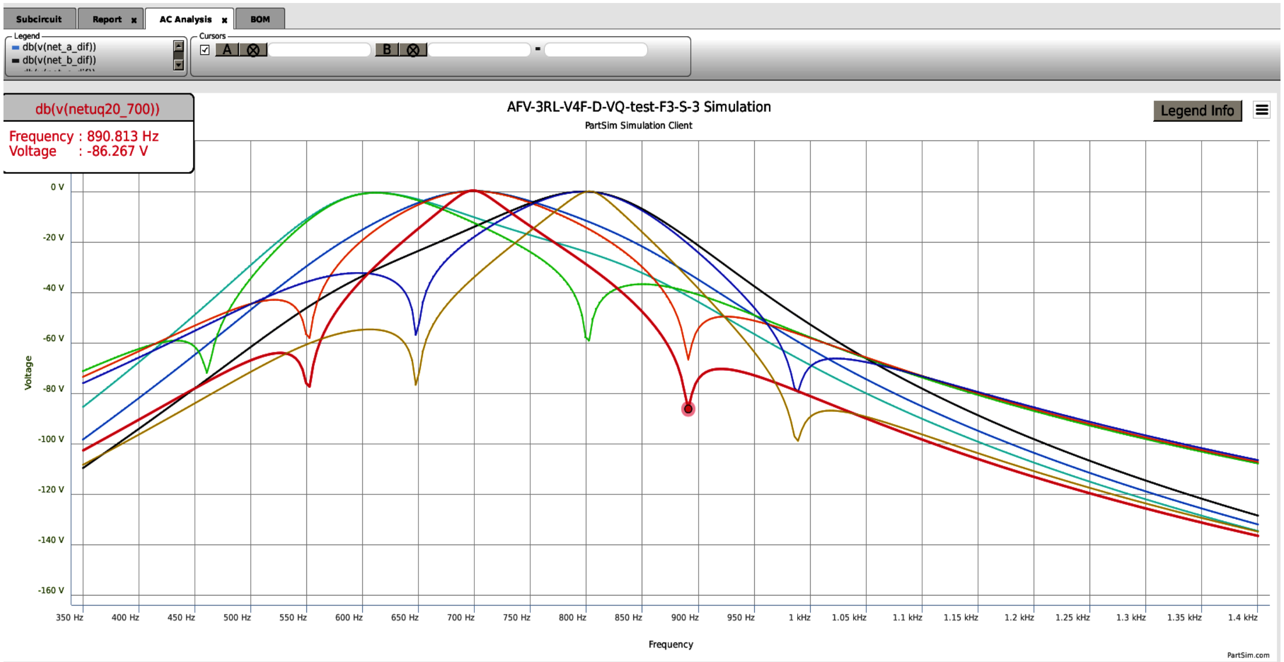
Three Triad-Roofing-Differential Filters for for max sideband control.

***** Dual-Notches are very Deep and Octave Stop-Band very low.**
***** Main Filter f(0) is Variable 600 - 700 - 800 by user in real-time.**
***** Sharp Q=20 filter is variable within the selected PassBand.**

***** Here, the R(freq) is currently controlled by one R(freq) Pot, which can be mounted on the front panel, for real-time control.**
***** The Four FET controllers are driven by a single Voltage Source, controlled by a Panel Mounted Pot.**
***** Front Panel Rotary Switch allows User to send any stage into the Audio Section.**
***** Front Panel Switch can be utilized to drive FxQ20 from any filter stage.**



Magnitude Plot: **AFV-3RL-v4F-D-vQ-Fet**



*** **At 900 Hz, the Red Dot on Notch indicates -86 dB attenuation for the f(700) trace .**

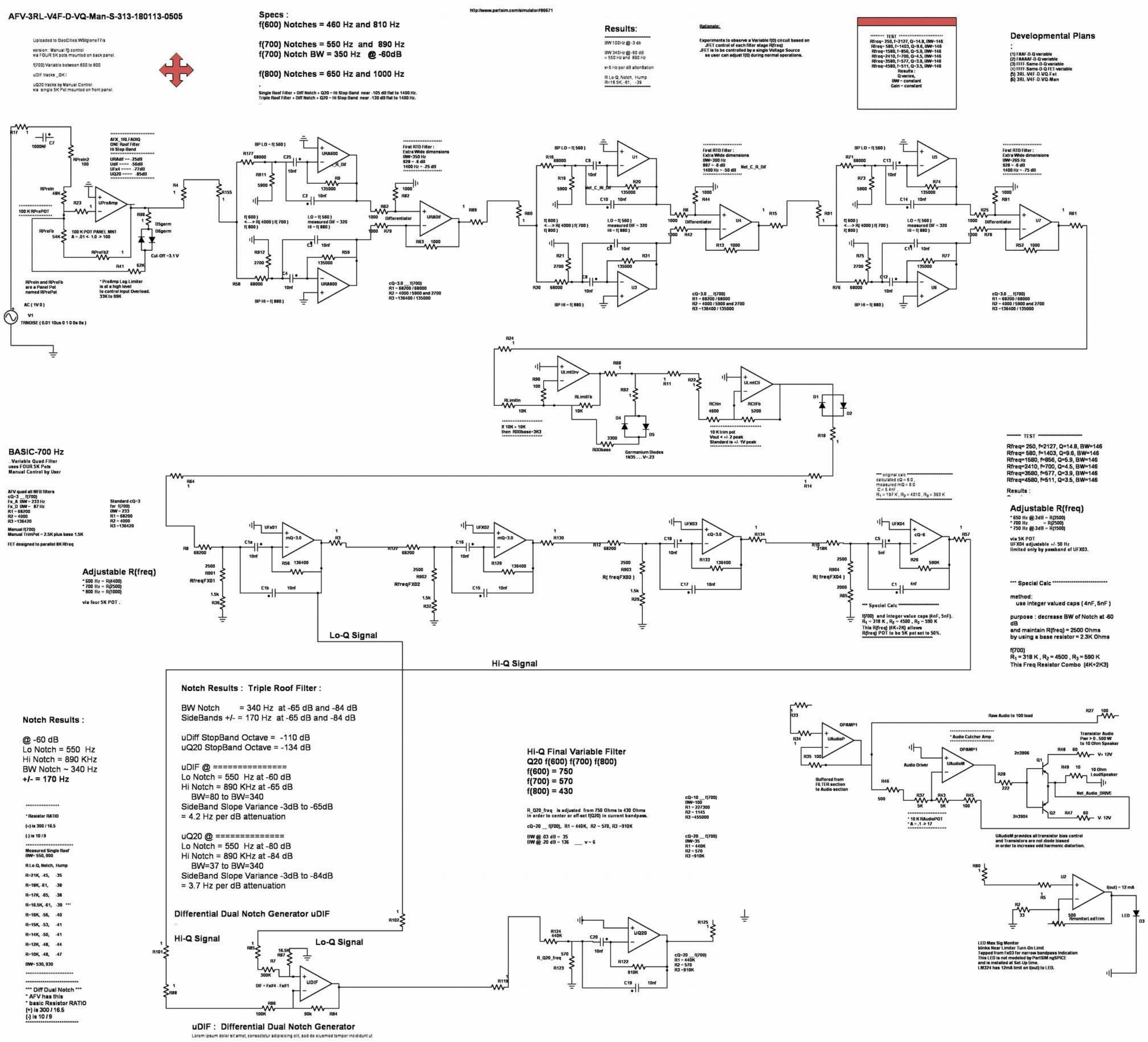
Trace to 1400 Hz is -76 dB attenuation.

Circuit: **AFV-3RL-V4F-D-VQ-Man-**

******* AFX ‘V’ with MANUAL TUNING
via Four 5K rear-panel mounted pots.

Designed to control all four Filter f(0), 600 Hz to 800 Hz, manually.

