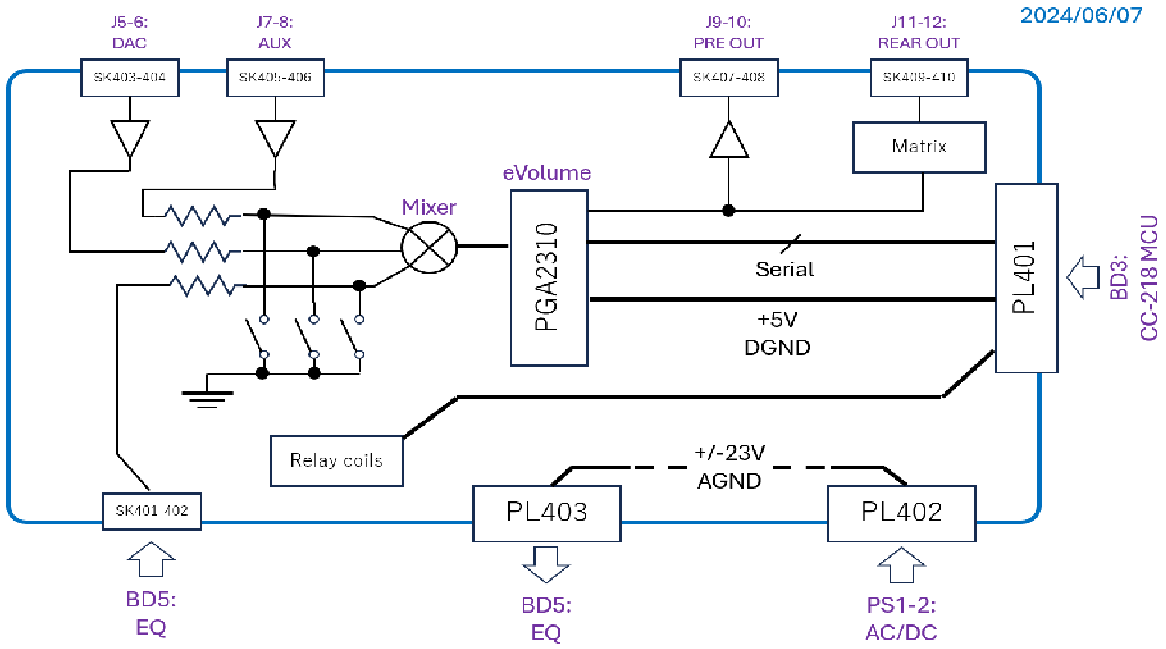
CC-218 VOL BOARD Design

2023/08/20
2025/06/08

Circuit Design

Block Diagram

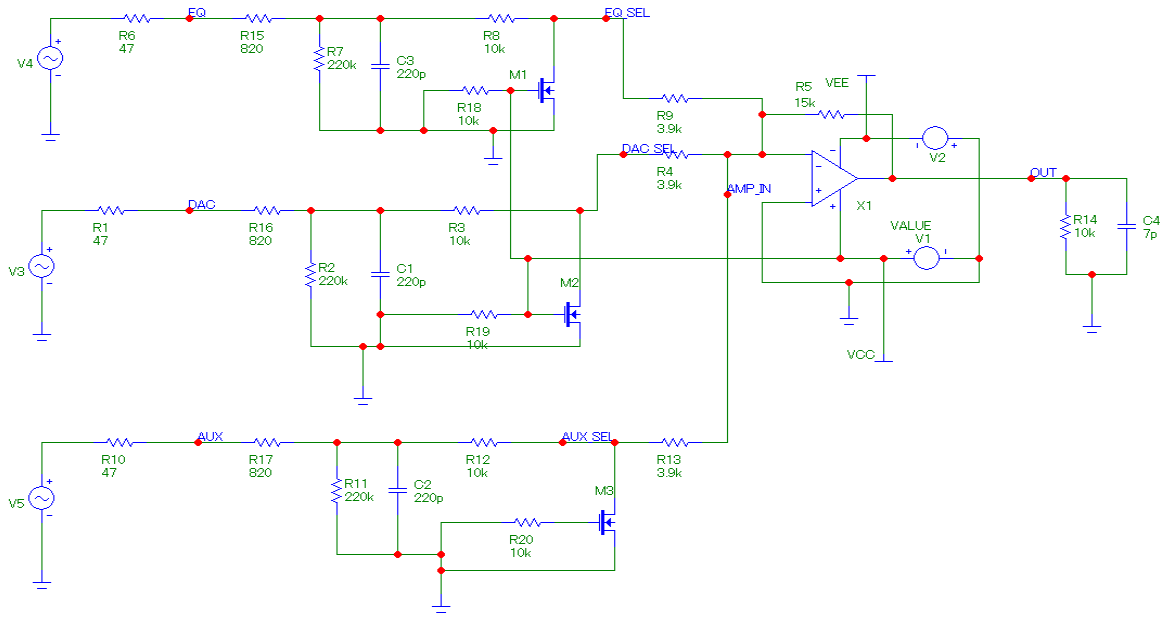


Block Diagram: CC-218 VOL (BD4)

Contents:

Simulation of Selector

*** Schematics for simulation**

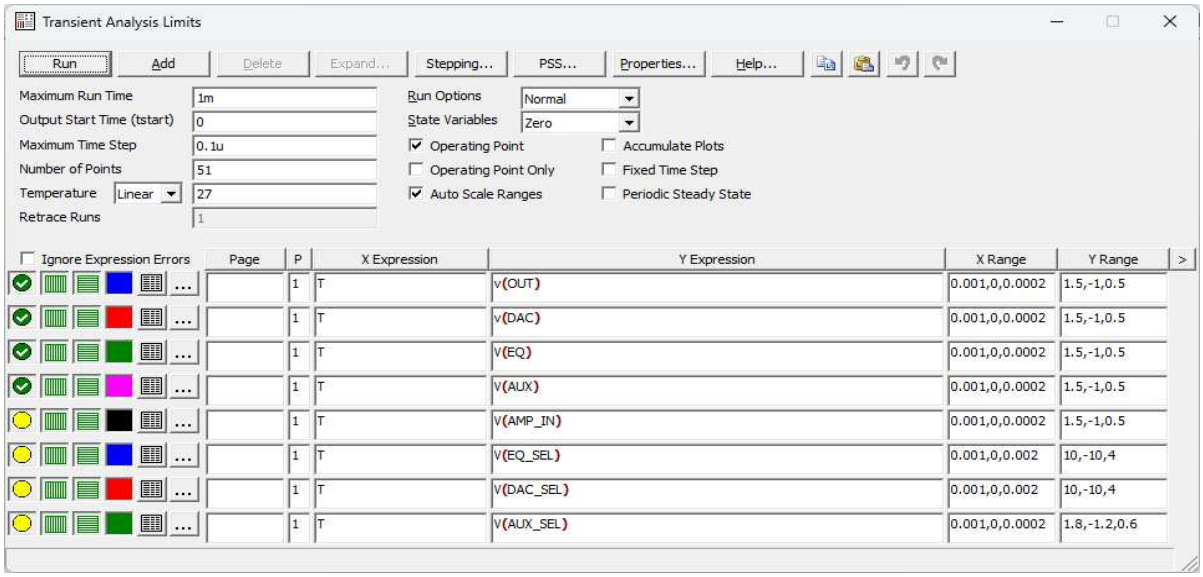


Op amp: OPA627

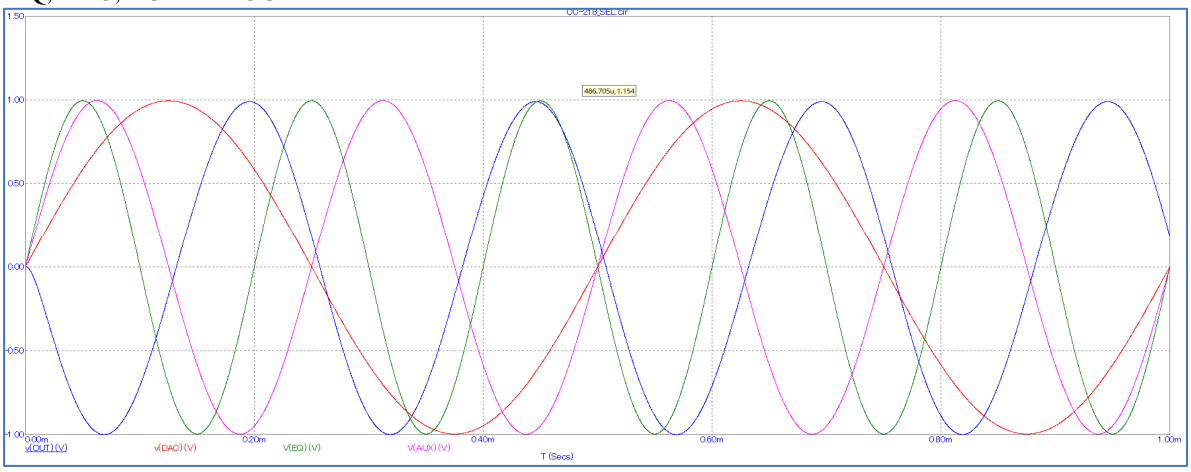
N-MOSFET: IRFP460

*** Transient analysis**

Settings

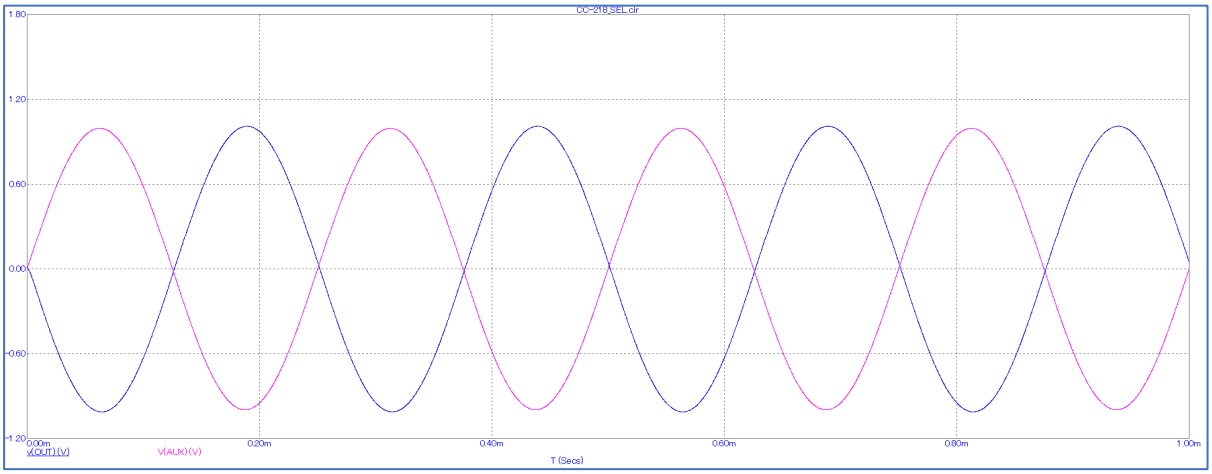


EQ, DAC, AUX ==> OUT



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

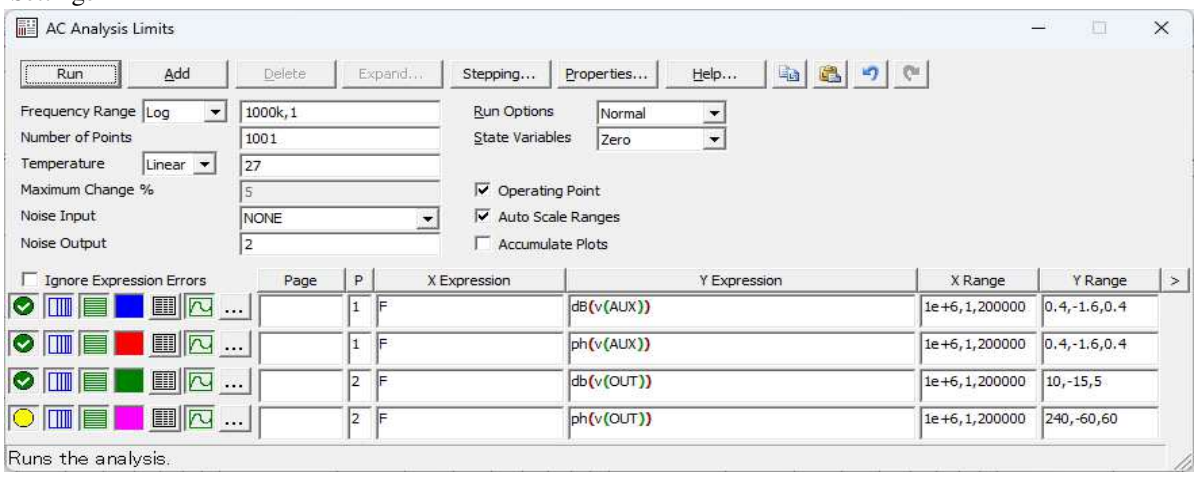
AUX ==> OUT



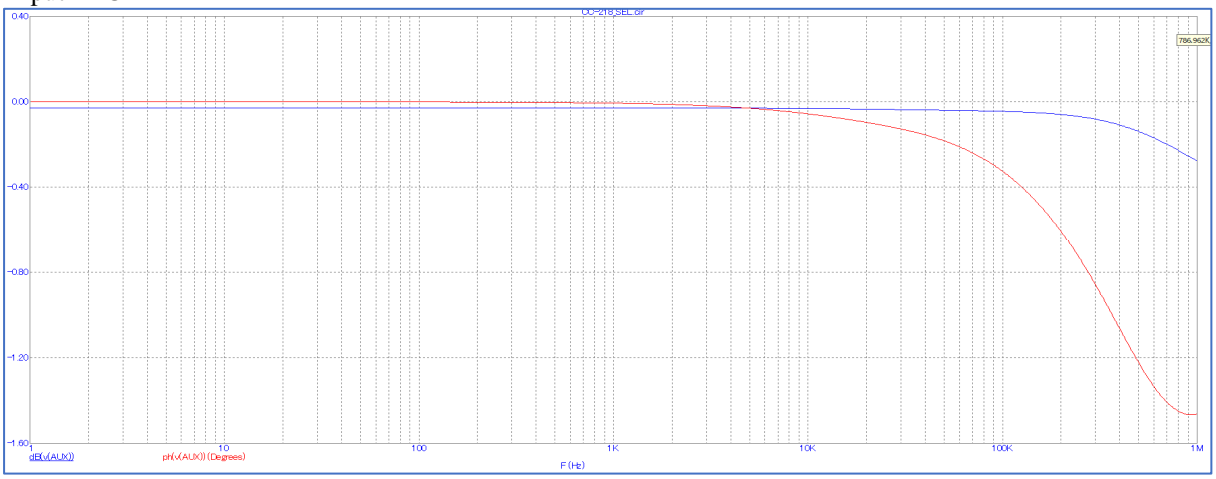
The waveform seems right.

