

CC-218 VOL BOARD

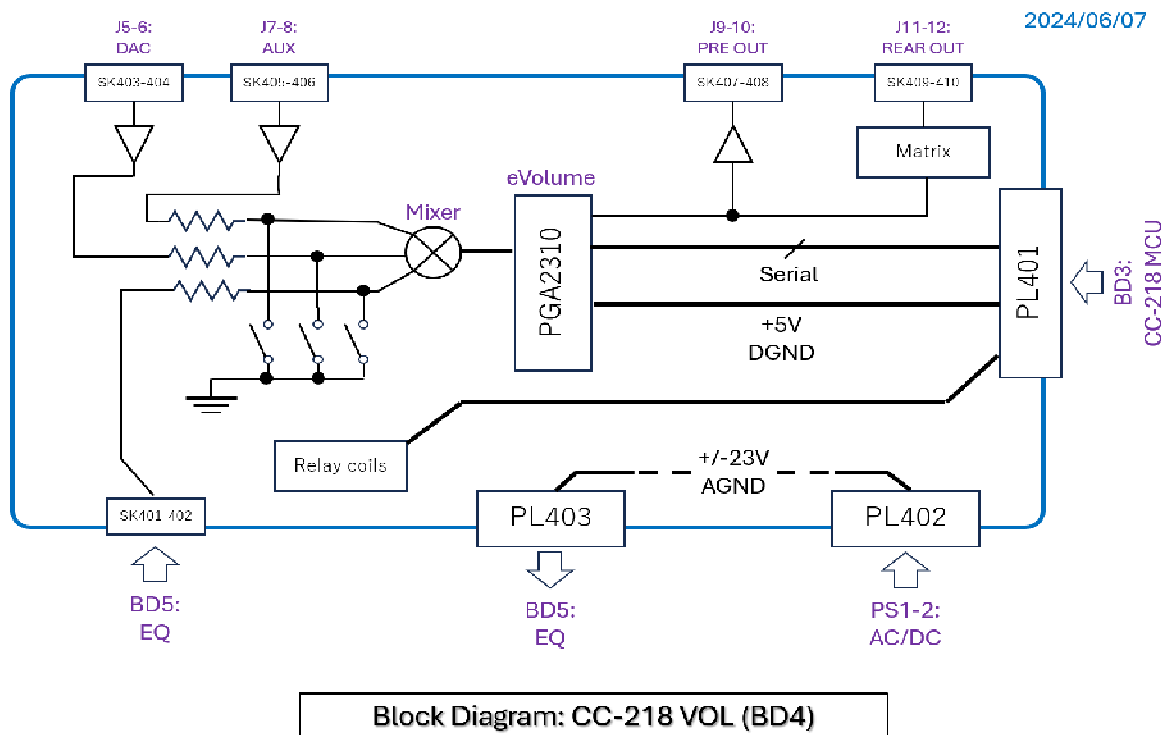
Design

2023/08/20

2025/03/21

Circuit Design

Block Diagram



Contents:

Simulation of Selector

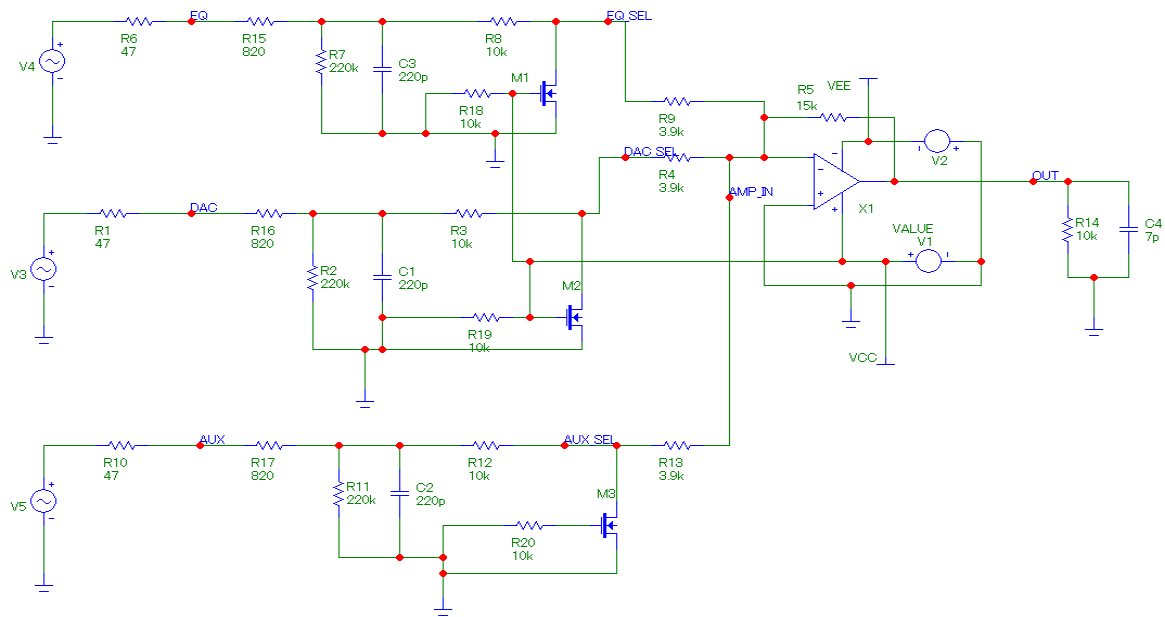
Simulation of Matrix

Schematic

Power Dissipation

Simulation of Selector

* Schematics for simulation



Op amp: OPA627
N-MOSFET: IRFP460

* Transient analysis

Settings

Transient Analysis Limits

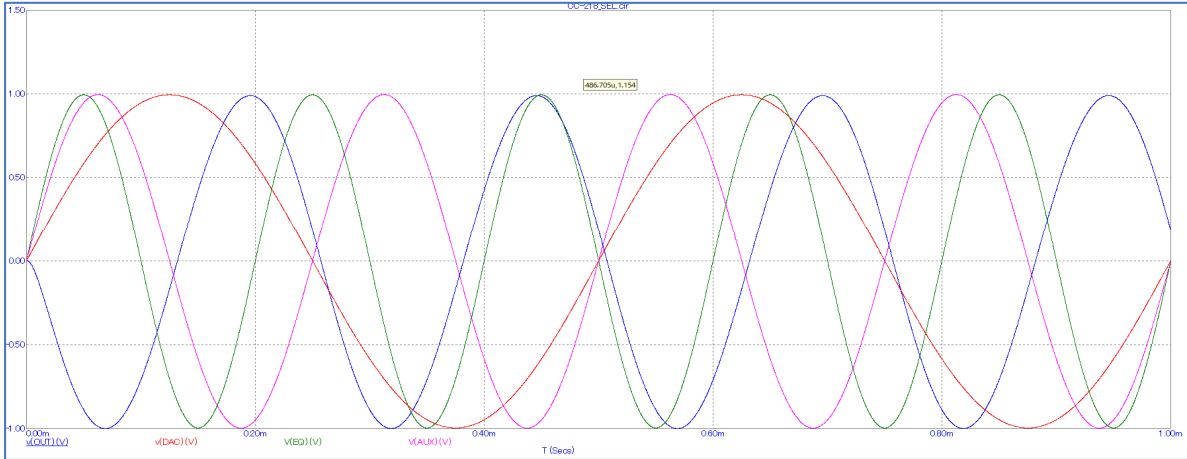
Run Options: Normal
State Variables: Zero

Maximum Run Time: 1m
Output Start Time (tstart): 0
Maximum Time Step: 0.1u
Number of Points: 51
Temperature: Linear 27
Retrace Runs: 1

☒ Operating Point
☐ Operating Point Only
☒ Auto Scale Ranges
☐ Accumulate Plots
☐ Fixed Time Step
☐ Periodic Steady State

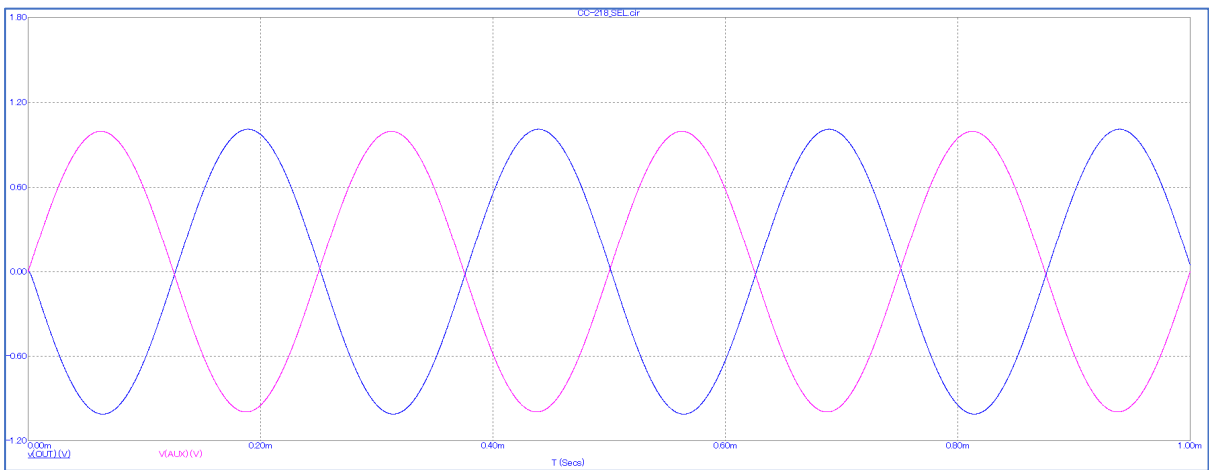
Page	P	X Expression	Y Expression	X Range	Y Range
1	T	v(OUT)	0.001,0,0.0002	1.5,-1,0.5	
1	T	v(DAC)	0.001,0,0.0002	1.5,-1,0.5	
1	T	V(EQ)	0.001,0,0.0002	1.5,-1,0.5	
1	T	V(AUX)	0.001,0,0.0002	1.5,-1,0.5	
1	T	V(AMP_IN)	0.001,0,0.0002	1.5,-1,0.5	
1	T	V(EQ_SEL)	0.001,0,0.002	10,-10,4	
1	T	V(DAC_SEL)	0.001,0,0.002	10,-10,4	
1	T	V(AUX_SEL)	0.001,0,0.0002	1.8,-1.2,0.6	