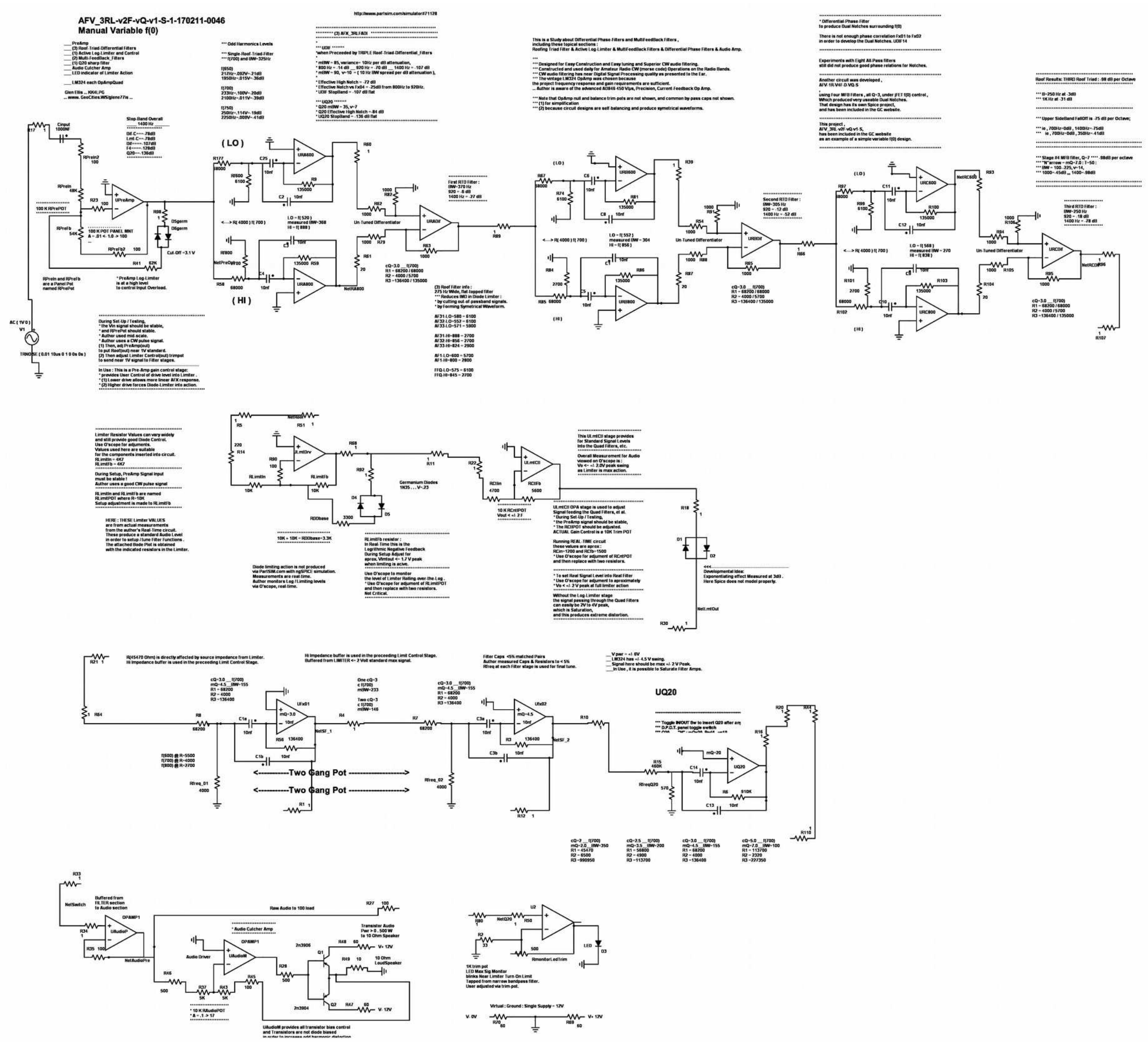
This is the Simplest approach and meets requirements.



circuit: **Sample:** 'AFV_3RL-v2F-vQ-v1-S '

This simple circuit was NOT spectacular
but was given a fair test.
... Goal was to prove the use of only **Two MFB filters**
which would require only a single dual-Pot for control of f(0)..

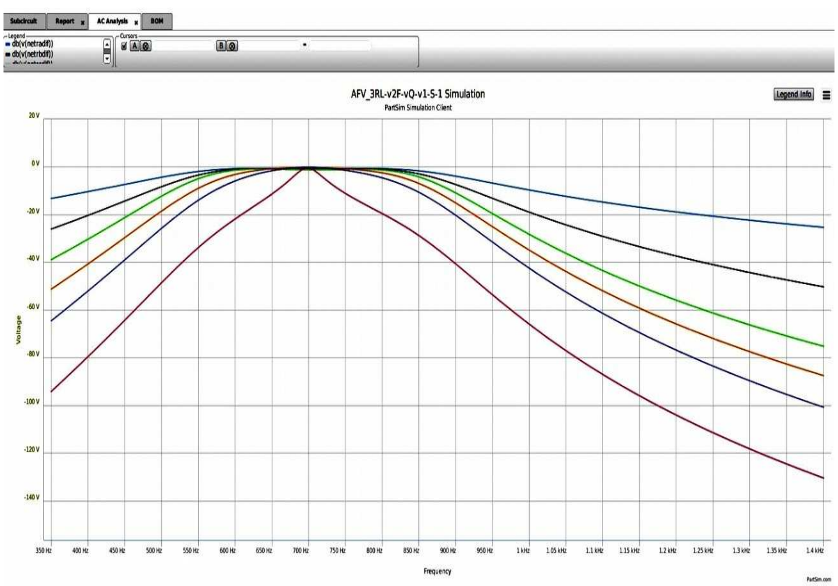
*** AFV_3RL-v2F-vQ-v1-S design :
*** (1) with **Three Roof Filters**
*** (2) with only **Two MFB filter stages**
*** (3) with R(freq) controlled by a Two-Gang Pot



***

Results: use of only **Two MFB filters**
which would require only a single dual-Pot for control of f(0)..

... Dual Notches could not be well developed
when using only Two MFB filters.
... More Phase-Alignment in the filter module
is required to generate the Dual Notches.
... Therefore,
No notches are presented in the below plots,
and this is the best Bode Plot .
The Sharp Band-Pass comes from the two Q=3 final filters.



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****

Chapter: **AFX_Filter_"T"**

Non-Resonant Dual-Notch Phase-Filter-

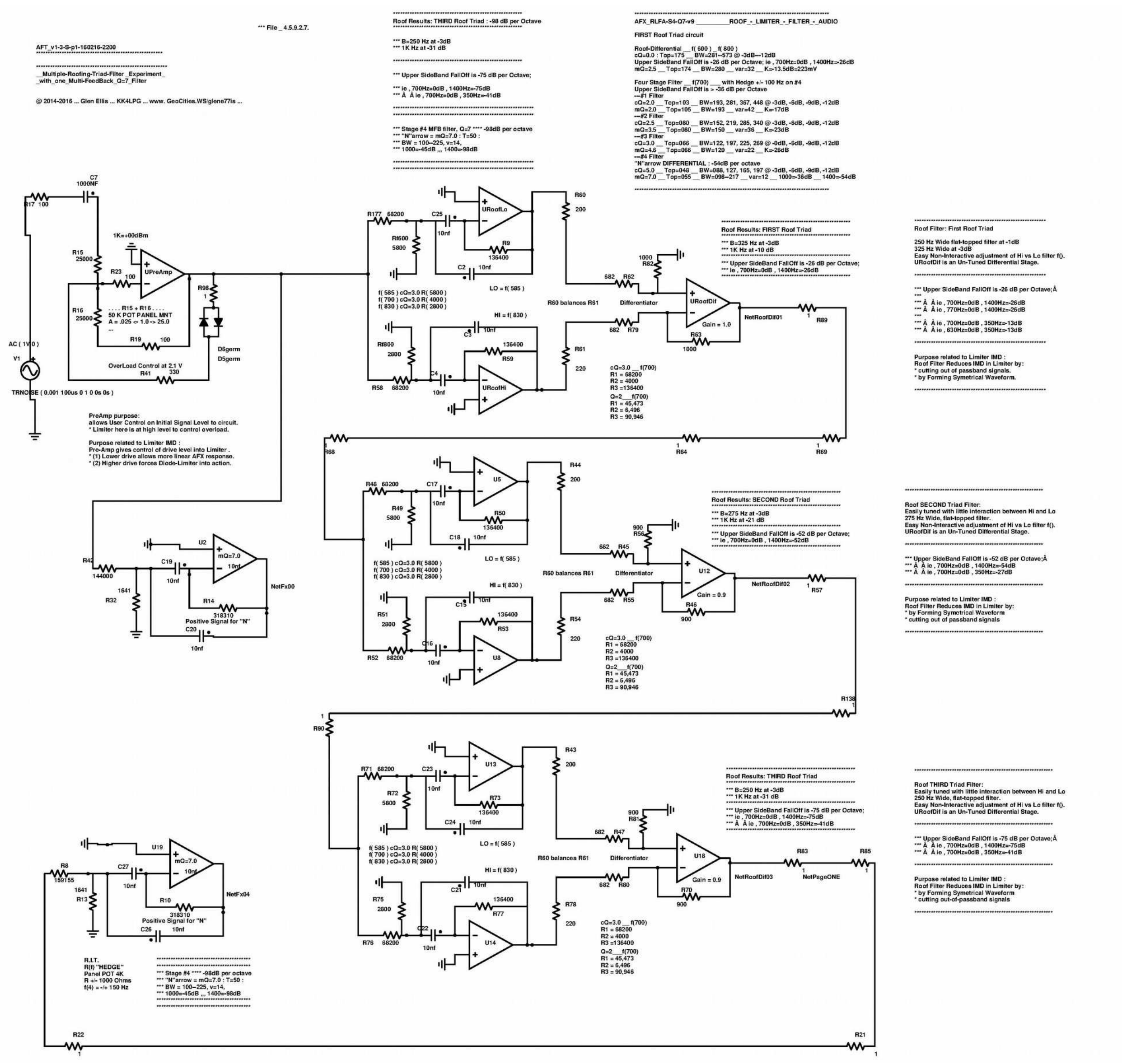
An AFX filter
Emphasizing the Roofing Filters “T” to supress the sidebands