*** AC analysis**

Settings

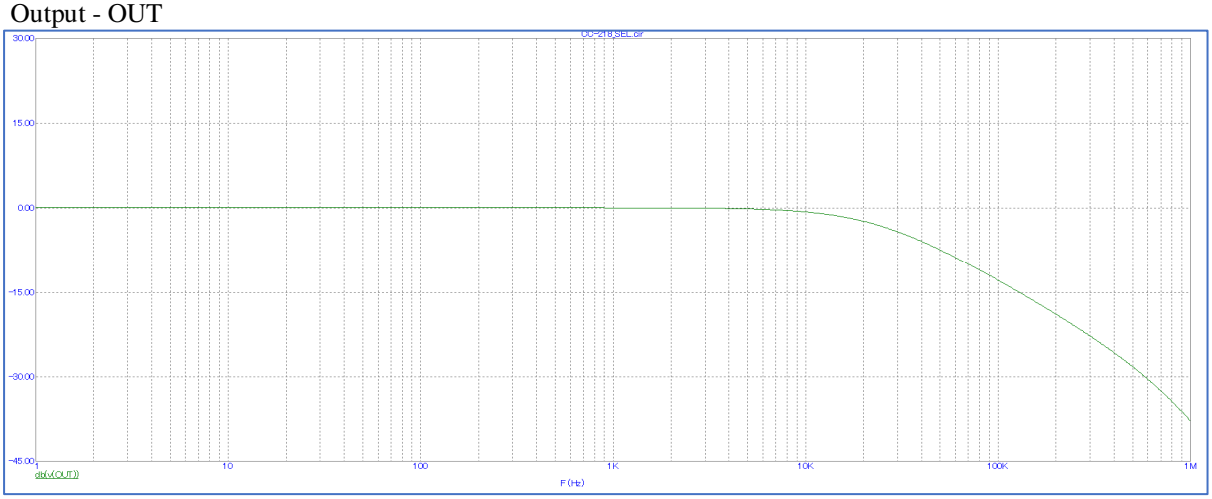


Input - AUX



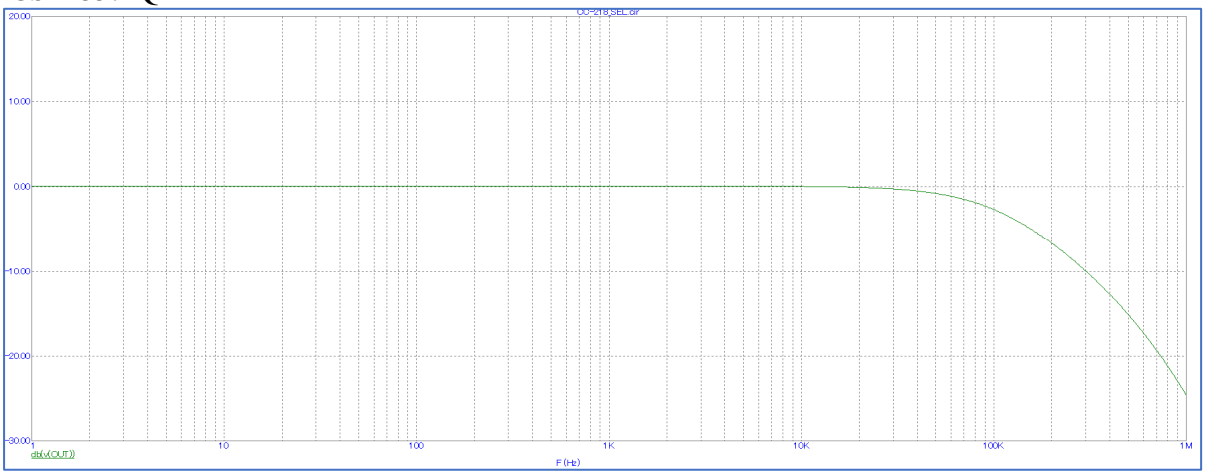
Freq resp is flat till 100kHz.

Output - OUT



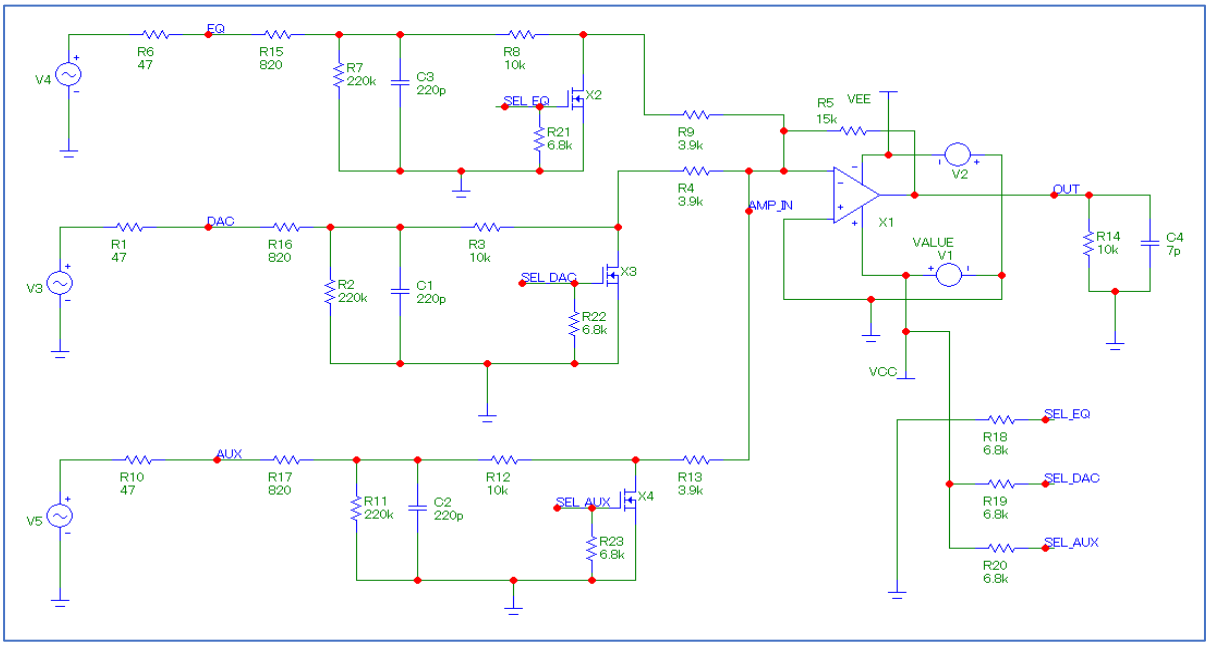
Treble rolls off!!!
It's probably due to the capacitance of IRFP460.
==> Replace IRFP460 w/ CSD15571Q2

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...

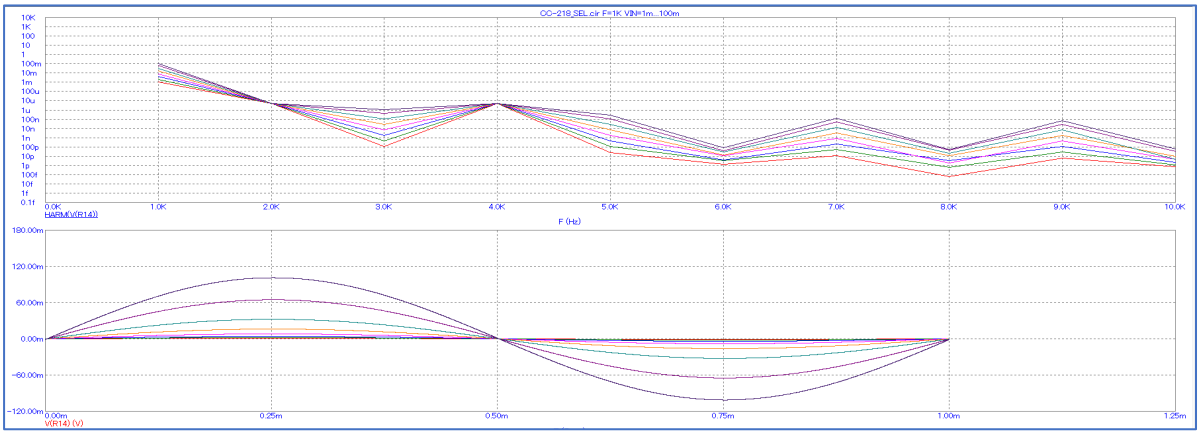
Fundamental Frequency	List	1K	
Name of Input Source		V4	
Input Source Amplitude	Log	100m,1m,2	
Name of Source Resistor		None	
Name of Load Resistor		R14	
Noise Frequency Range		100K,1	
Temperature	Linear	27	
Max Simulation Cycles		50	
Steady State Tolerance		1u	
Time Step Ratio		1m	
Highest Harmonic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