EQ, DAC, AUX ==> OUT



EQ: 5kHz, 1Vpeak
DAC: 2kHz, 1Vpeak
AUX: 4kHz, 1Vpeak

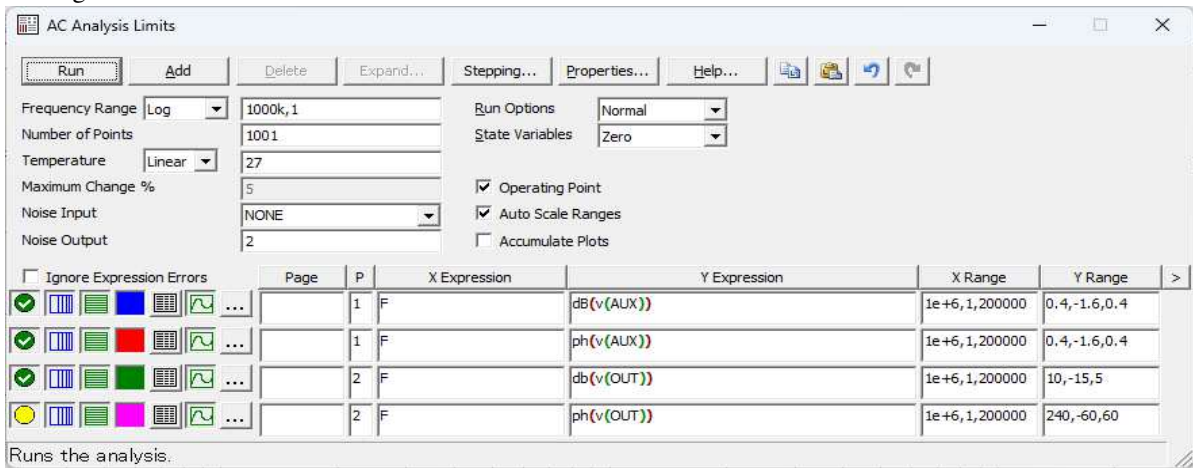
AUX ==> OUT



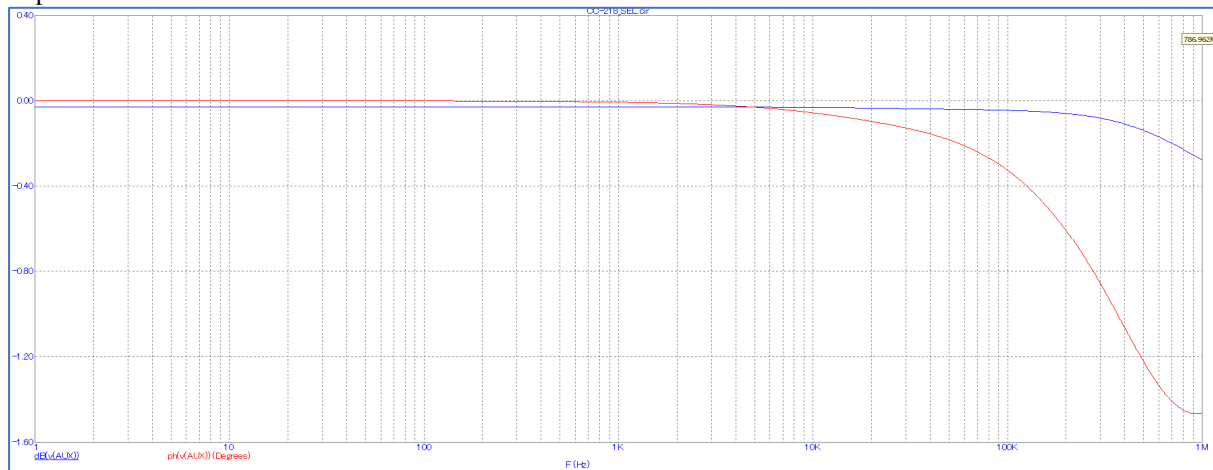
The waveform seems right.

* AC analysis

Settings

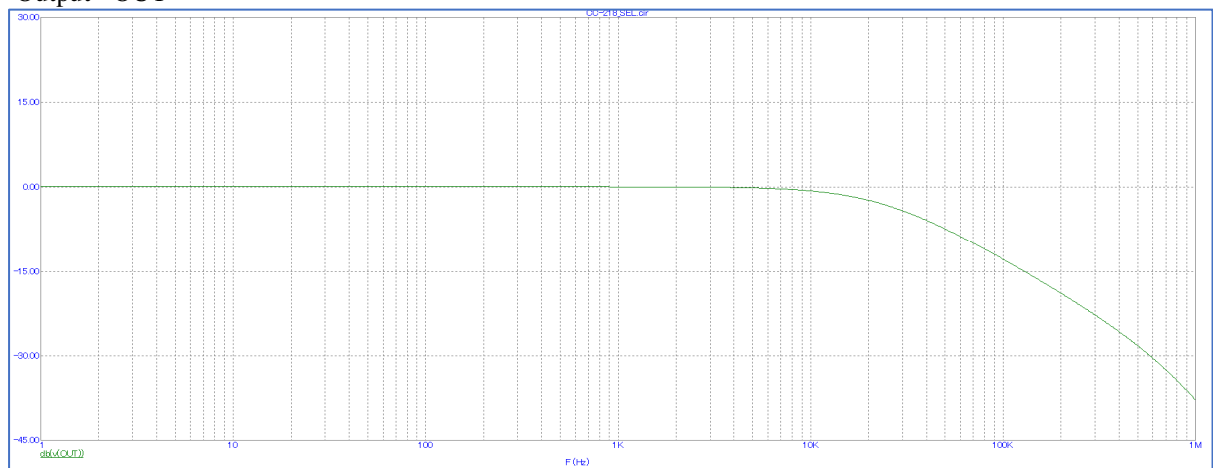


Input - AUX



Freq resp is flat till 100kHz.

Output - OUT

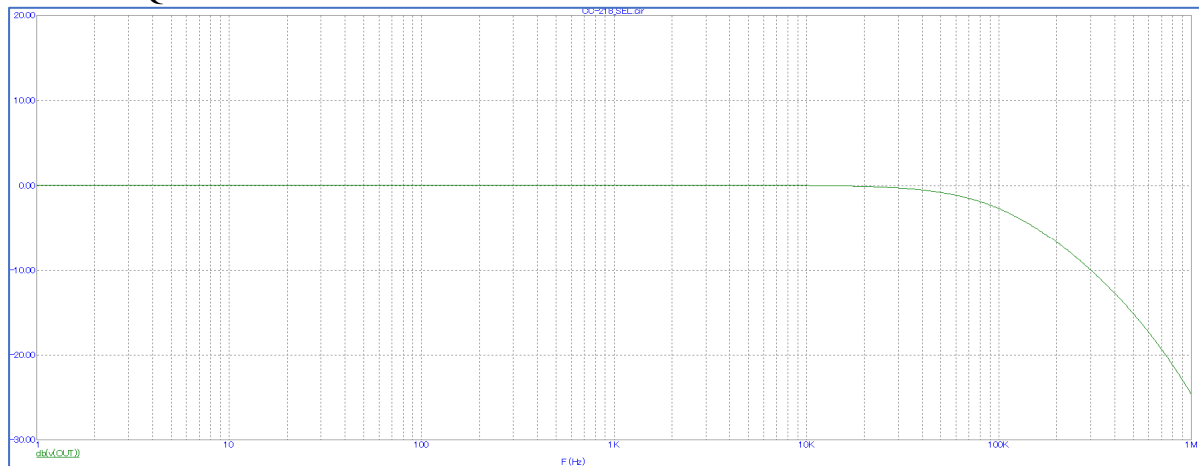


Treble rolls off!!!

It's probably due to the capacitance of IRFP460.

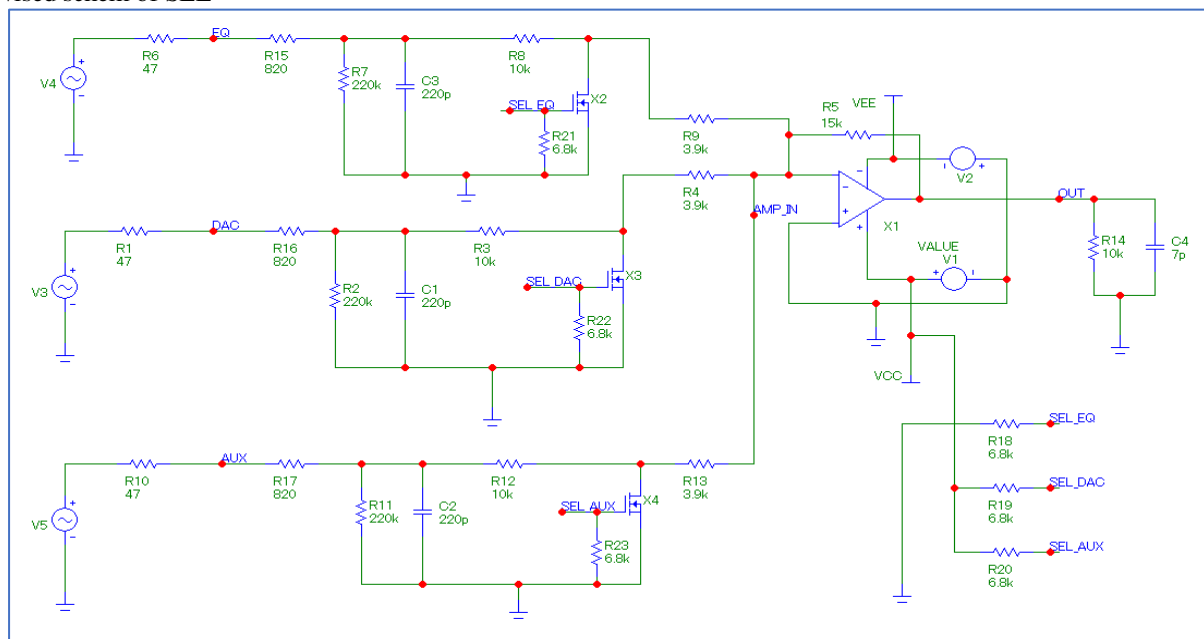
==> Replace IRFP460 w/ CSD15571Q2

CSD15571Q2



Treble still rolls off but the cutoff frequency is higher.
 GSF2301 may raise the cutoff frequency, because it has smaller capacitance.
 Unfortunately, the SPICE model of GSF2301 is not available.