***** Triple Roof-Triad-Differential Filters preparing the signals**
***** to drive a single Q=7 MFB bandpass filter**
***** Triple Roof-Triad-Filter is 1400 Hz = -76 dB per octave.**
***** Last stage Q=7 MFB is 1400 Hz = -98 dB per octave.**
***** Last stage Q=20 MFB is 1400 Hz = -110 dB per octave.**

****
***** Roof-Triad-Filter info :**
***** all sections with same f(0) and same components .**
***** design is very tolerant of minor component variations .**
***** “cQ” is the calculated ‘Q’ for each stage :**
f(585) cQ=3.0 R(5800)
f(700) cQ=3.0 R(4000)
f(830) cQ=3.0 R(2800)
***** “mQ” is the measured ‘Q’ accumulated through to the last stage.**

Circuit: AFT_v1-3-S-p1

*** Triple Roof-Triad-Differential Filters plus one Q7 Filter.



Results: **AFT_v1-3-S-p1**

****

Roof Results: FIRST Roof Triad

****

calc design BW=325 Hz at -3dB
***** ie , 700Hz=0dB , 1400Hz=-26dB**
***** ie , 700Hz=0dB , 350Hz=-13dB**
***** SideBand FallOff is -26 dB per Octave;**

****

Roof Results: SECOND Roof Triad

****

calc design BW=325 Hz at -3dB
***** ie , 700Hz=0dB , 1400Hz=-54dB**
***** ie , 700Hz=0dB , 350Hz=-15dB**
***** SideBand FallOff is -54 dB per Octave;**

****

Roof Results: THIRD Roof Triad

****

calc design BW=325 Hz at -3dB
***** ie , 700Hz=0dB , 1400Hz=-75dB**
***** ie , 700Hz=0dB , 350Hz=-18dB**
***** SideBand FallOff is -75 dB per Octave;**

***** Design for Sharp Filter **************************
calc Design Final MFB filter, Q=7
***** BW = 100 @ -3 dB range=100---225, v=14,**
***** 1000 Hz=-45dB ,,, 1400 Hz = -98 dB**

****

***** Cumulative Results after the Sharp Filter**
***** cumulative measured results : Q=20**
***** cumulative measured -98dB per octave**
***** BW = 35 @ -3dB , range 35---126, v= 10,**
***** 1000 Hz=-75dB ,,, 1400 Hz = -110 dB**

****

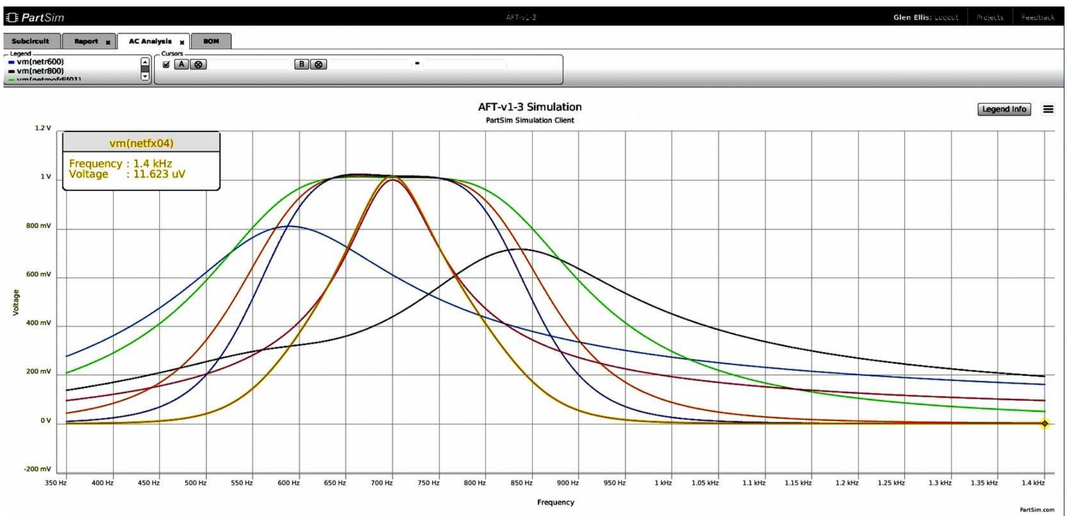
Bode Plot: **AFT_v1-3-S-p1**

Triple Roof-Triad-Differential Filters plus one Q7 Filter. .

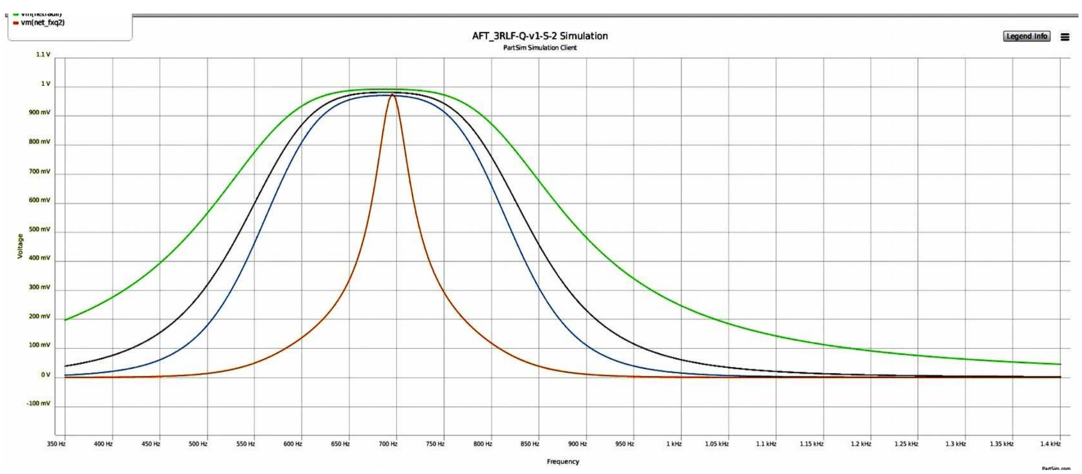
Most complex waveforms displayed.

Red trace is Q=7 signal Before Roofing Filters.

Yellow trace is Q=7 signal After Roofing Filters.