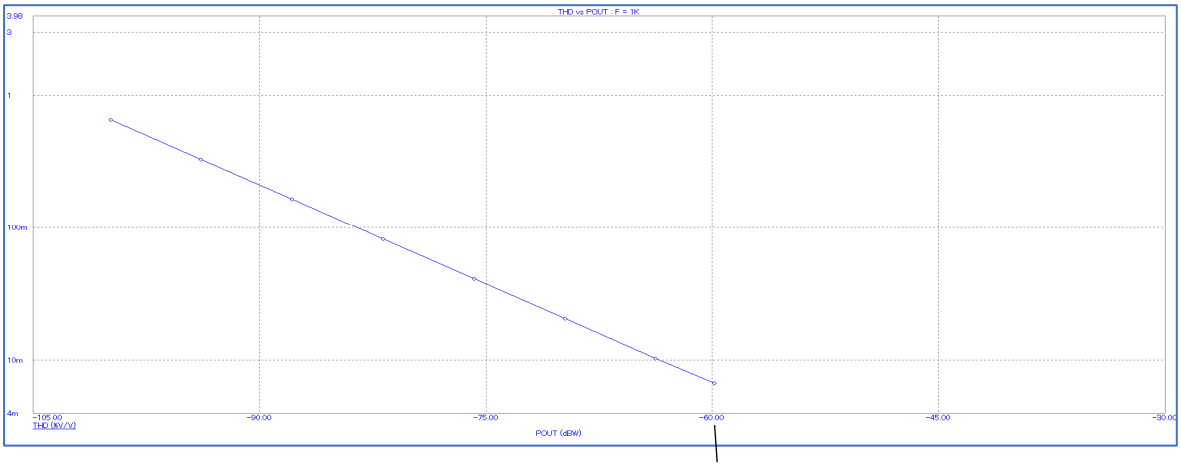
Run Options: Normal
State Variables: Zero
Operating Point
Auto Scale Ranges
Accumulate Plots
Periodic Steady State

Ignore Expression Errors

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

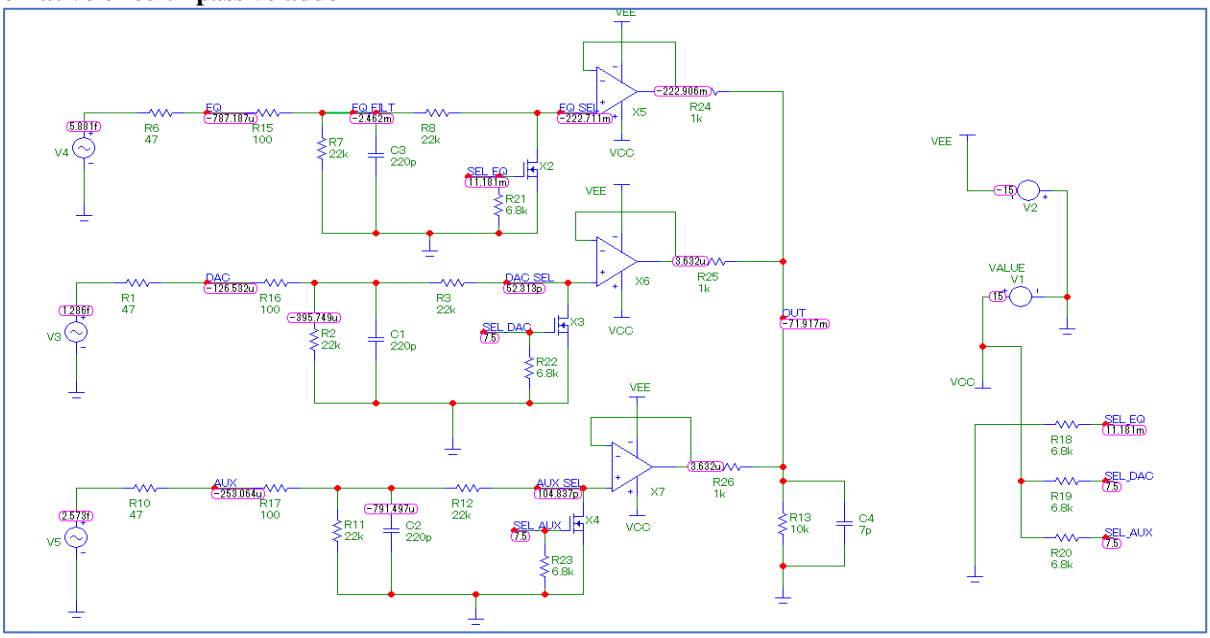




Too large harmonics!

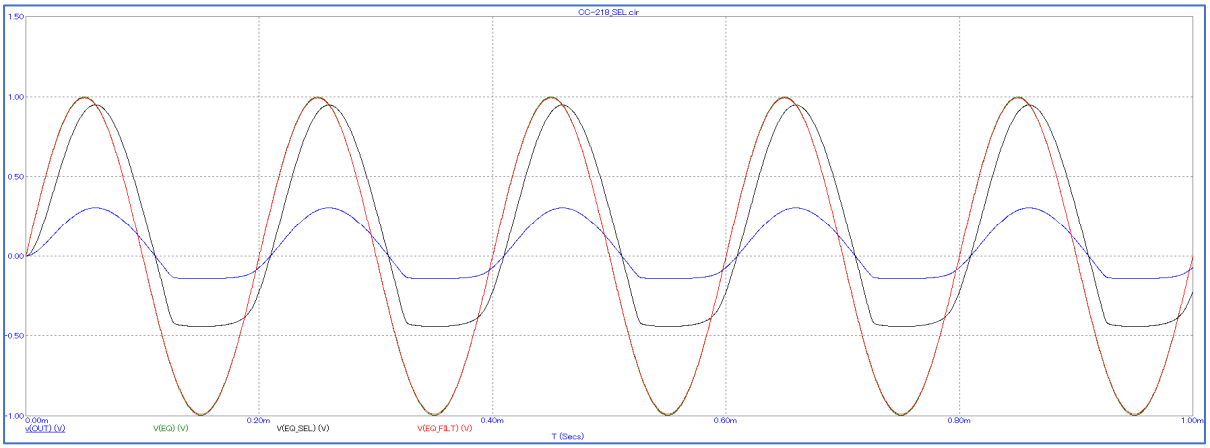
1uW (100mV into 10kohm)