* Revised schem of SEL



Op amp: OPA627

N-MOSFET: CSD15571Q2

In the figure above, EQ is selected.

* THD

Settings

Harmonic Distortion Analysis Limits

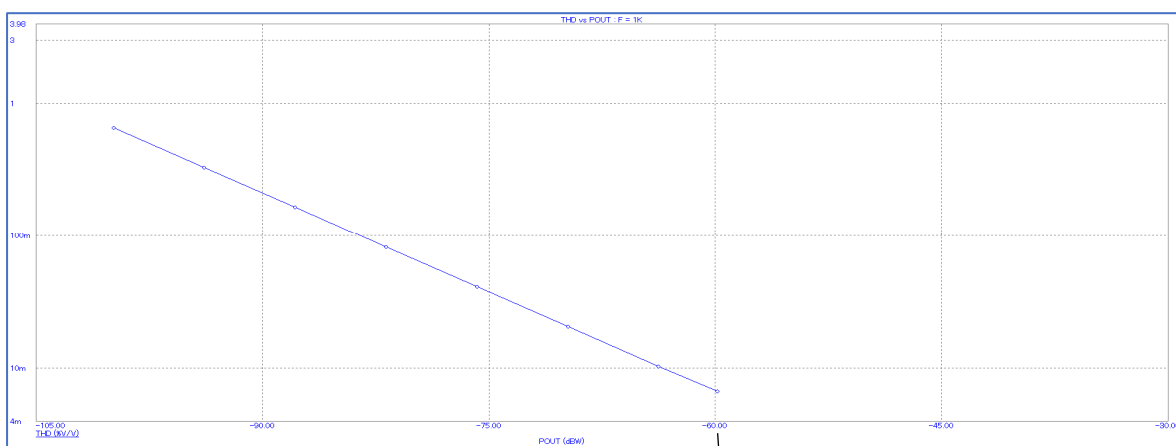
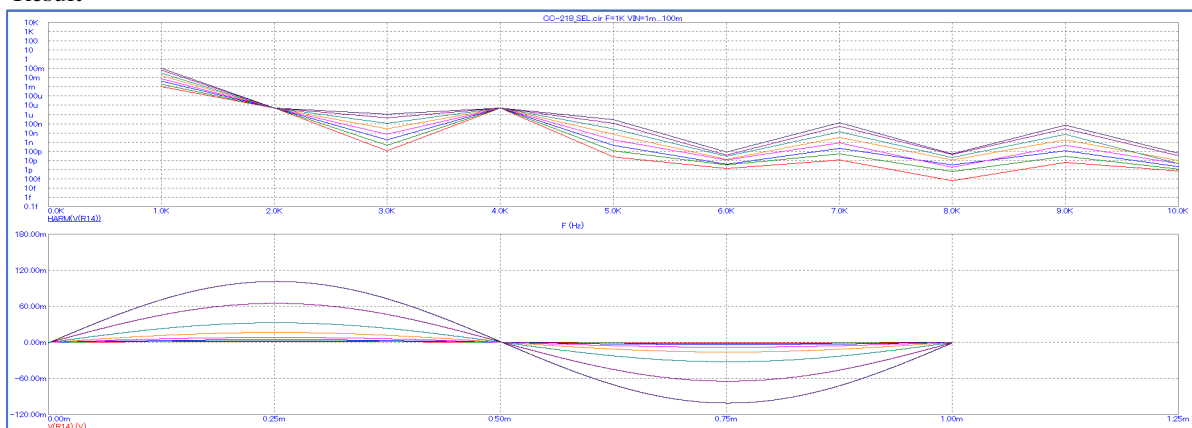
Run Add Delete Expand... Stepping... PSS... Properties... Help...

Fundamental Frequency: List 1K
Name of Input Source: V4
Input Source Amplitude: Log 100m, 1m, 2
Name of Source Resistor: None
Name of Load Resistor: R14
Noise Frequency Range: 100K, 1
Temperature: Linear 27
Max Simulation Cycles: 50
Steady State Tolerance: 1u
Time Step Ratio: 1m
Highest Harmonic in THD: 7
Number of Time Points: 51
Number of Frequency Points: 51

Run Options: Normal
State Variables: Zero
☒ Operating Point
☒ Auto Scale Ranges
☐ Accumulate Plots
☒ Periodic Steady State

Page	P	X Expression	Y Expression	X Range	Y Range
1	F	HARM(V(R14))	10000,0,1000	10000,1e-16	
2	T	V(R14)	0.00125,0,0.000	0.18,-0.12,0.06	
	F	THD(HARM(V(R14)))	10000,0,1000	1,0,0.2	
	F	THDN(HARM(V(R14)))	10000,0,1000	5,0,1	
	F	HARM(I(V4))	10000,0,1000	1,1e-20	
			Auto	Auto	

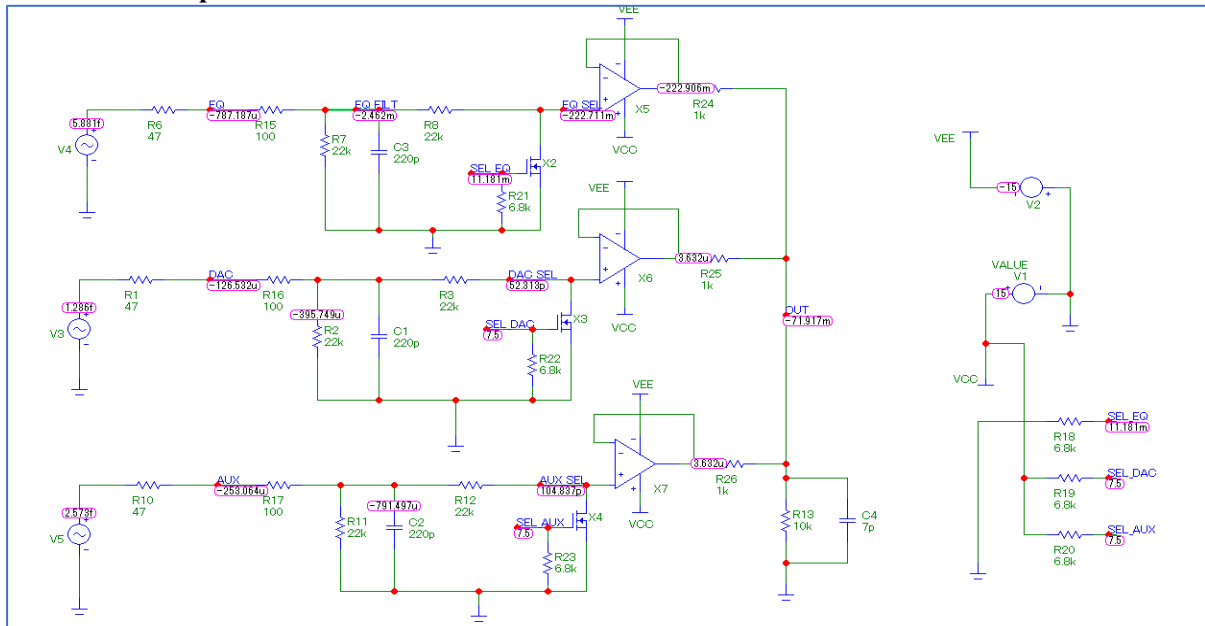
Result



Too large harmonics!

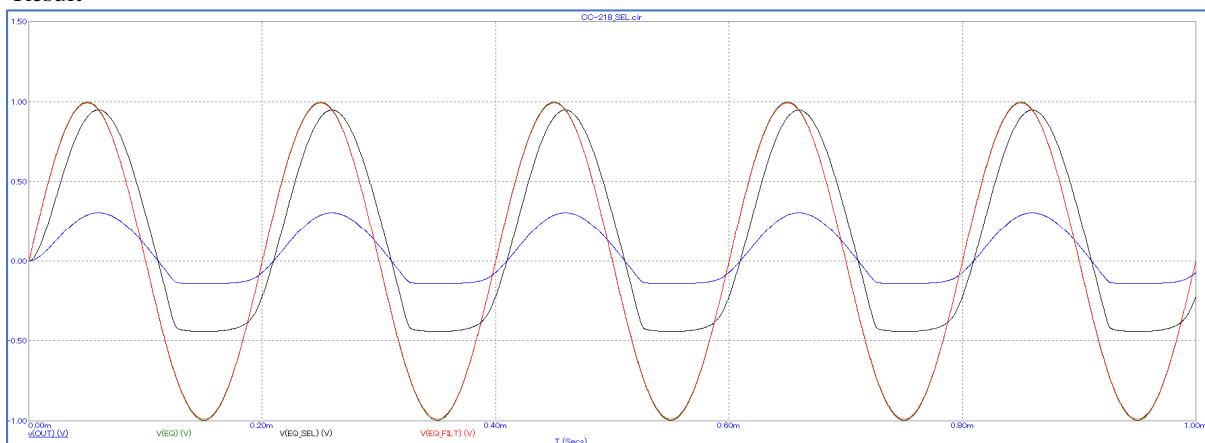
1uW (100mV into 10kohm)