***** Notice the Roof Filters contribute to sideband suppression.**

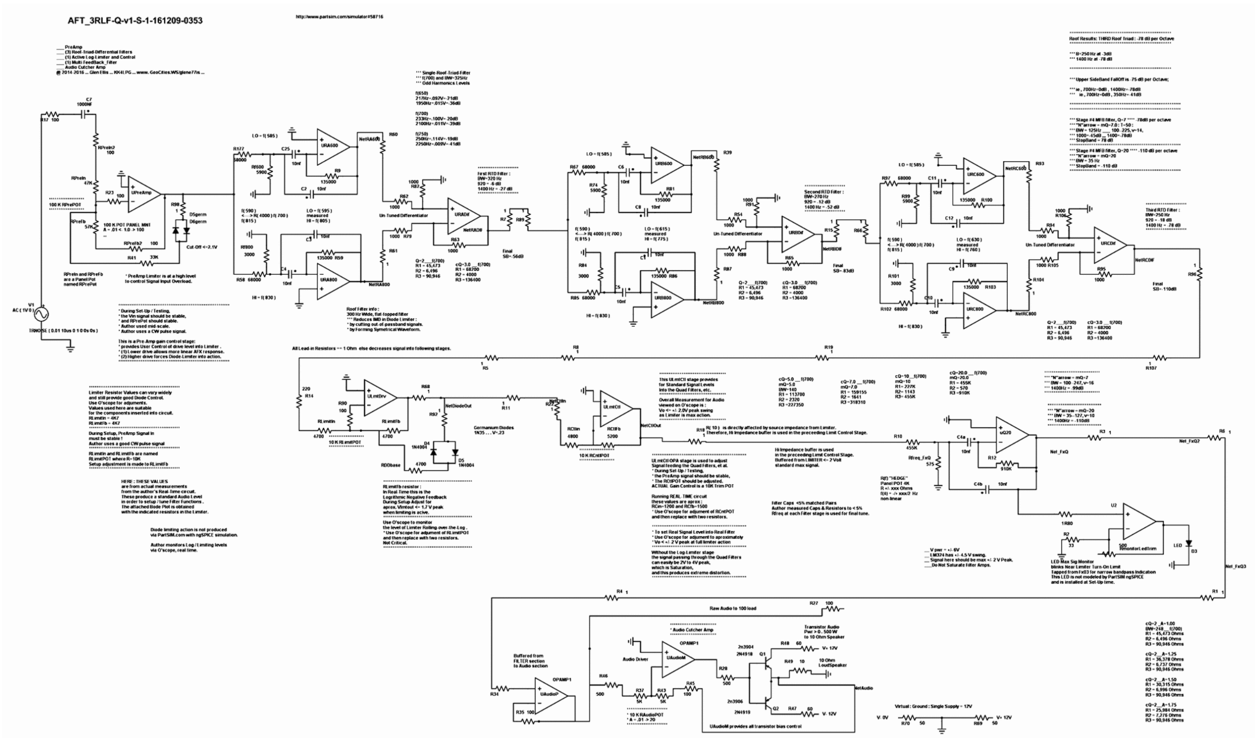


Circuit: **AFT_v1-3-S-p1**

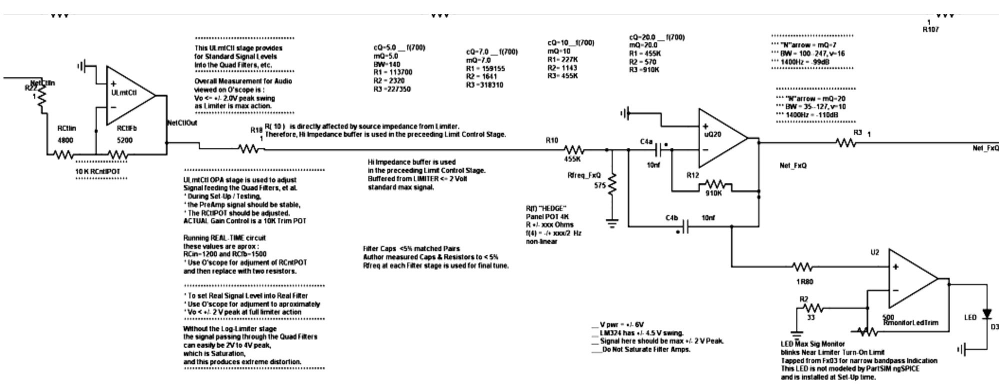
a Developed ‘AFT’ Circuit

*** No Dual Notches ***

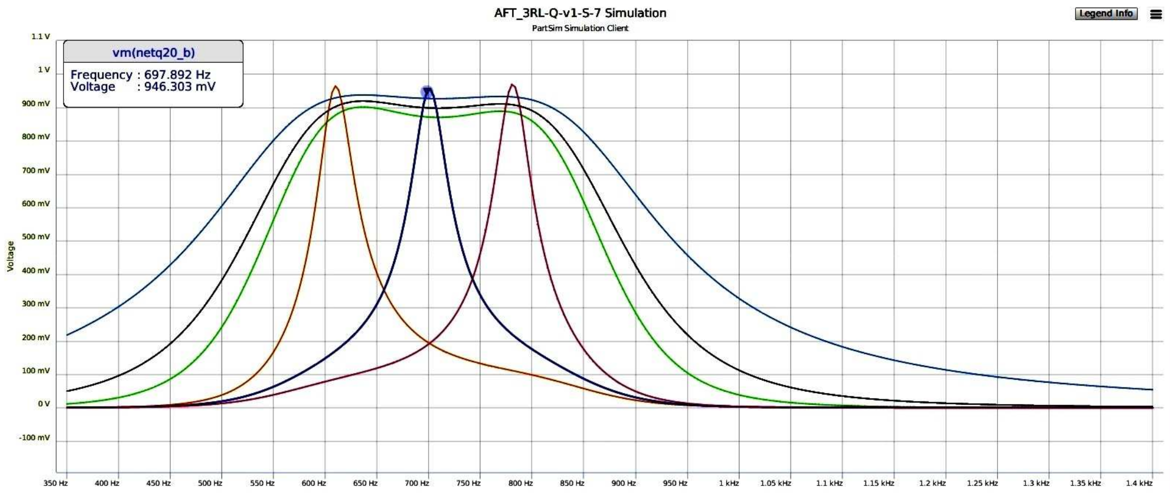
with PreAmp + three Roof-Filters + Active-Limiter + Q20 Filter + Audio :



Circuit: for single Narrow Filter:



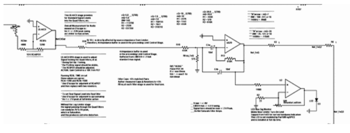
Bode Plot : **AFT_v1-3-S-p1**



f(0) adjusted 600 – 700-- 800

****

****

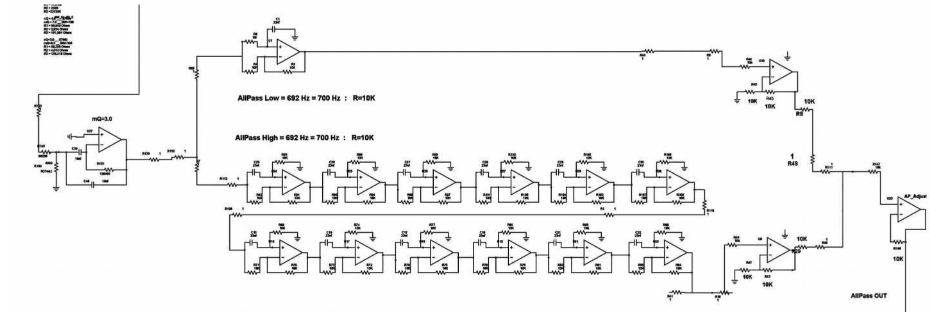


Chapter: **All-Pass Band-Pass Filter**

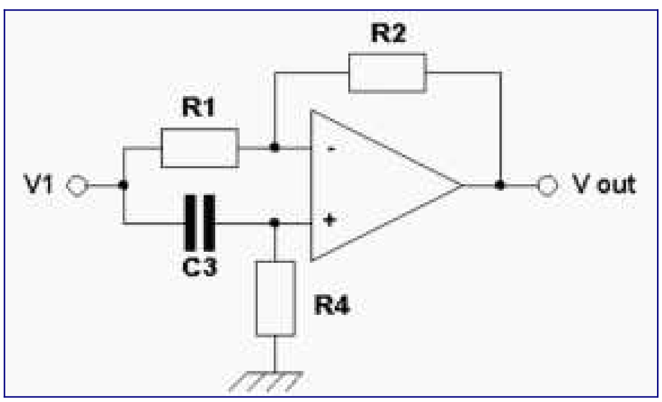
Phase-Filter Non-Resonant Dual-Notch

We examine a Phase-Filter-built from All-Pass Filters

Circuit: AFC core
1Lo-12Hi All-Pass

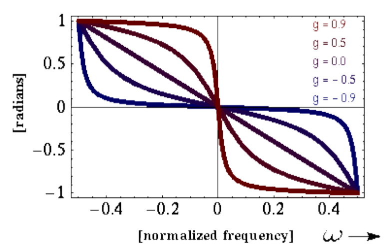


Some Electrical Theory
from common Electrical Enginering textbooks :