*** Alternative circuit - passive adder**



Passive adder

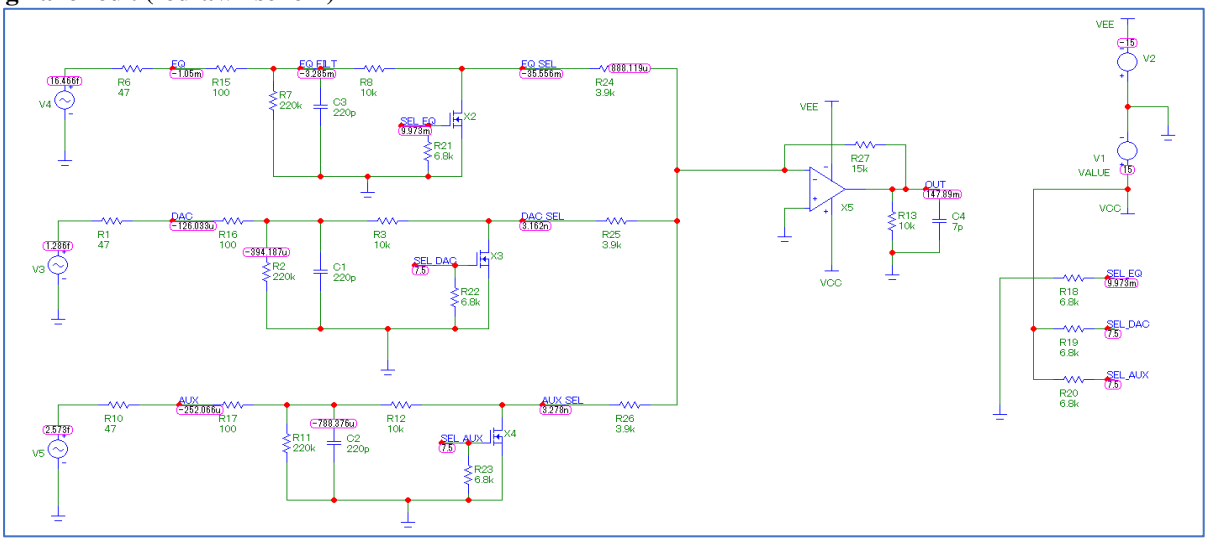
Result



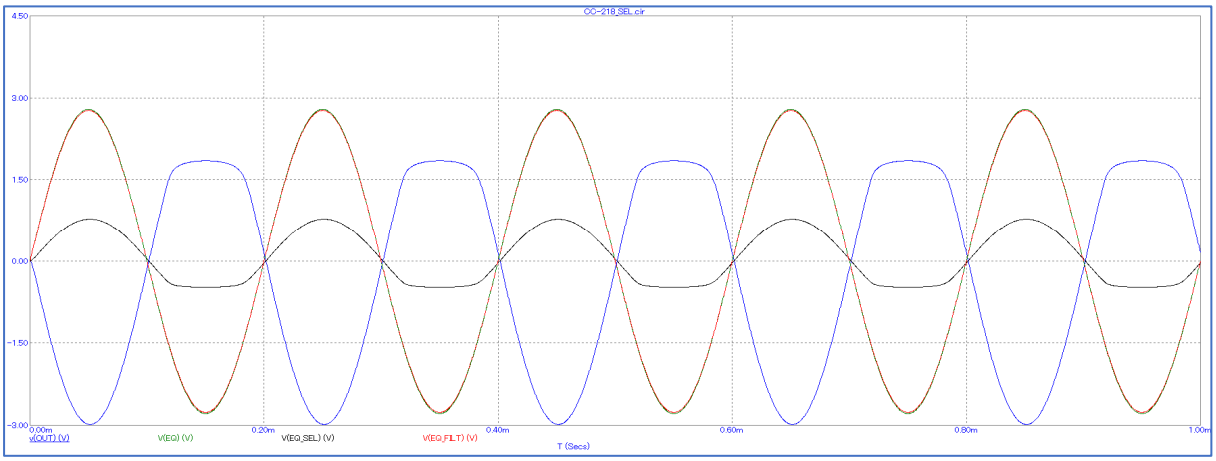
NMOS acts as diode clump!

EQ_SEL can't swing below 0.44V

*** Original circuit (redrawn schem)**



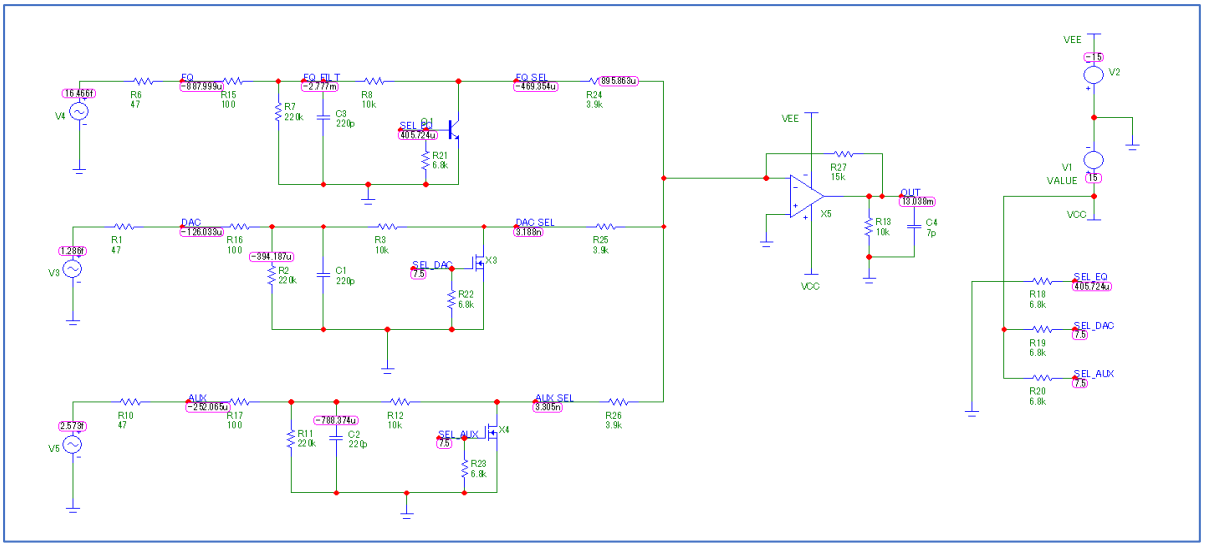
Result



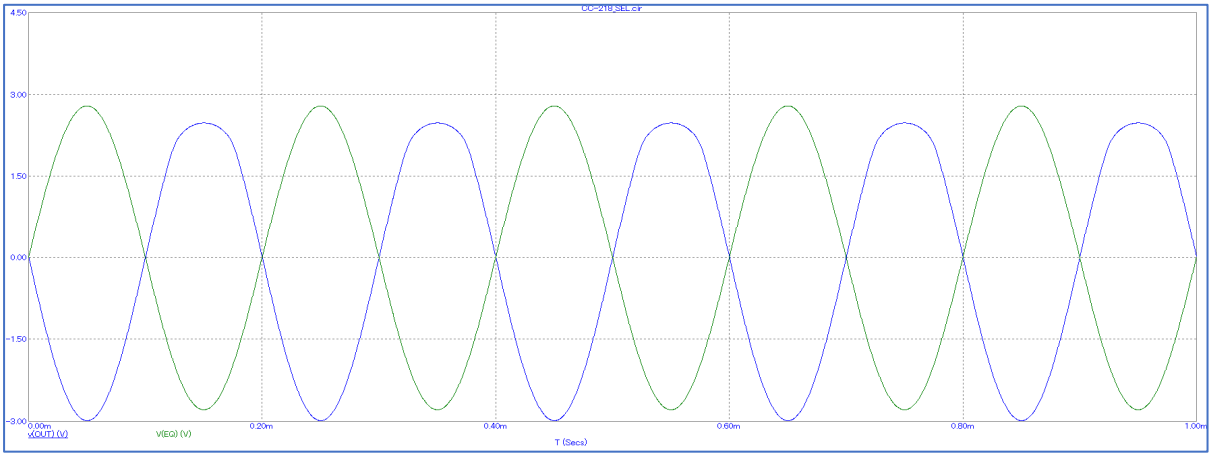
The level of EQ (V4) is increased 2.8V_{peak} (=2V_{rms})

==> EQ_SEL is clumped!