*** Alternative circuit - passive adder**



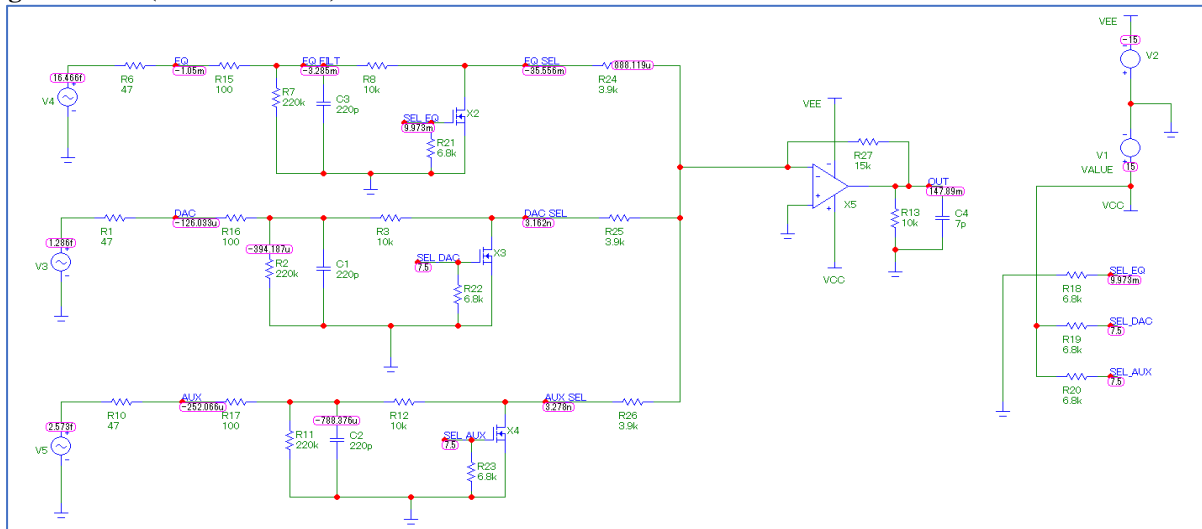
Passive adder

Result

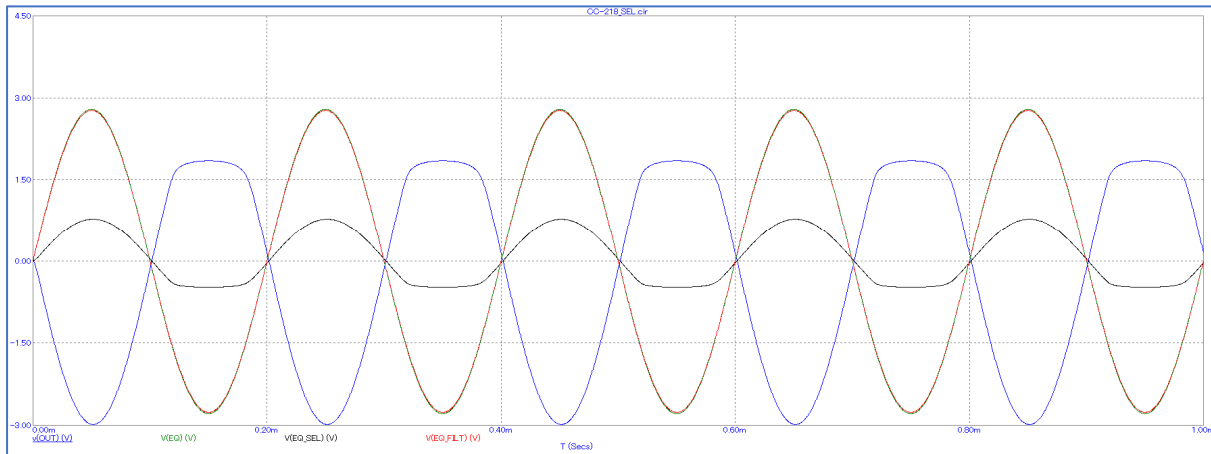


NMOS acts as diode clamp!
EQ_SEL can't swing below 0.44V

* Original circuit (redrawn schem)

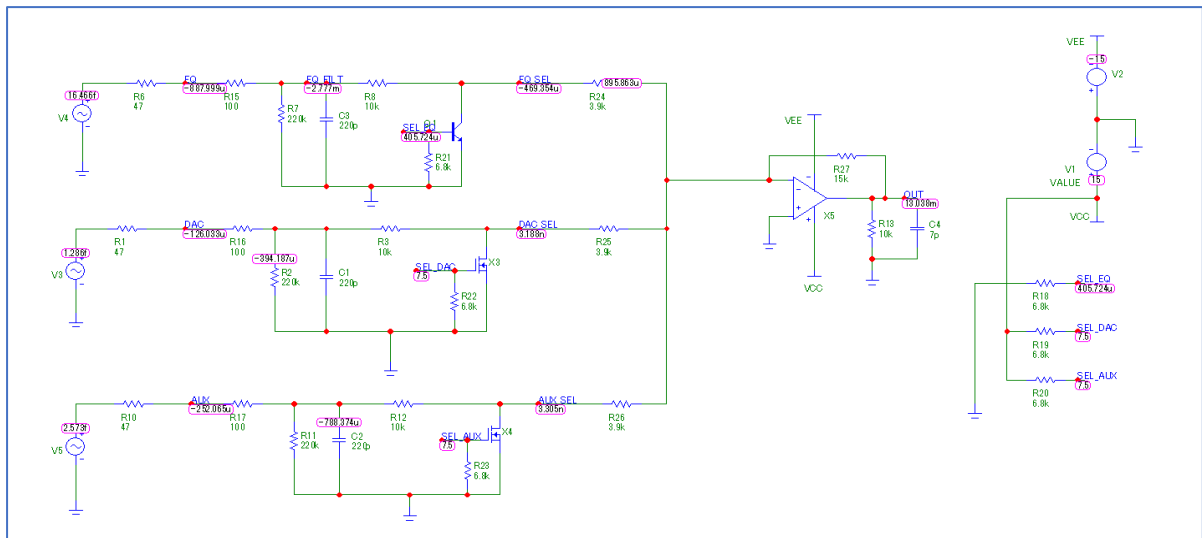


Result

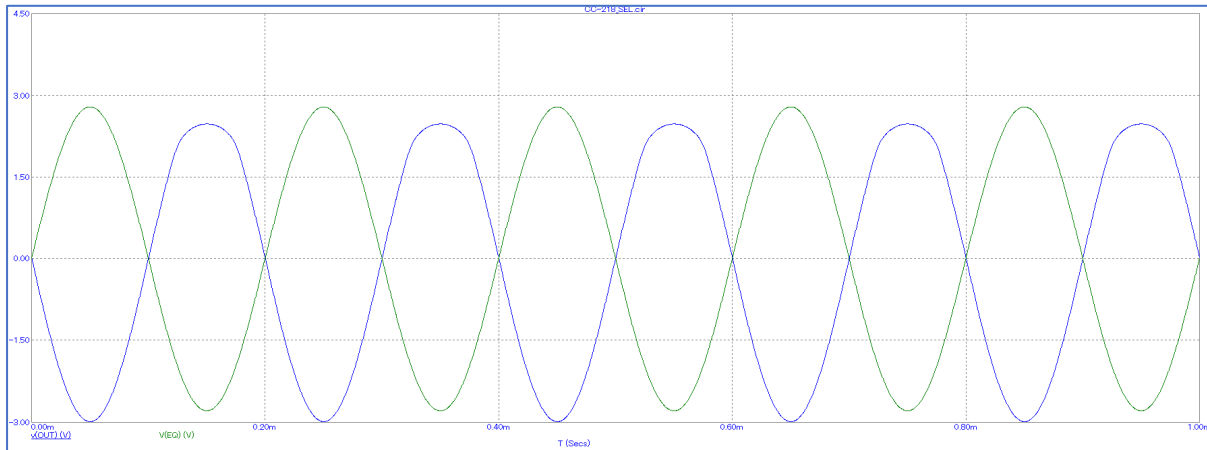


The level of EQ (V4) is increased $2.8V_{\text{peak}} (=2V_{\text{rms}})$
 \Rightarrow EQ_SEL is clumped!

BJT is used instead of NMOS

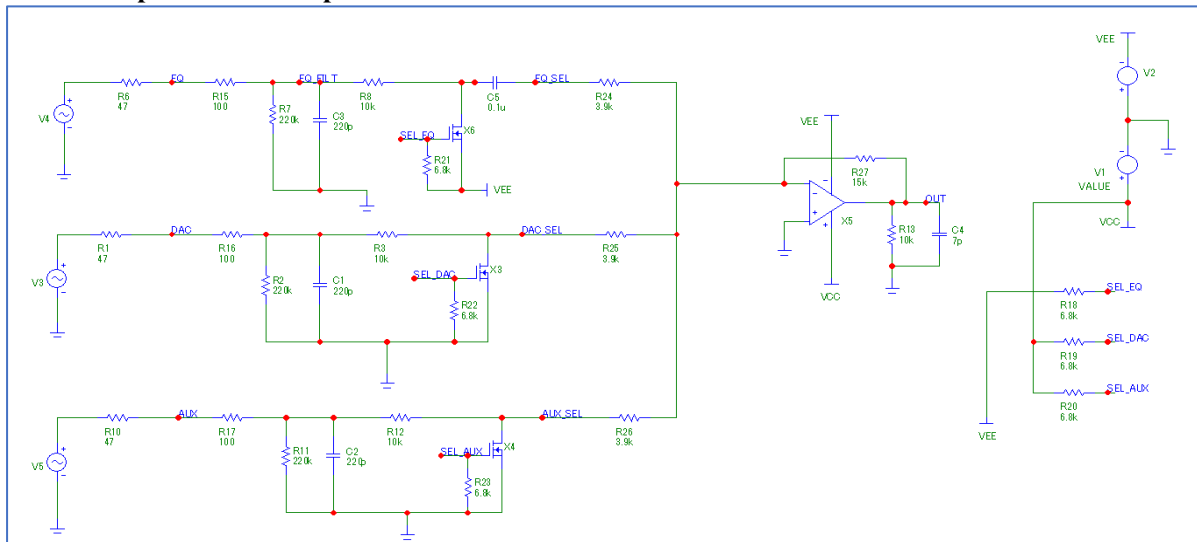


Result



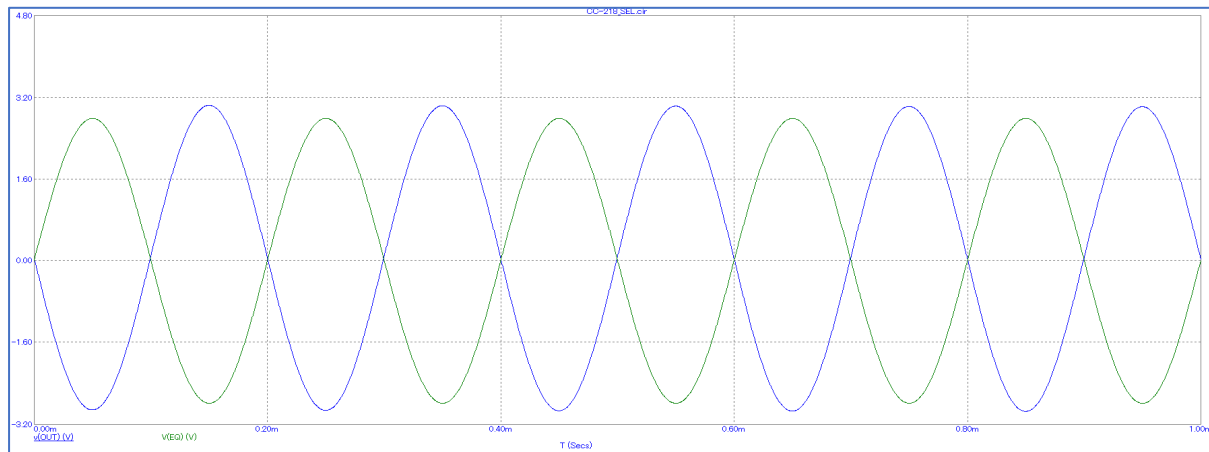
Output still distorted!