First-Order Allpass Phase Response (let $g = re^{j\theta}$)

$$\Theta(\omega) \triangleq \angle H\left(e^{j\omega}\right) = -\omega - 2\tan^{-1}\left[\frac{r\sin(\omega-\theta)}{1-r\cos(\omega-\theta)}\right]$$



"The All-Pass filter has **frequency responses**
which **must be zero at w=0 and at w=pi**." wiki

This paper presents

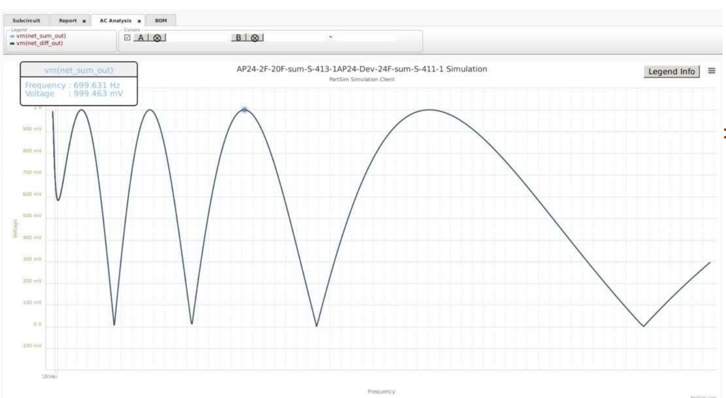
a Non-Resonant Dual-Notch Phase-Filter

producing a Band-Pass function
as an "ngSPICE project"
produced via the PartSIM.com browser based Simulator.

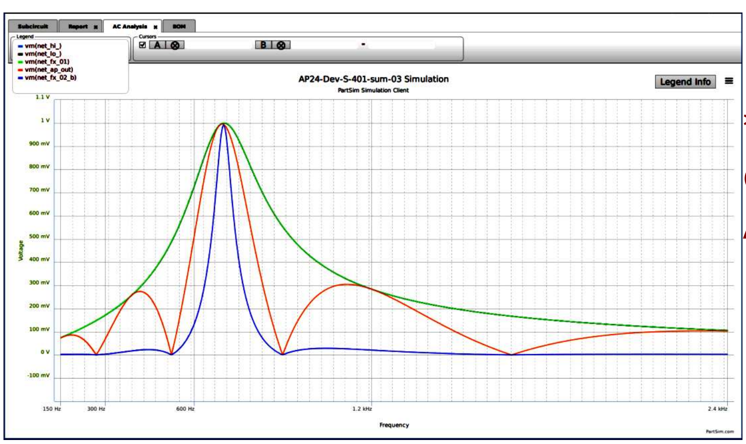
Introduction:

In all researched texts, the traditional academic texts specify that All-Pass filters CanNOT be used for Low-Pass nor High-Pass functions , nor for Band-Pass functions.

*** However, the author has developed
working **Dual-Notch Band-Pass** circuits
*** which utilize the **All-Pass Filter**
in both LoPass and HiPass configurations



*** Raw All-Pass



*** Bode Plot
of "APC" circuit
All Vout signals

****

In this #1 circuit,
f(Lo) = 700 Hz and f(Hi) = 700 Hz
This accentuated the "w" notches at :
each "0" point
each "pi" point
in the spectrum.

***** In the #1 fully developed working circuit,**
***** based on normal f(Lo) = 700 Hz and f(Hi) = 700 Hz**
***** we preceeded and followed the All-Pass array**
***** with Multi-FeedBack Band-Pass OpAmp filters**
***** to reduce unwanted side-band signals (away from f(0) = 700 Hz).**

****
***** Experiments were done using the"UnBalanced" design**
***** with (1) AP-Lo at 700 Hz and (12) AP-Hi at 700 Hz**
***** to observe the patterns ,with good results.**
****

***** Our design is presented here.**
***** (with (1) AP-Lo at 700 Hz and (12) AP-Hi at 700 Hz)**
****

700 Hz All-Pass resonance is based on R=10K and C=23nF.

*** All observations confirm the validity of this design.**
****

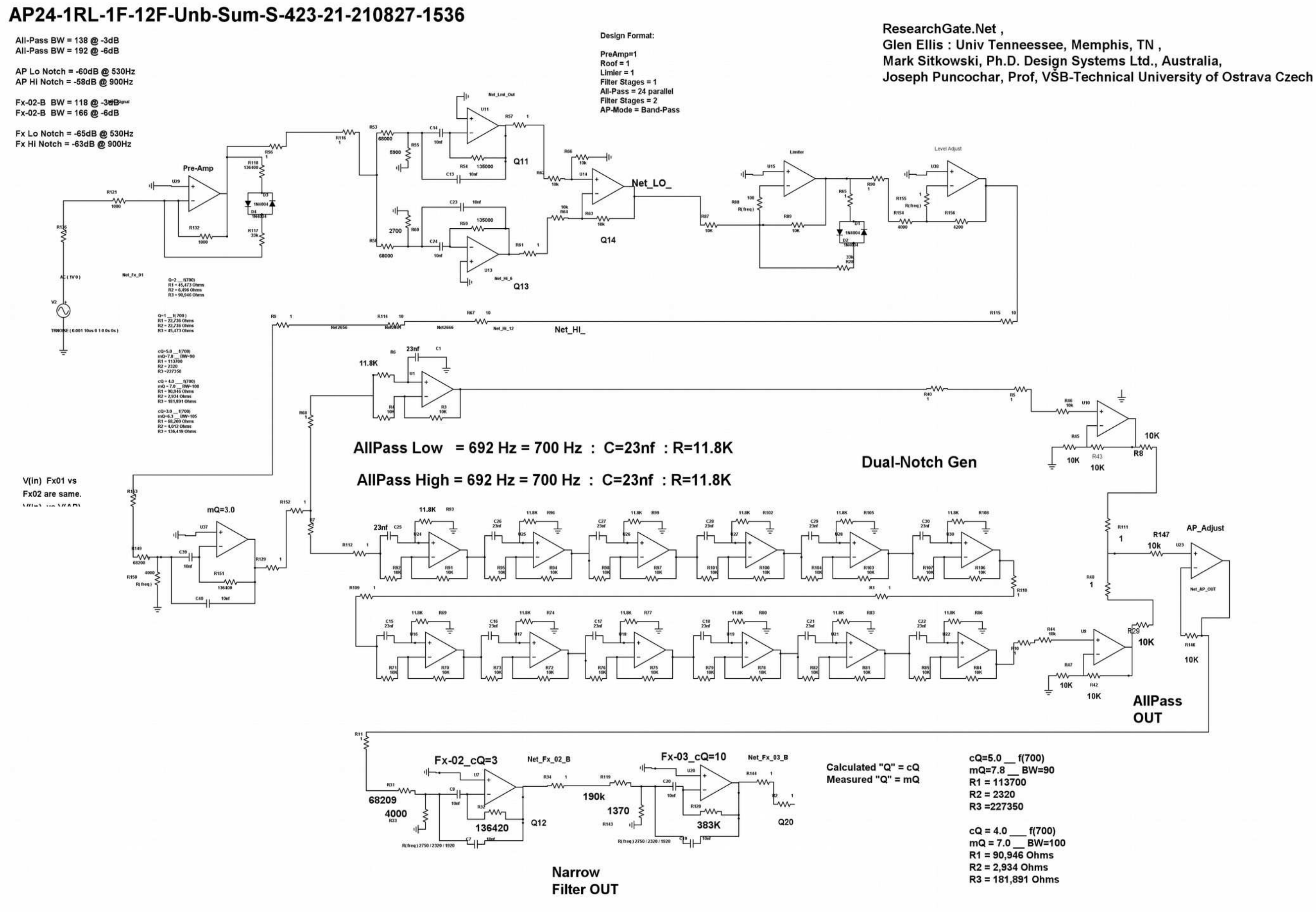
Circuit: #1 Developed working circuit , on next page
***** Using the "UnBalanced" topology**
***** ONE f(Lo) = 700 Hz and Twelve f(Hi) = 700 Hz .**

***** 700 Hz resonance is based on R=10K and C=23nF.**
*****
***** Combined Lo and Hi to produce**
***** a Band-Pass Filter Signal.**