BJT is used instead of NMOS

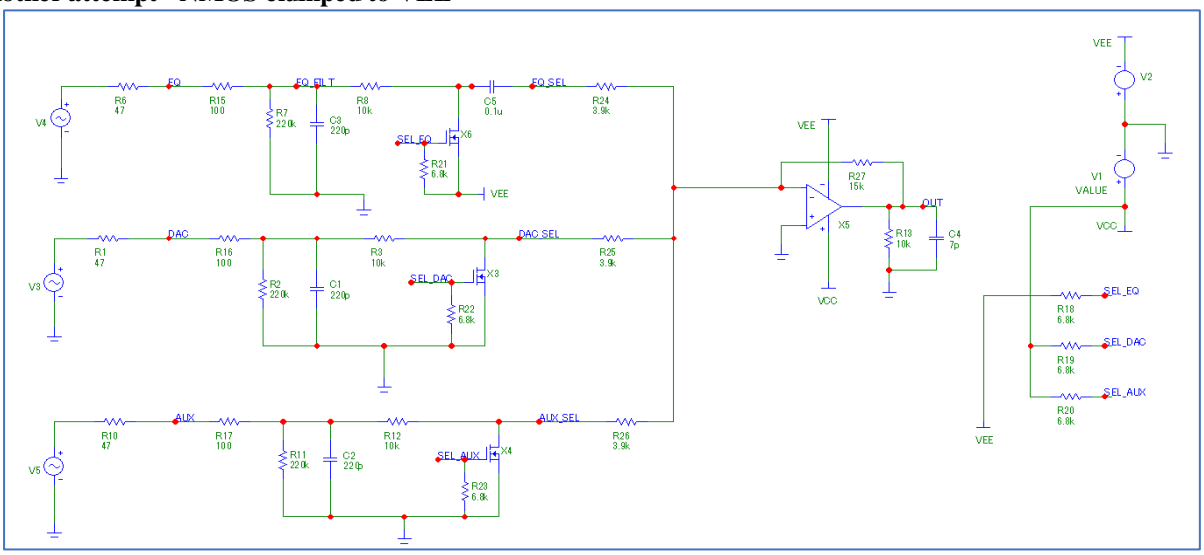


Result



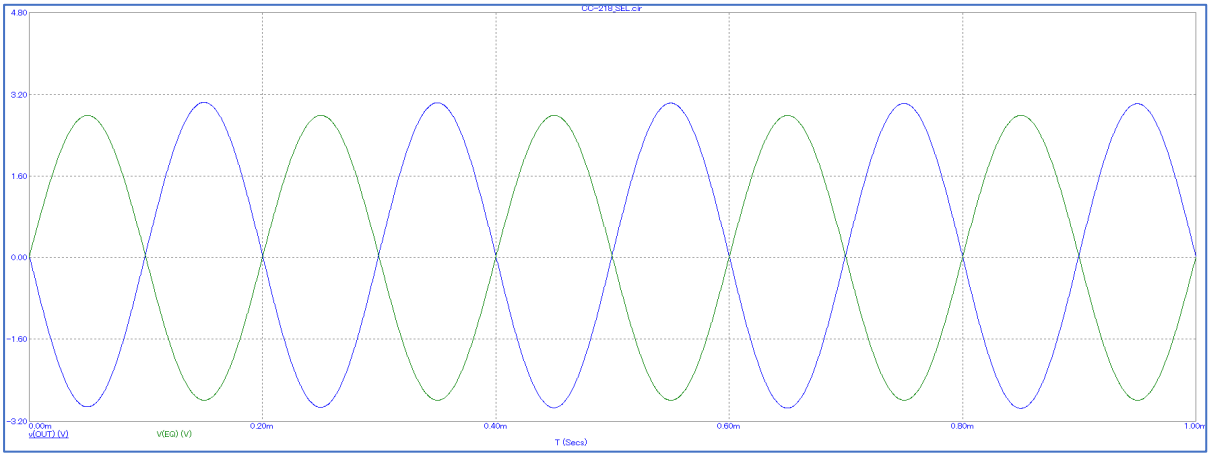
Output still distorted!

*** Another attempt - NMOS clumped to VEE**



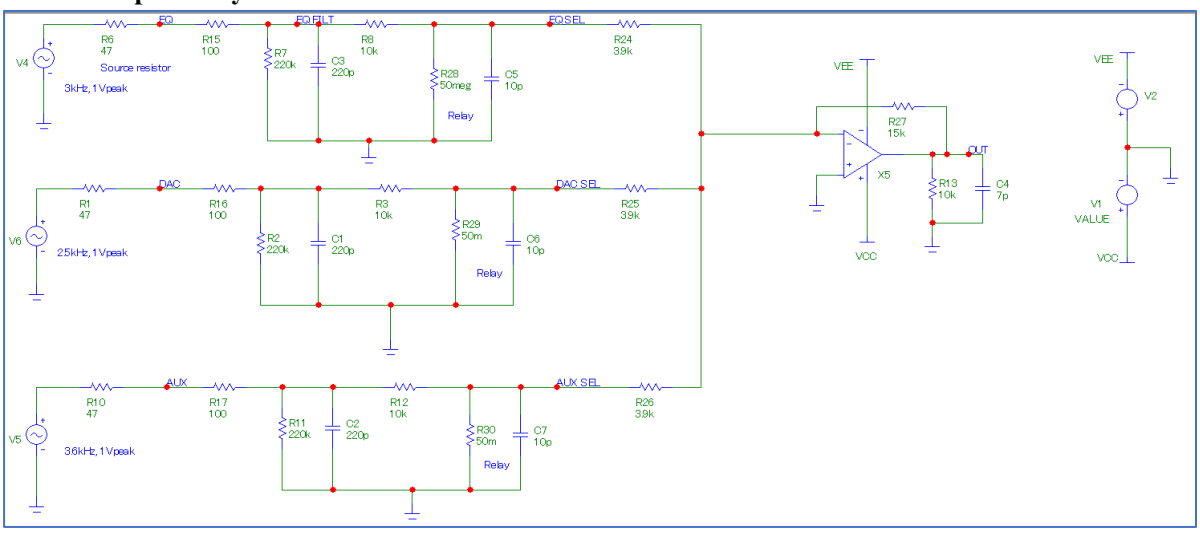
The source of NMOS connected to VEE (-15V)
AC coupling to the adder

Result

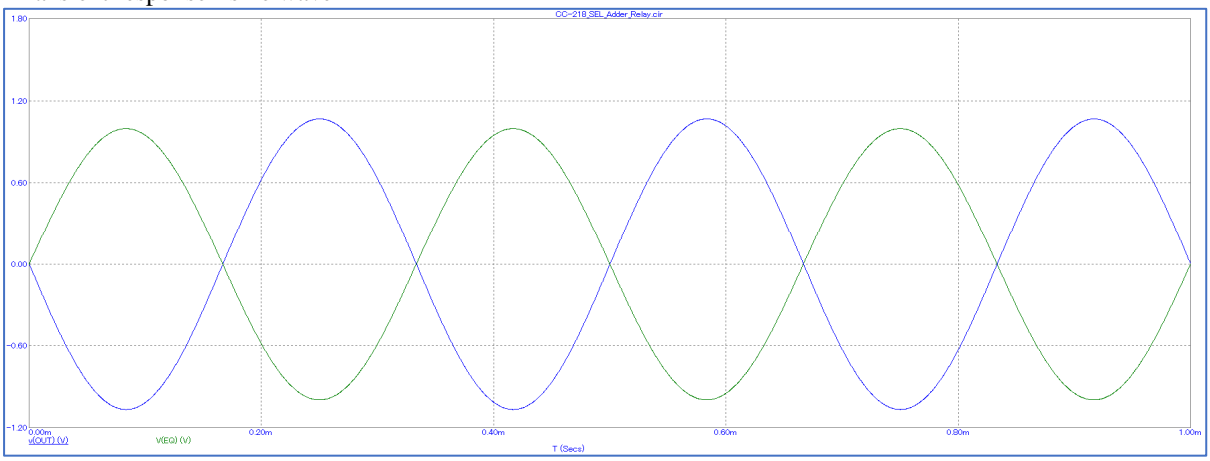


Less distortion!

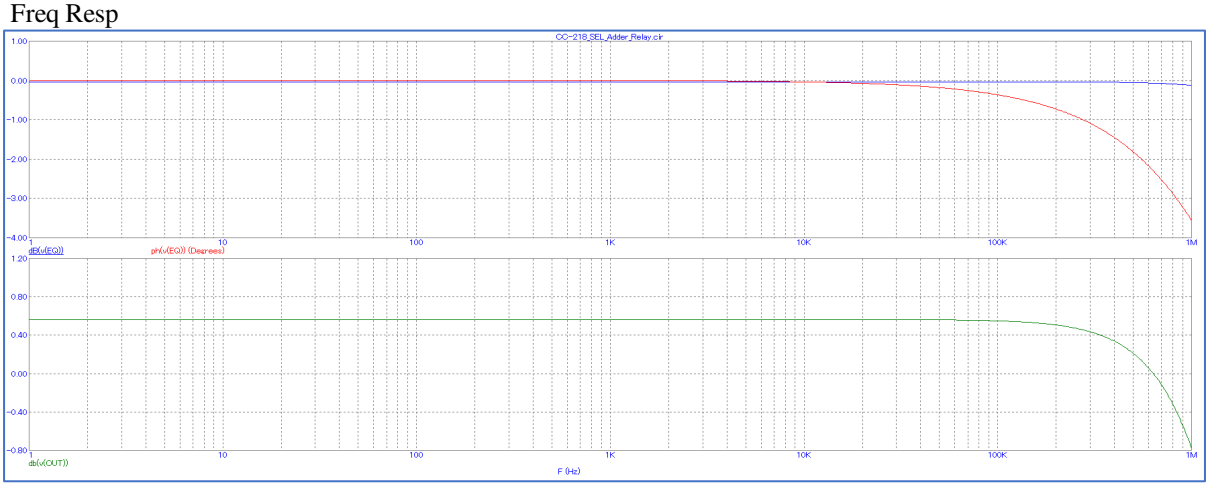
*** Another attempt - Relays used for shunt**