* Another attempt - NMOS clumped to VEE



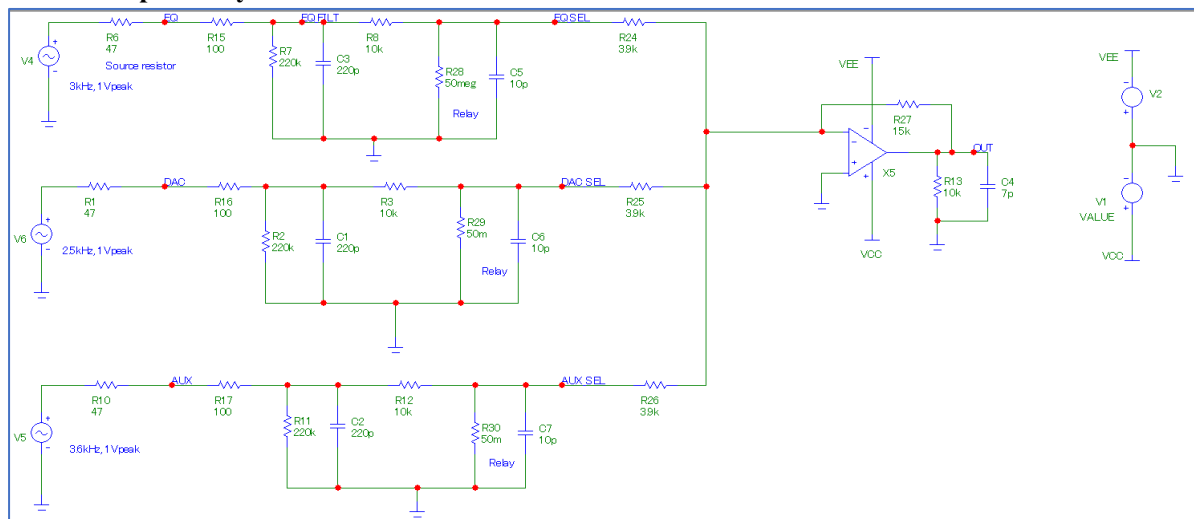
The source of NMOS connected to VEE (-15V)
AC coupling to the adder

Result

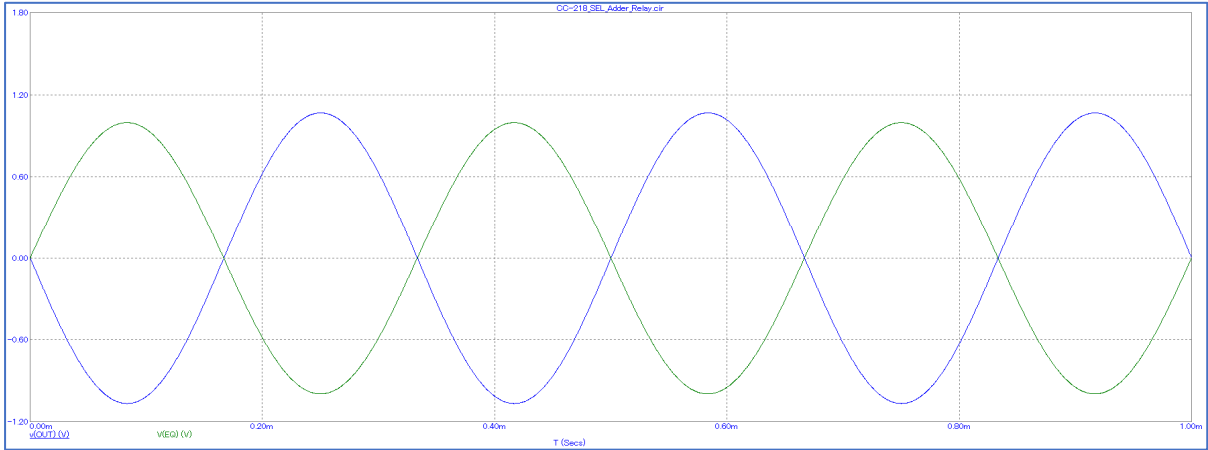


Less distortion!

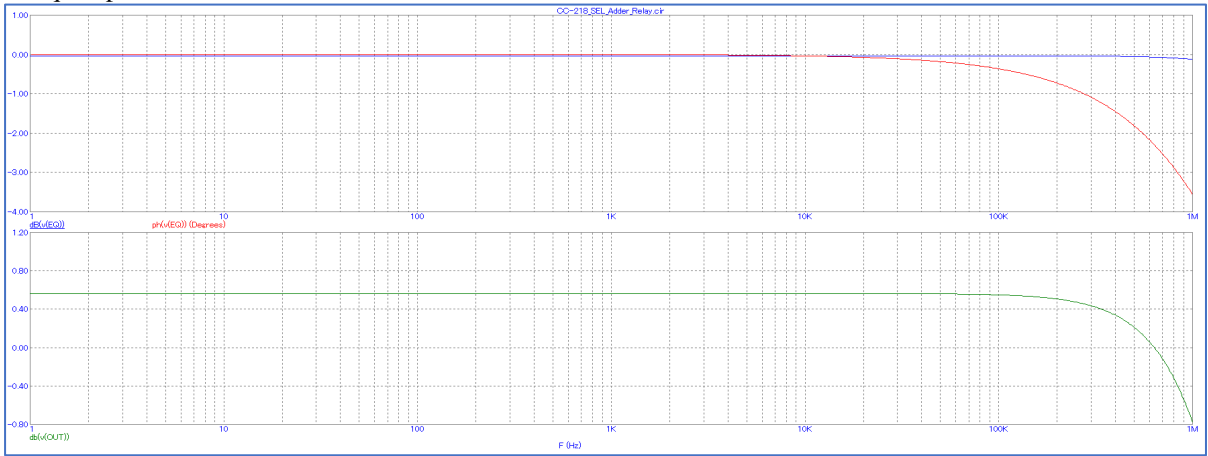
*** Another attempt - Relays used for shunt**