***** U09 and U10 are Voltage Buffers.**
***** U23 “APadjust” is a voltage-combining circuit.**
***** Combining f(Lo) and f(Hi)**
***** to produce a Dual-Notched Filter Signal.**

***** Final Filters: Fx02 Q=5, and Fx03 Q=10**
pull out a very usable Narrow Dual-Notched Band-Pass signal.

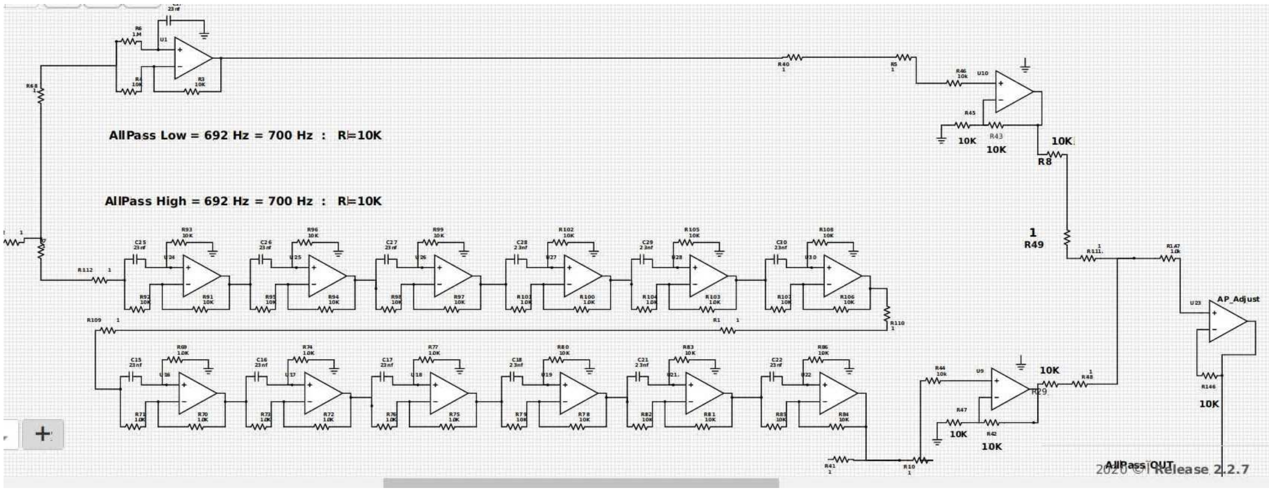
Circuit: **"APC"** (AP24-1RL-1F-12F-Unb-Sum)



All-Pass Non-Resonant Phase-Filter Band-Pass

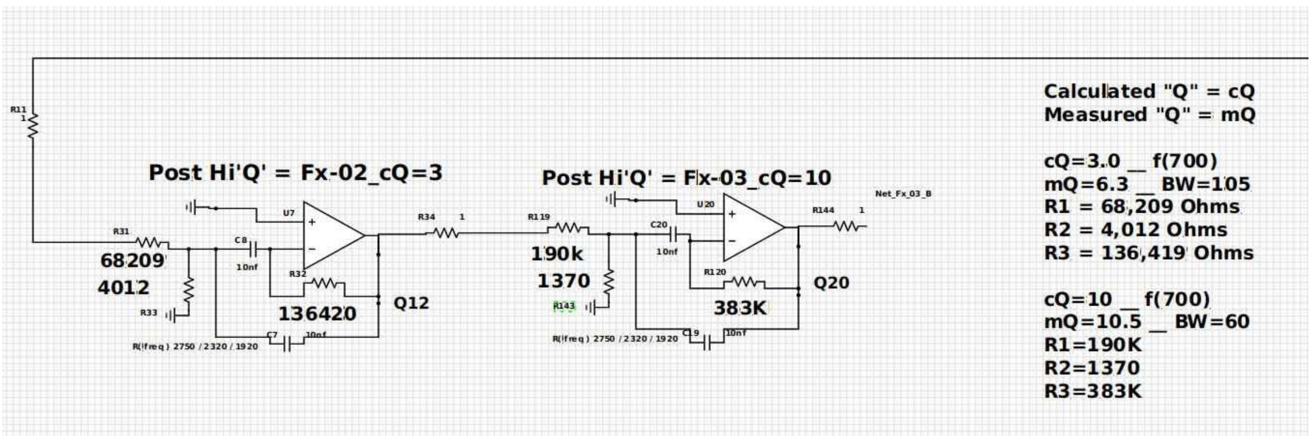
which produces Dual-Notch Band-Pass.

Below: Detail: APC
All-Pass module generates Dual-Notches :
The All-Pass-Lo and the All-Pass-Hi are Buffered and Summed to generate the Narrow Dual-Notch Pass-Band. .



Dual Notch Bode Plot generated from this stage.

Below: Detail: APC
Hi 'Q' Filters sharpen the Band-Pass inside of the Dual-Notches :



Final Filter 03 and Filter 04
are for producing an enhanced Narrow Band-Pass.

Notes: AFC

Bode Plot : Yellow trace is AllPass output.
###

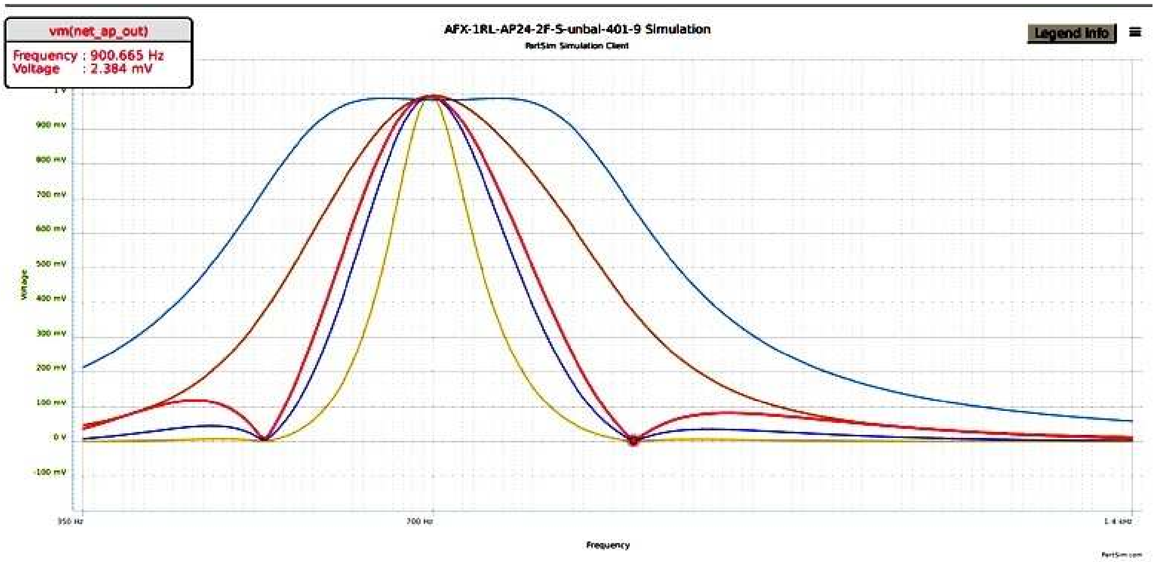
Plots LiteBlue, Red, DarkBlue show Filter-02 Q=3
when tuned +/- 70 Hz (-3dB)
within the All-Pass Output Yellow Trace.