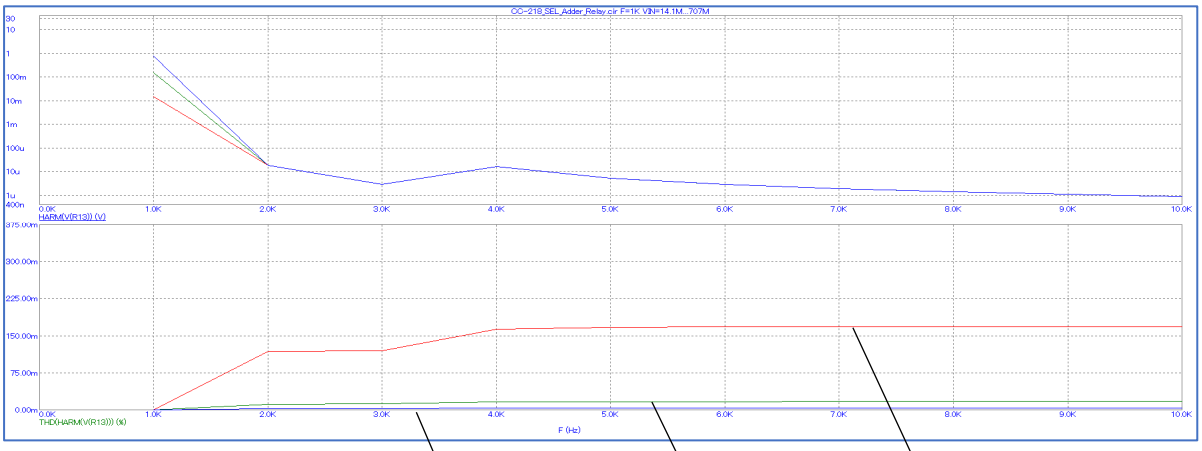
Transient response - sine wave



Freq Resp



Harmonic distortion

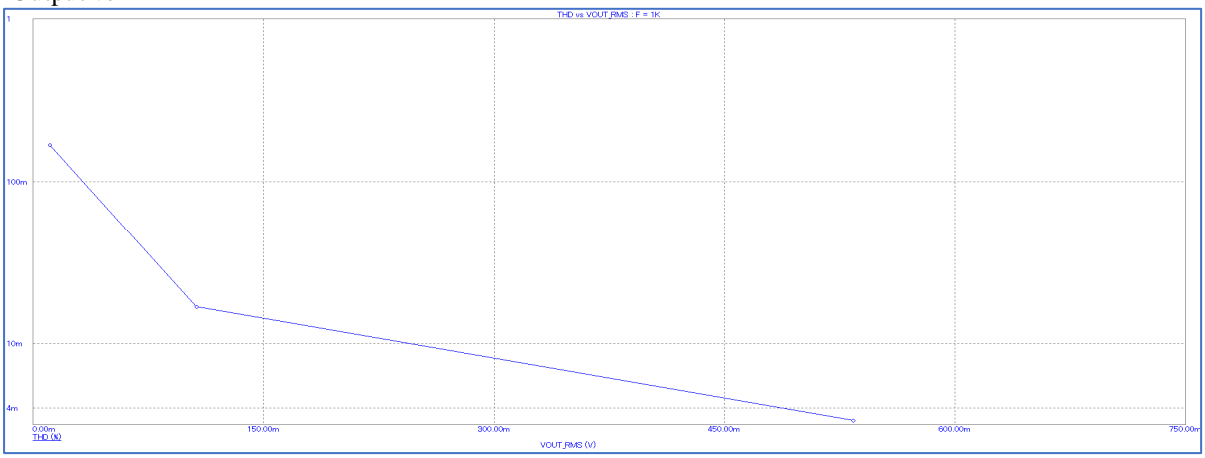


0.004% for Vin=0.5Vrms

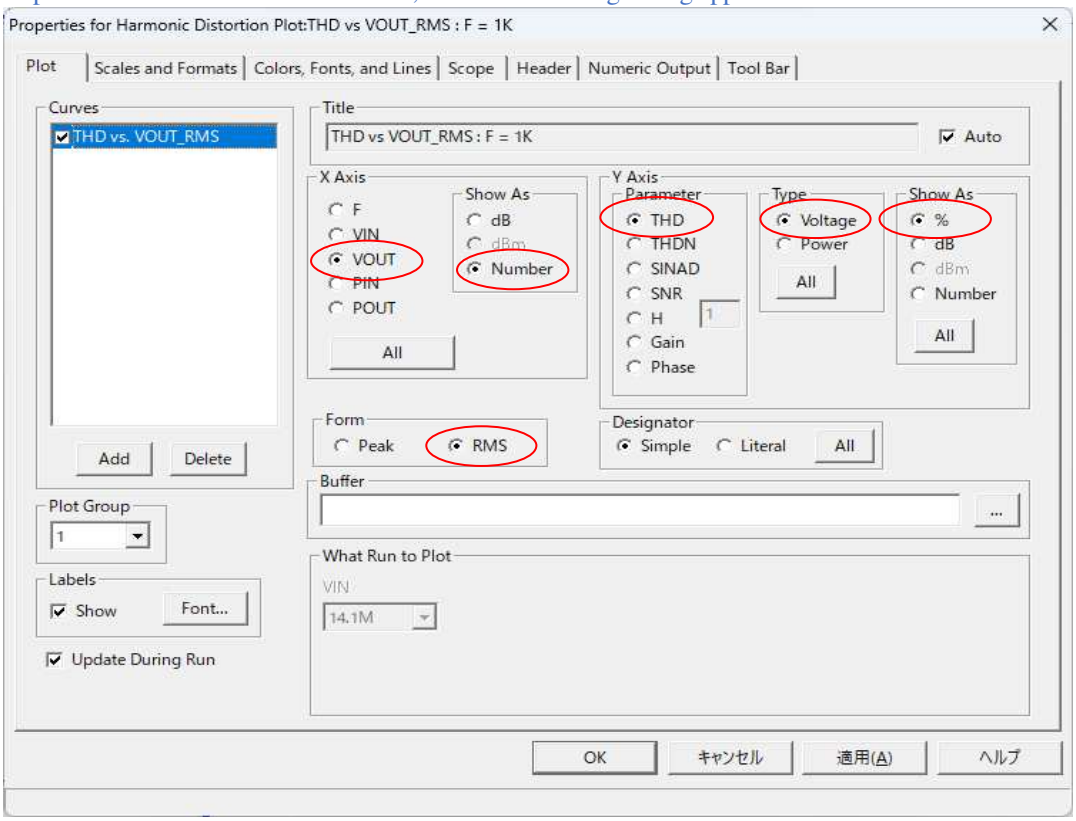
0.017% for Vin=100mVrms

0.17% for Vin=10mVrms

Output vs THD

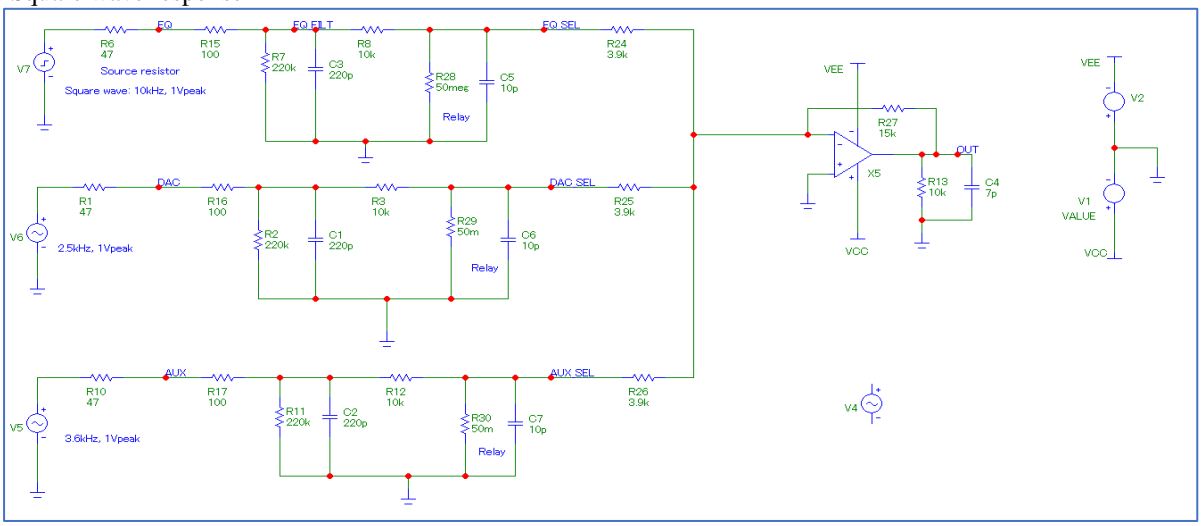