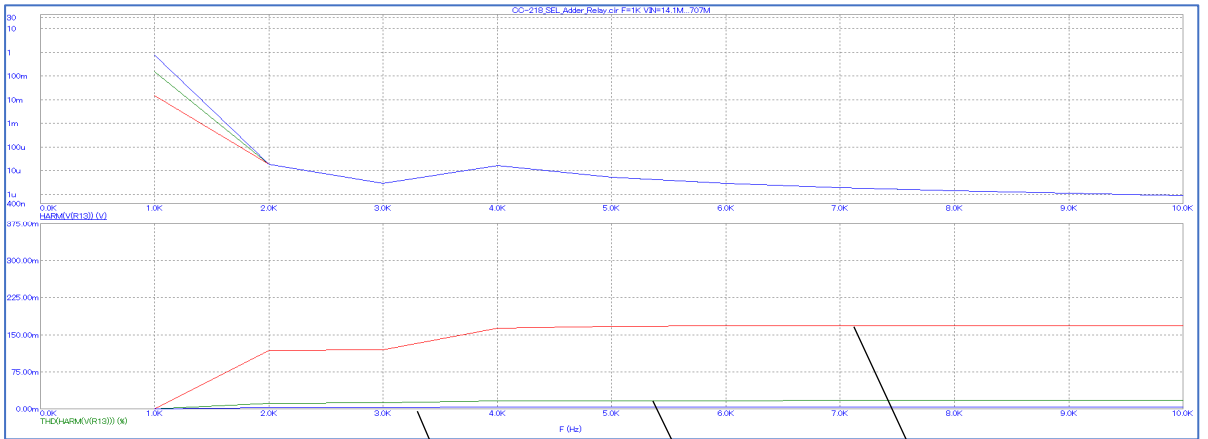
Transient response - sine wave



Freq Resp



Harmonic distortion

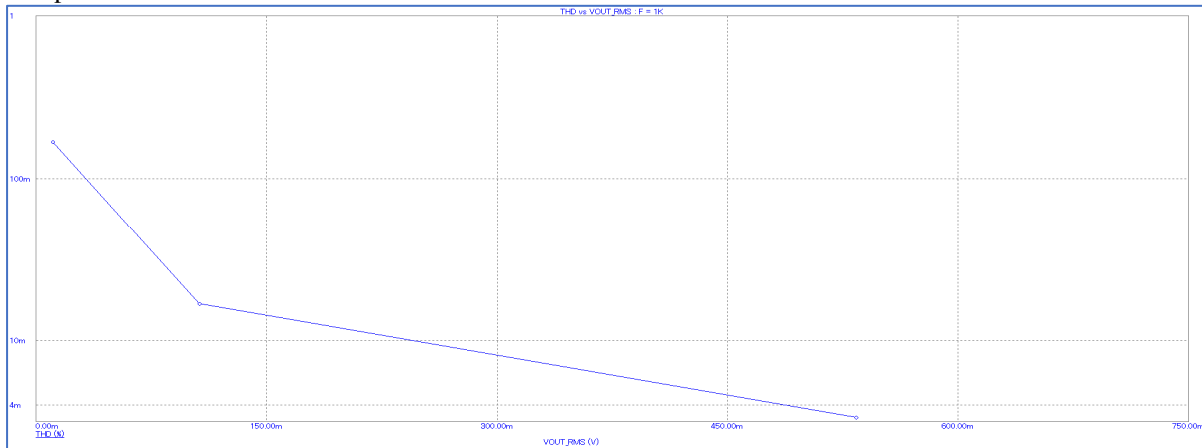


0.004% for
Vin=0.5Vrms

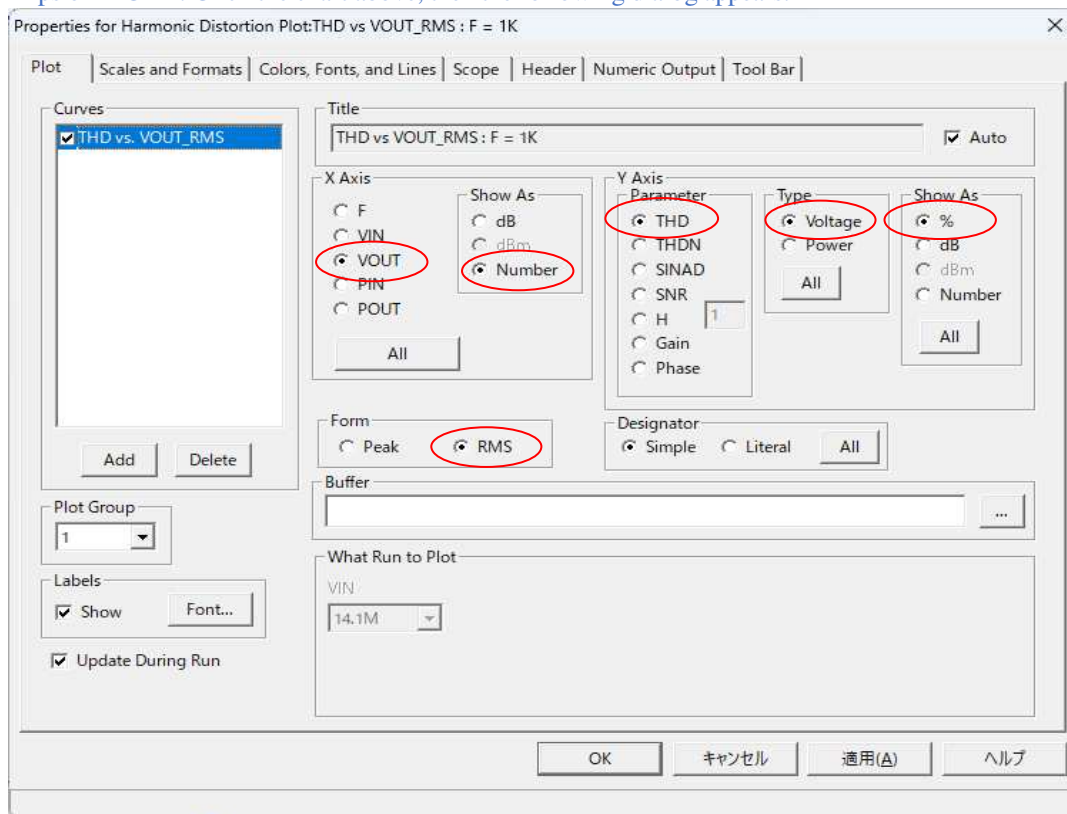
0.017% for
Vin=100mVrms

0.17% for
Vin=10mVrms

Output vs THD

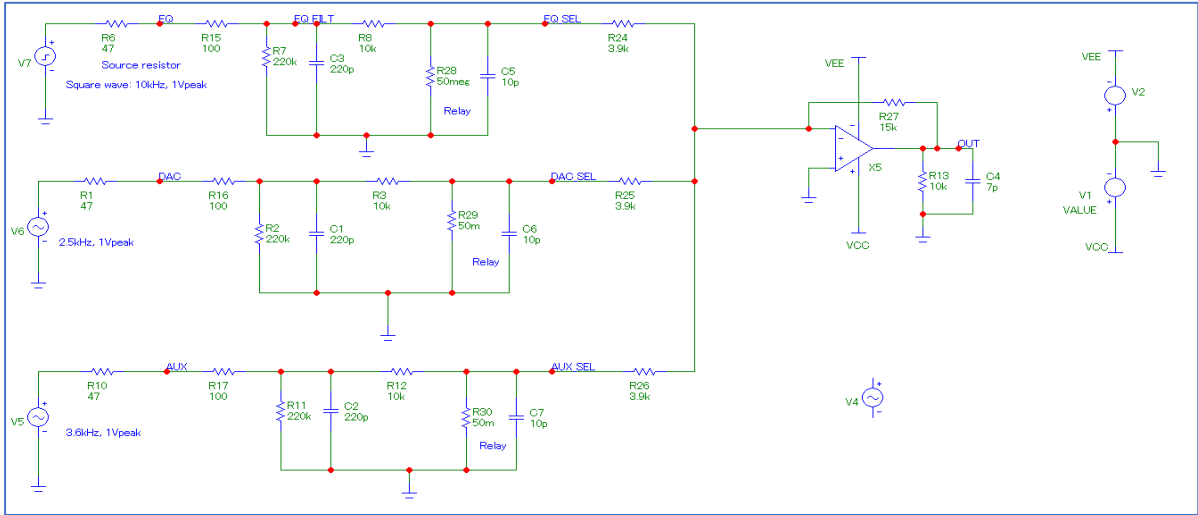


Tips on MC-12: Click the chart above, then the following dialog appears.



Select the options indicated by the red circles.

Square wave response



Settings of square wave source

Pulse Source

Name: MODEL Value: SQUARE

Display: ☐ Pin Markers ☐ Pin Names ☐ Pin Numbers ☒ Current ☒ Power ☒ Condition

Shape: Border Fill

PART=V7
MODEL=SQUARE
SMOKE=
COST=
POWER=
SHAPEGROUP=Default
PACKAGE=

OK Cancel Font... Add Delete Browse...
New Find... Plot... Syntax... IBIS... Help...

Enabled: TRUE Columns: 3

☒ Help Bar [File Link](#)

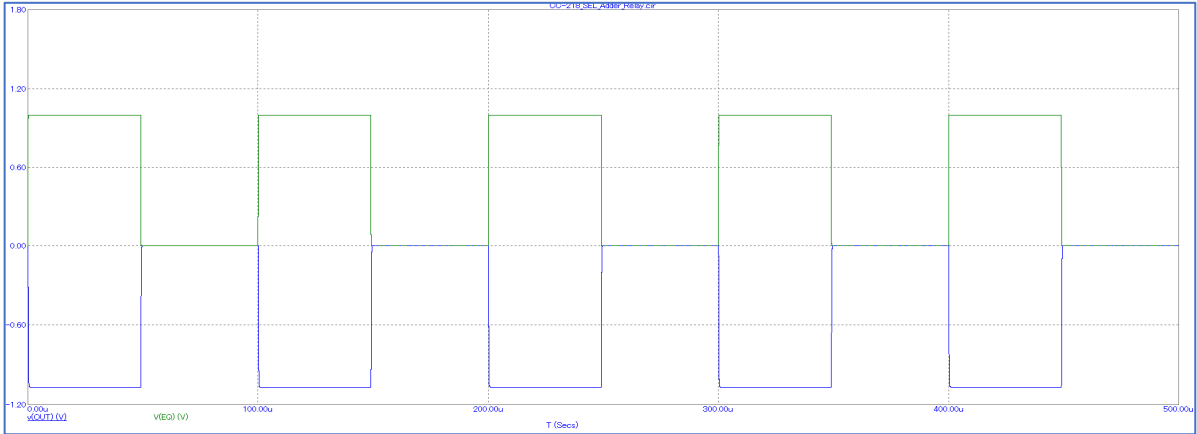
☐ Show Data on Exit

Source: Local page 'Models'