The flat-topped trace is the "Roofing-Filter"
which preceeds the Limiter circuit,
Notice the -27 dB per Octave attenuation of side-band signals,
outside of BW=350Hz.
***** This Version used Fx-02 Q=3 (red) and Fx-03 Q=10 (narrow blue)**

***** Scale : 700mV = -3dB ; 500mV = -6dB**
***** Notch High 900 Hz = -53 dB, Notch BW = 360 Hz**

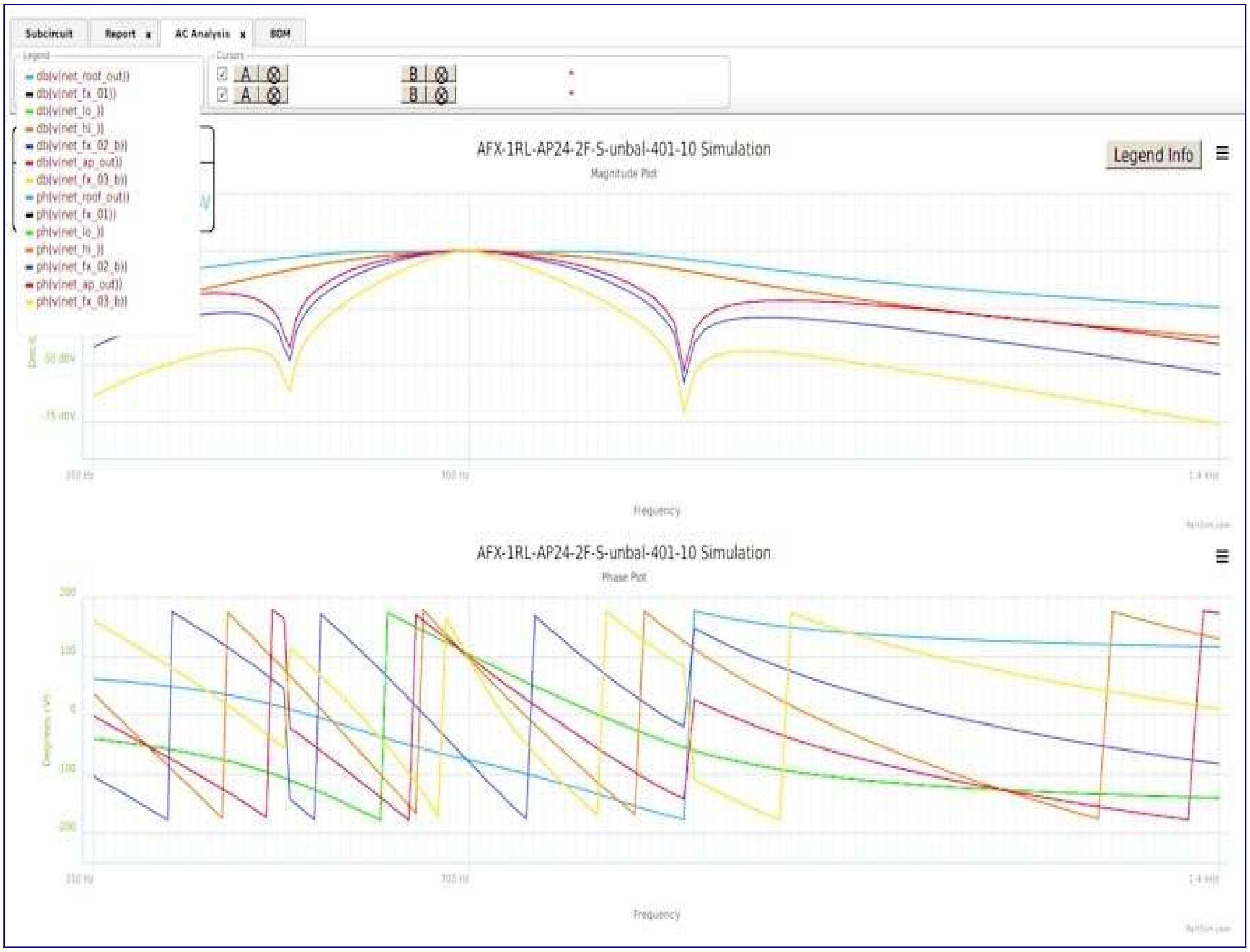
Bode plot : AFC

***** Notice the Dual-Notches Red trace, around f(0)**
***** Yellow trace is the final filter, with Sharp Band-Pass.**
***** Notice: Fx-02 Q=3 and Fx-03 Q=10**
are for extremely narrow Band-Pass, inside of Dual-Notches.



Magnitude Plot : AFC

*** Below : YELLOW trace is final Q=20 result
shown is the f(0) changed +\- to -3dB points.
*** f(0) Shifts are confined to the AllPass Ouput plot.



Magnitude Plot : *** Magnitude Scale readings : V = -dB

*** Magnitude Scale readings : V = -dB
These Band-Pass signals-are NOT a Gaussian Shape.

*** Yellow trace Filter-03 at Hi-Notch = -70 dB
*** Yellow Spreads at the rate of 5.2 Hz per -dB attenuation
(aprox "**Brick-Wall**").

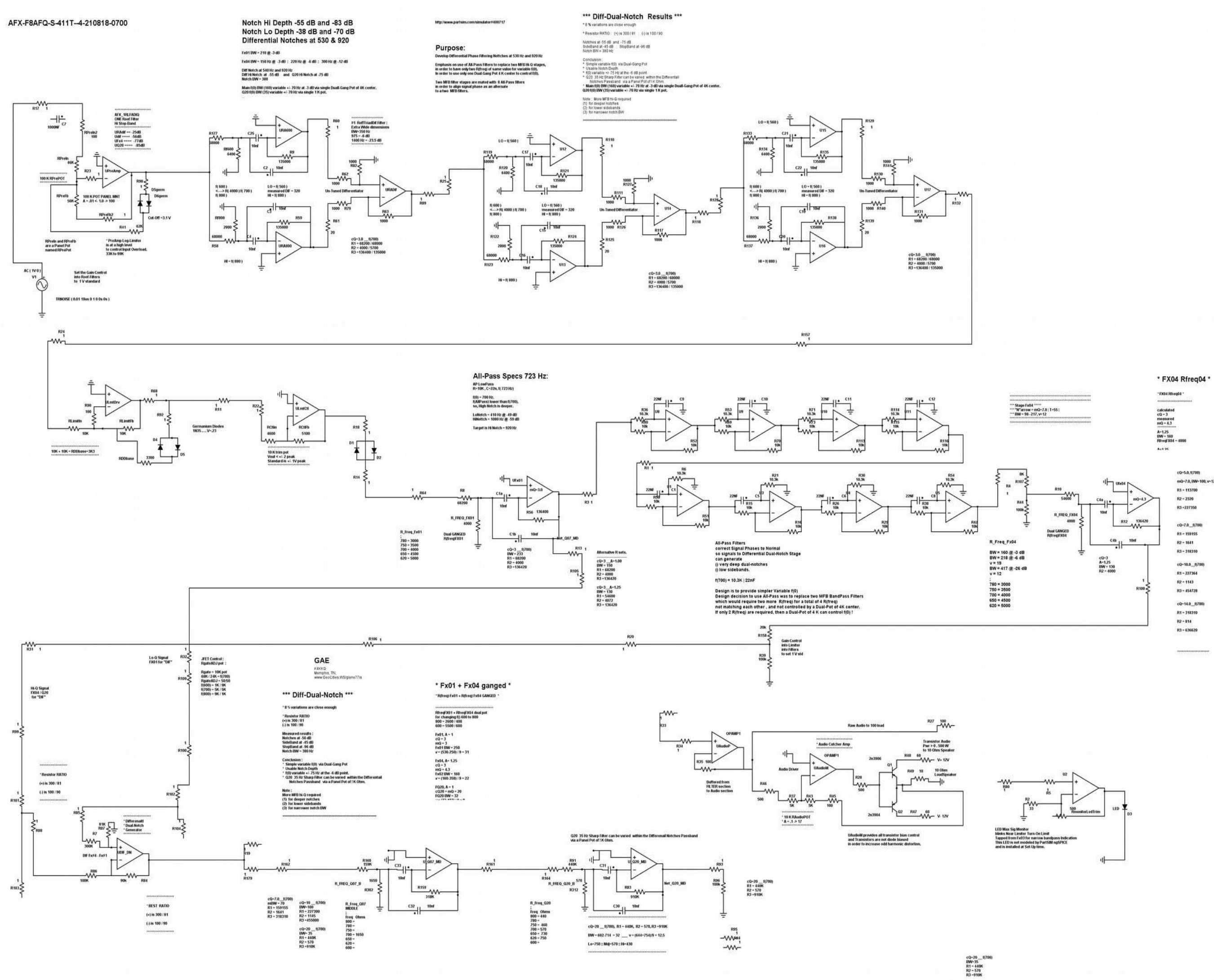
Circuit: **AFX_3RL-F8AFQ**

Special Advanced All-Pass Band-Pass circuit combining AFX and APC concepts.

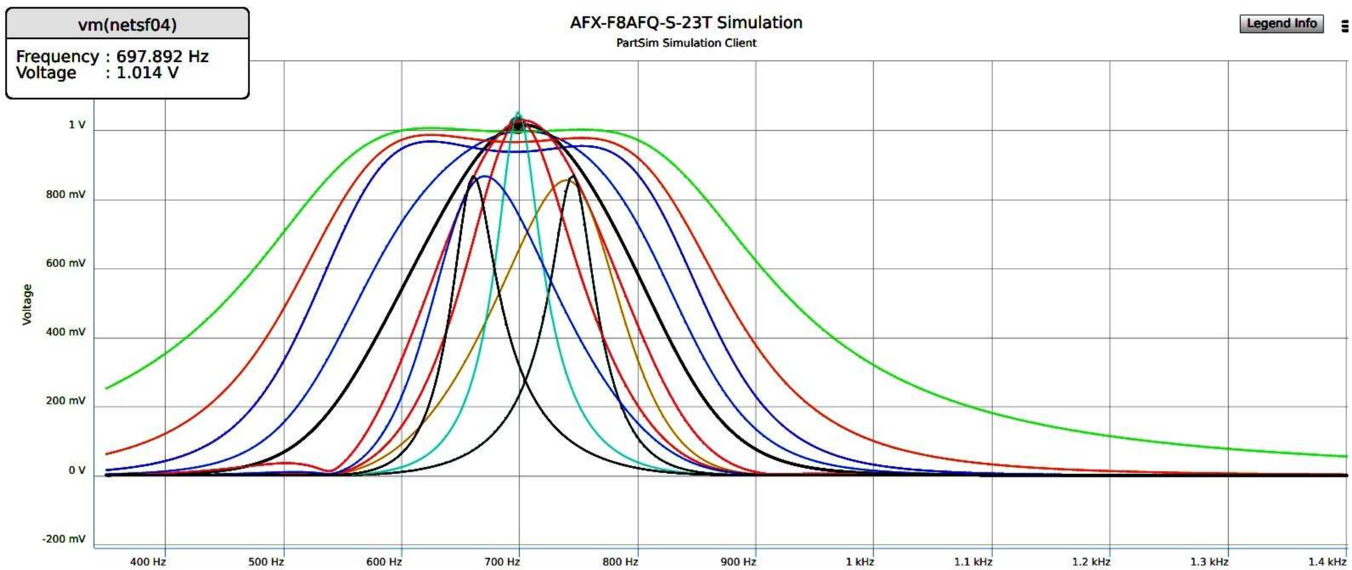
***** Two Variable MFB Filters with 8 All-Pass stages inserted in the middle**

An effective combo-design, which is simpler but not as effective as the AFX’V’-3RL-V4F-D-VQ version.

Result One Dual-Pot can control f(0) +/- 75 Hz, reading at the -3dB level.



Bode Plot : **AFX_3RL-F8AFQ**



Results: **AFX_3RL-F8AFQ** **with Dual-Notches.**

*** Compared to the AFX’V’ ("AFV-3RL-V4F-D-VQ" version)

(1) BW @ -3dB is wider ;
160 Hz vs 90 Hz.

(2) Dual Notch BW is wider ; 380 Hz vs 330 Hz.
but the FX Q20 will narrow this to 35Hz.

(3) Variability of f(0) is much narrower ; +/- 75 Hz is good (at -3dB),
vs +/- 100 Hz for the AFX’V’ versions.
At f(700 Hz) , +/- 75 Hz is similar to +/- one piano note.
Changing the f(0) of the All-Pass stages and/or the gain of AP stages
(1) will change the f(0) of the AP notches up/dn factor of 2.
(2) will change the Band-Width of the notches w/n factor of 2..
F(700) is best freq for the intended usage of this Filter Circuit ,
and is a compromise the author selected for this project.

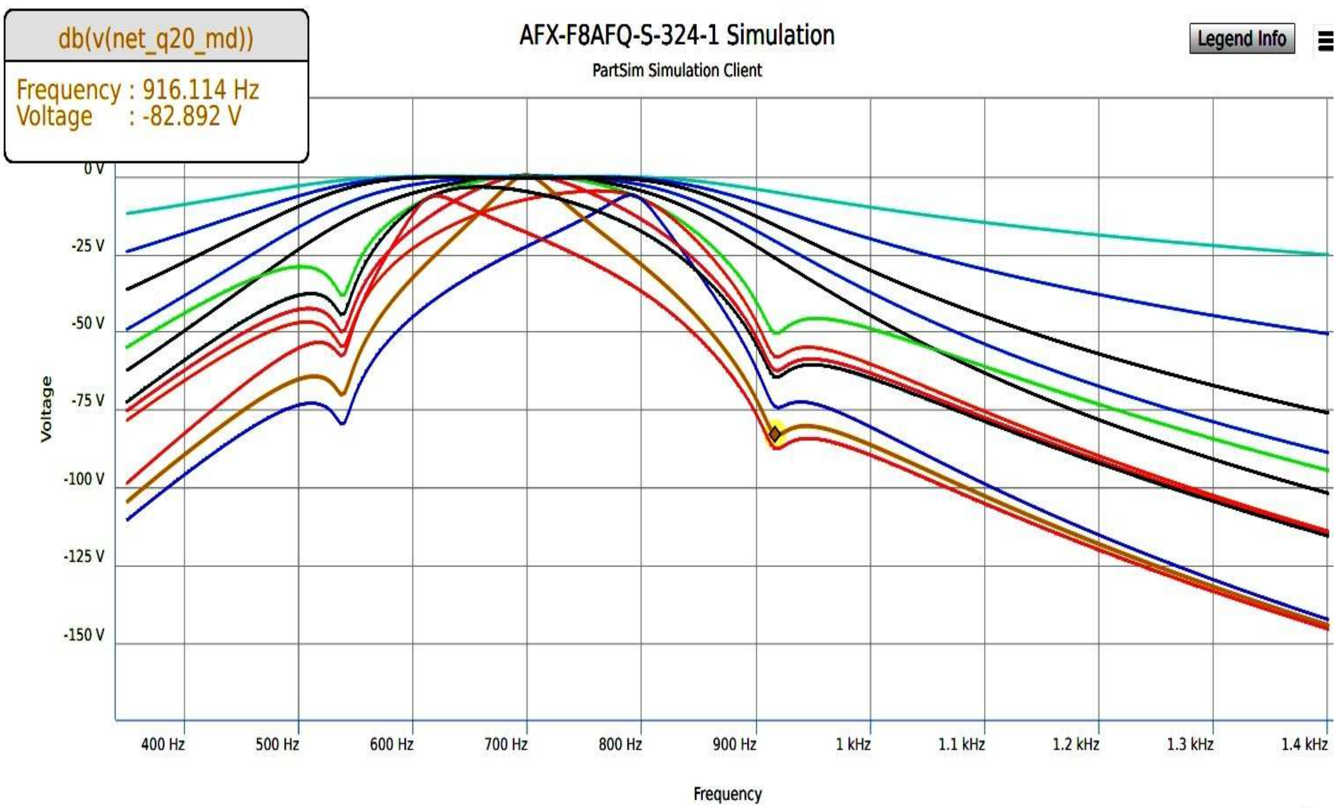
(4) Variable f(0) controlled physically
by a Single Panel-Mounted dual-gang Pot
is a good feature, even if not very much variation.

Magnitude Plot: **AFX_3RL-F8AFQ**

Magnitude Plot clearly shows the Notch Depth
while shifting f(0) +/- 100 Hz

*** Notch Generator freq tracks with f(0)
*** at +/- 100 Hz
*** Fx(100Hz) is -0.5dB down
*** Fx(35Hz) is -1.0dB down

*** At f(700) normal settings
Deep Notch (Yellow/Black trace)
is -82 dB 920Hz.



note:

*** Also authors explored the "UnBalanced" (7 Hz and 700 Hz) approach.
*** The All-Pass-Lo is tuned to 6.20 Hz (aprox. 7 Hz)
*** The All-Pass-Hi is tuned to 692 Hz. (aprox. 700 Hz)
*** Results: equal success in circuit performance.
*** Further experiments were done using the"UnBalanced" design
*** with f(0) at 70, 137, 175, 350, 650 Hz vs. 750 Hz
to observe the patterns, with good results.
***
*** Further experiments were done using the"UnBalanced" design
*** with filter pairs of 2, 4, 6, 8, 10, 12, 14, 16, 18, 24
to observe the patterns ,with good results.
*** These circuits are not discussed in this paper.
****

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****