P1: 0 P2: 0.1u P3: 49u
P4: 49.1u P5: 100u VONE: 1
VZERO: 0

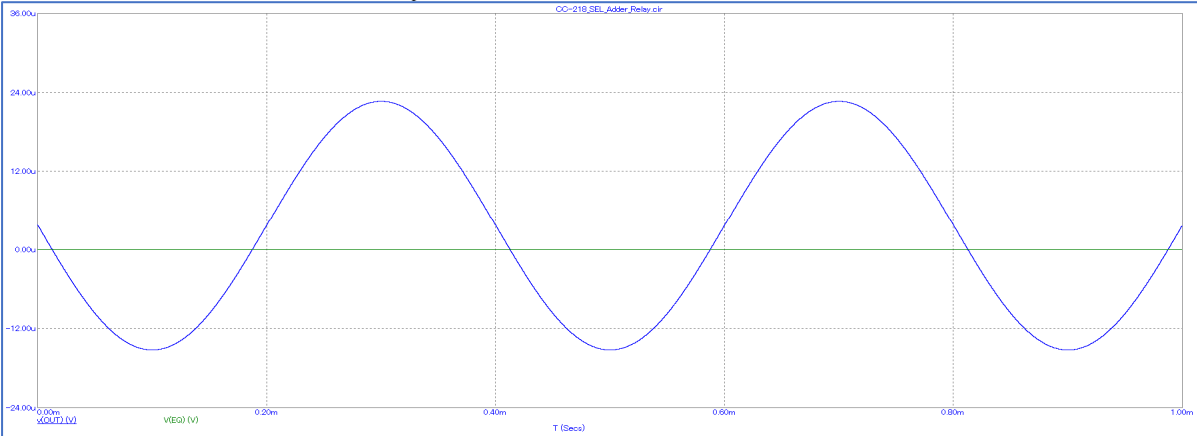
10kHz square wave

Result



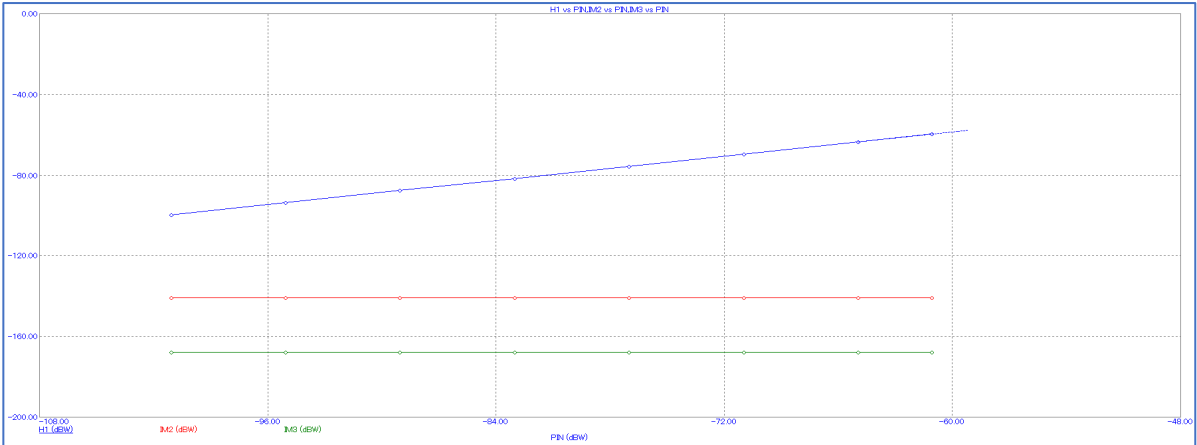
Crosstalk

EQ selected, EQ=0V, DAC=1V_{peak}, AUX=0V



Crosstalk from DAC: 19uV_{peak}... -94.4dB

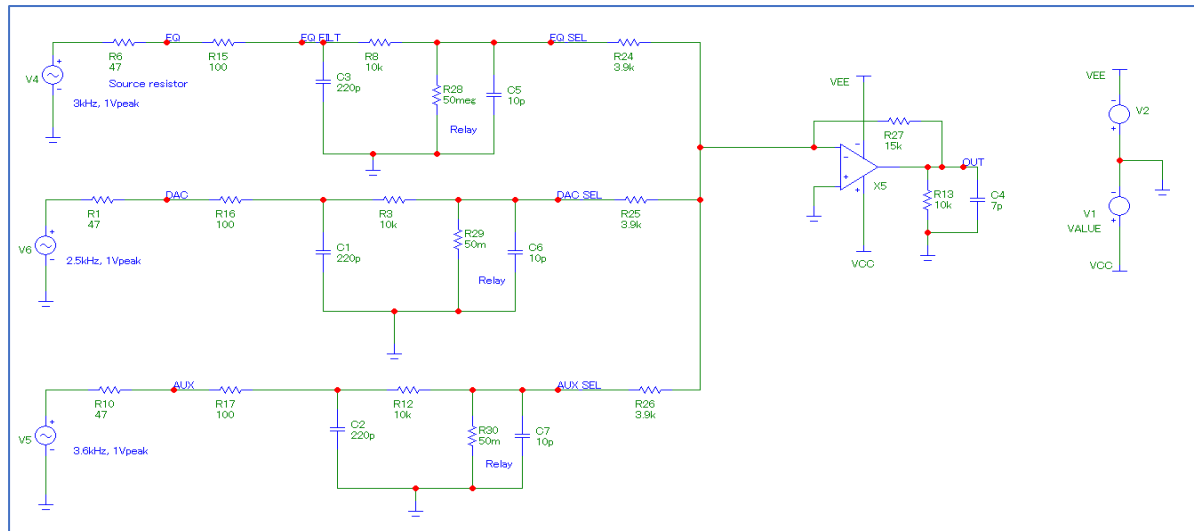
IMD



* Conclusion

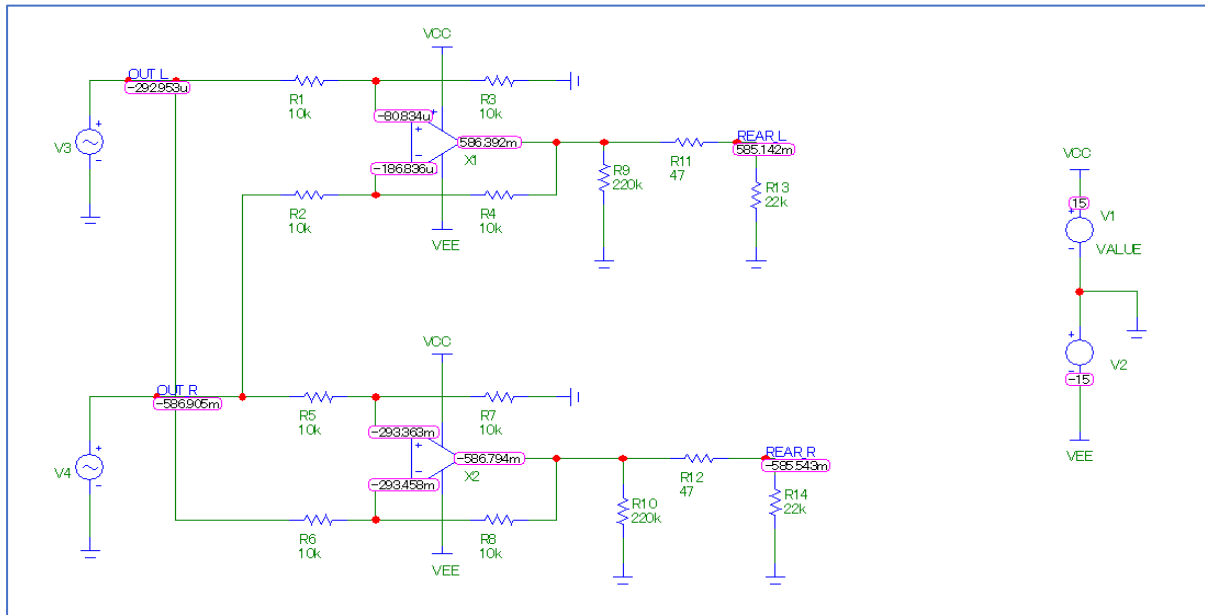
Relay + Adder is the best solution!

Final circuit



Simulation of Matrix

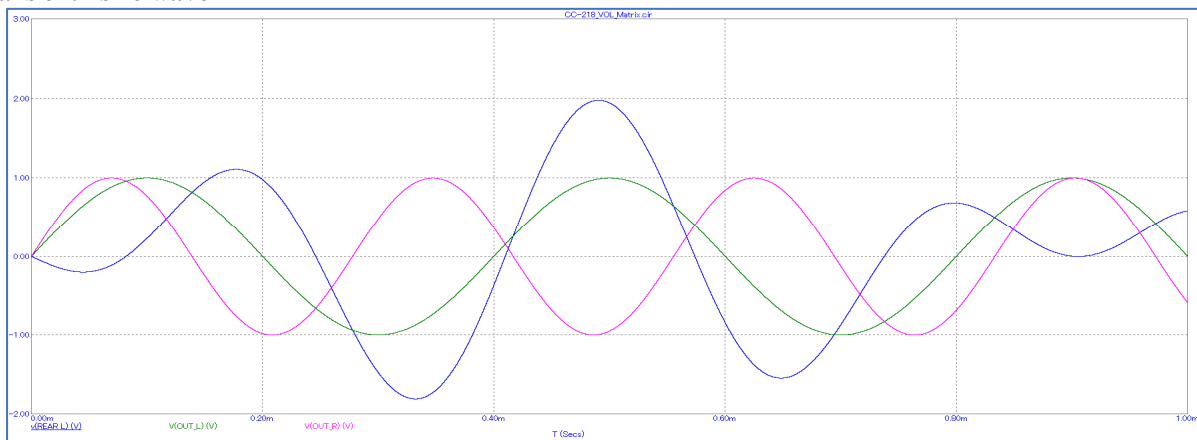
* Schematics for simulation



Op amp: LME49860 (similar to LME49720)

Original schem is wrong: R3 and R7 are connected to the output!

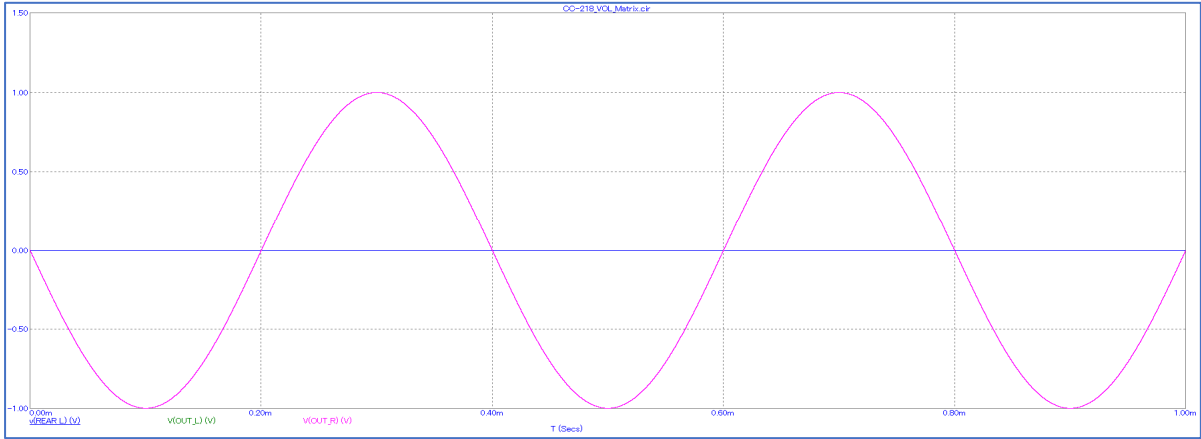
* Transient - sine wave



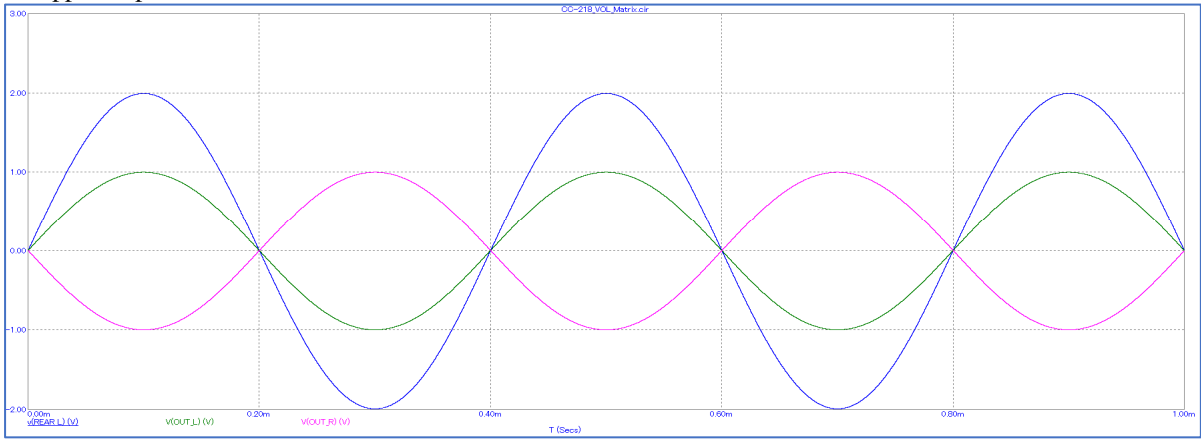
V3 (OUT_L): 2.5kHz, 1V_{peak}

V4 (OUT_R): 3.6kHz, 1V_{peak}

In phase

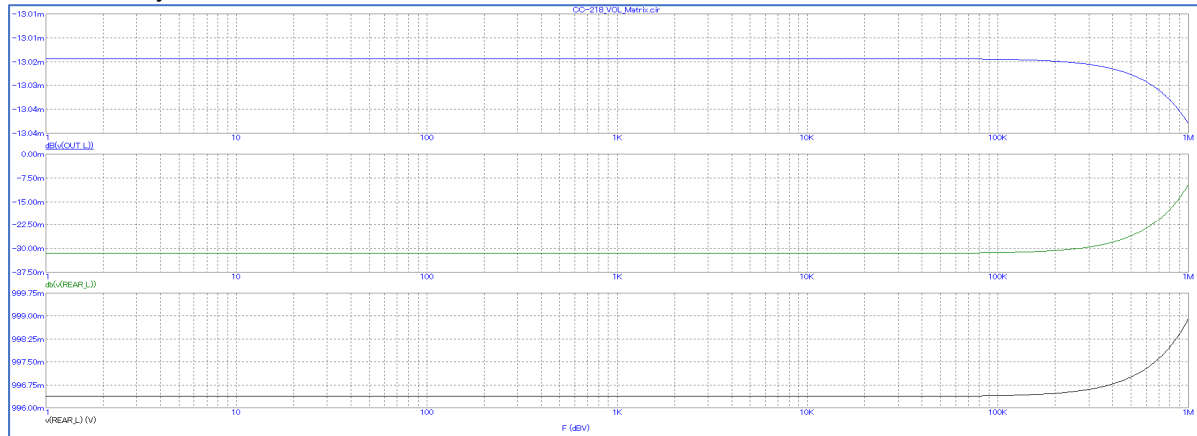


In opposite phase



*** Freq resp**

REAR_L only



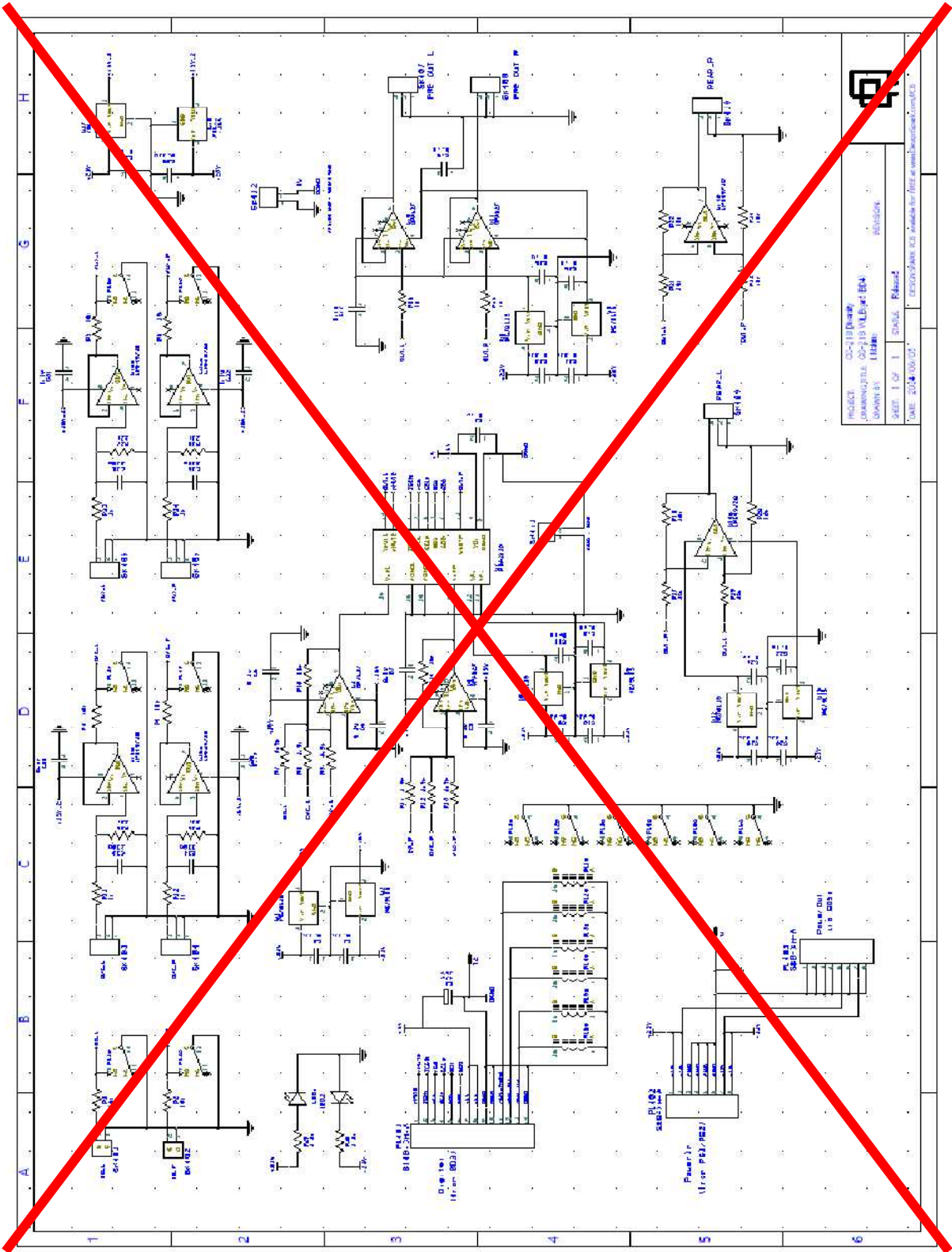
I quit simulation of Matrix here, because its SQ is not important.

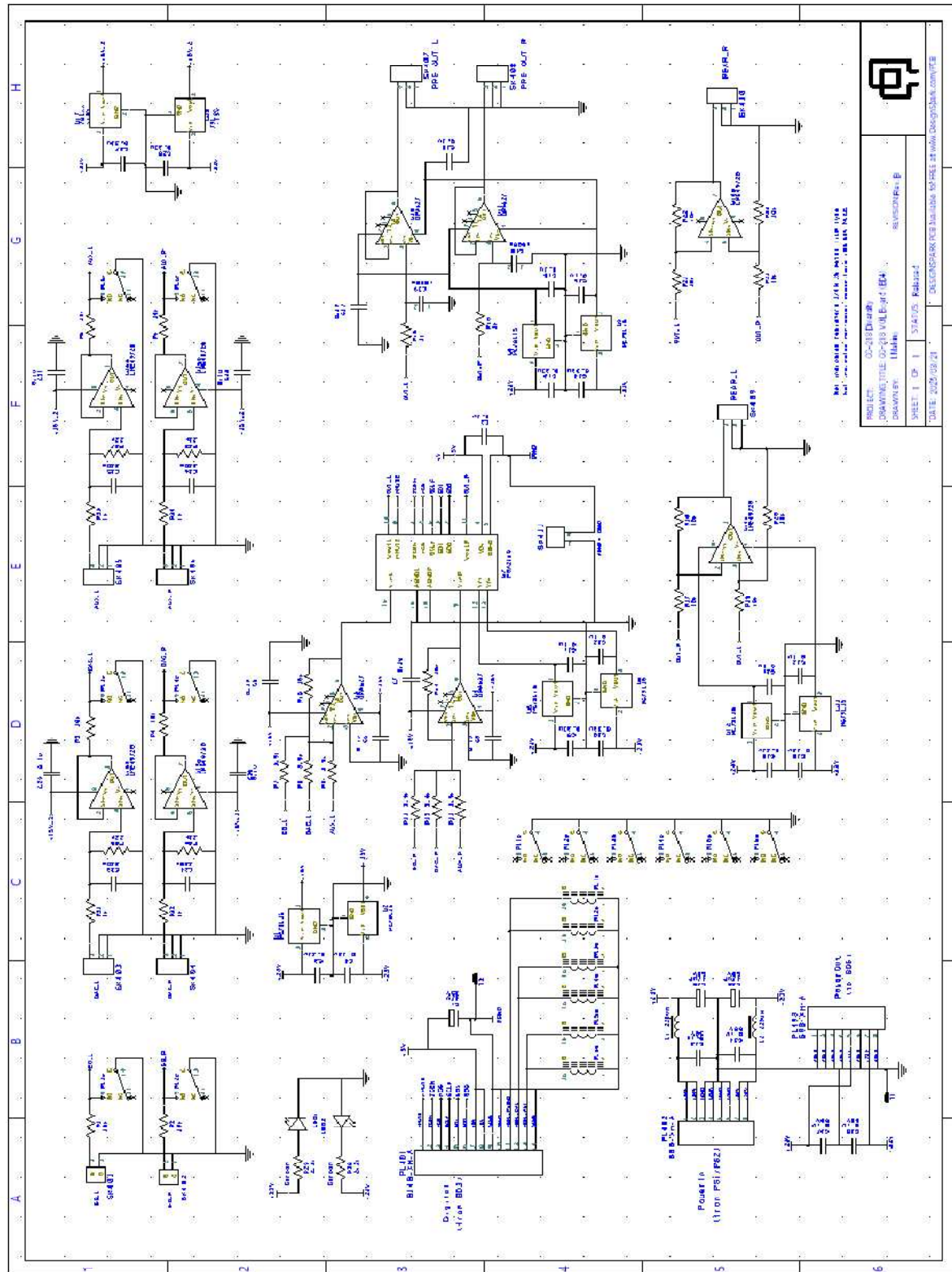
Schematic

For the latest schematic, see [CC-218_VOL - Schematic.pdf](#)

[CC-218_VOL_B - Schematic.pdf](#)

2025/03/21





Power Dissipation

2024/12/20

* Current dissipation estimate

Device	Qty	Current dissipation		Total current dissipation	
		V+	V-	+23V	-23V
LME49720	3	12. 0mA	12. 0mA	36. 0mA	36. 0mA
OPA627	4	7. 0mA	7. 0mA	28. 0mA	28. 0mA
PGA2310	1	10. 0mA	10. 0mA	10. 0mA	10. 0mA
LED	1	10. 5mA	10. 5mA	10. 5mA	10. 5mA
Total				84. 5mA	84. 5mA

[END OF DOCUMENT]