Tips on MC-12: Click the chart above, then the following dialog appears.

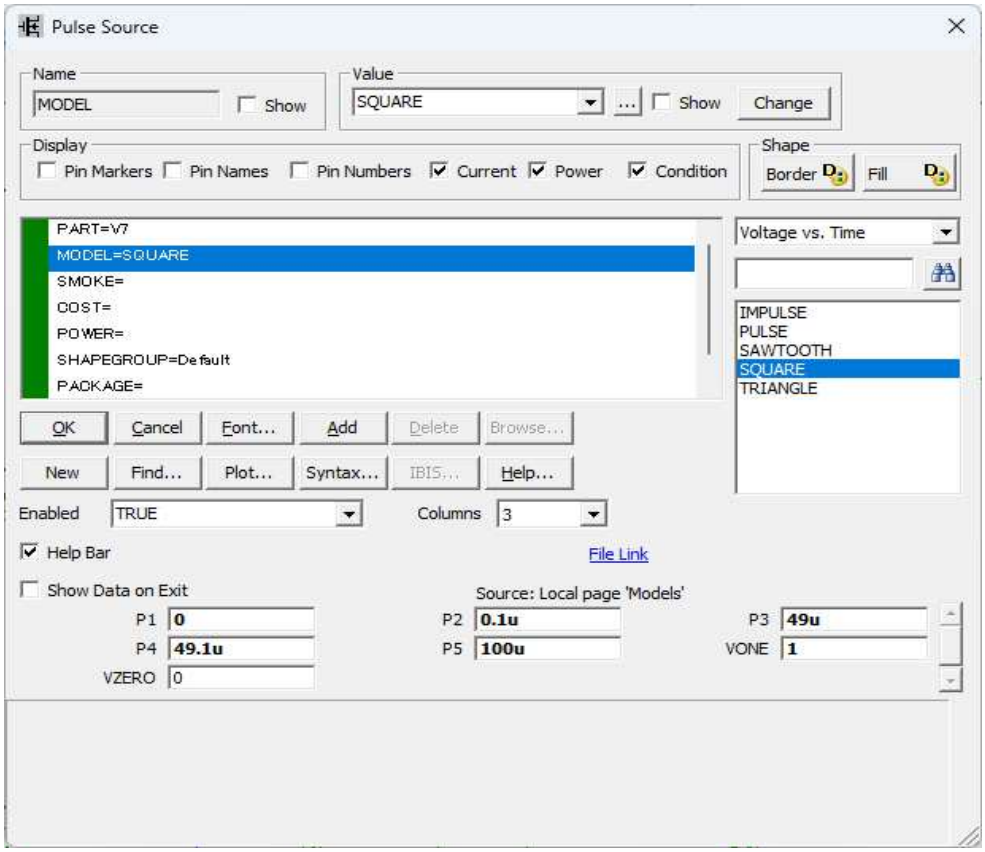


Select the options indicated by the red circles.

Square wave response

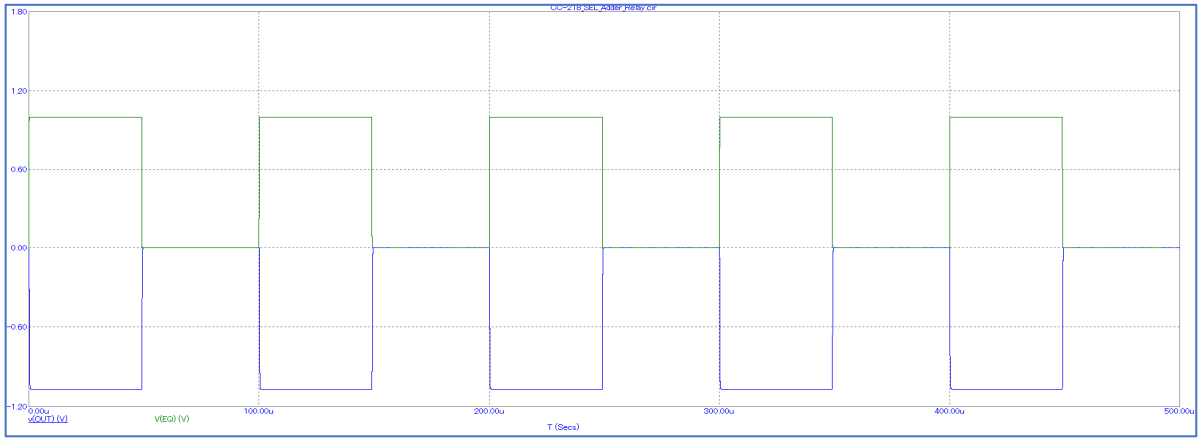


Settings of square wave source



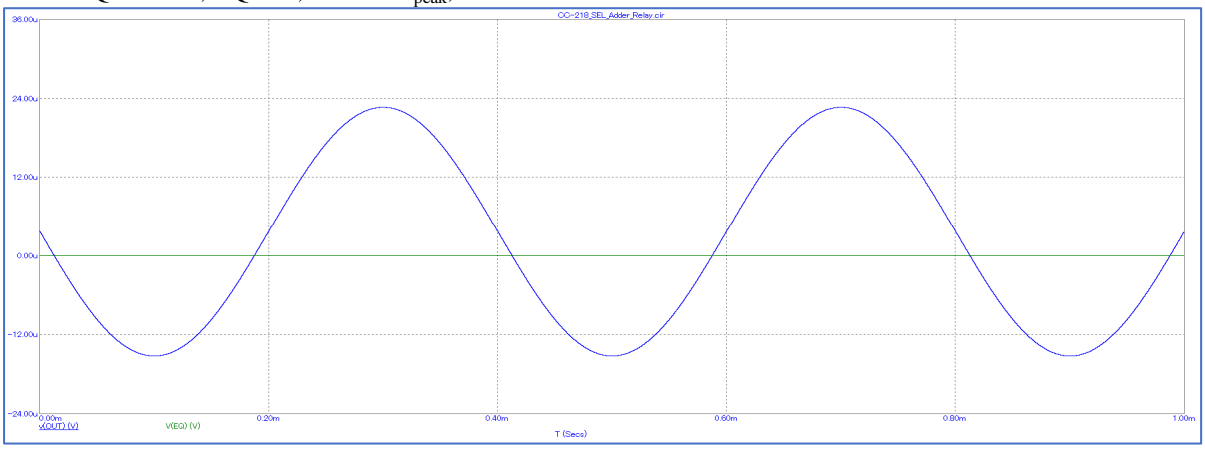
10kHz square wave

Result



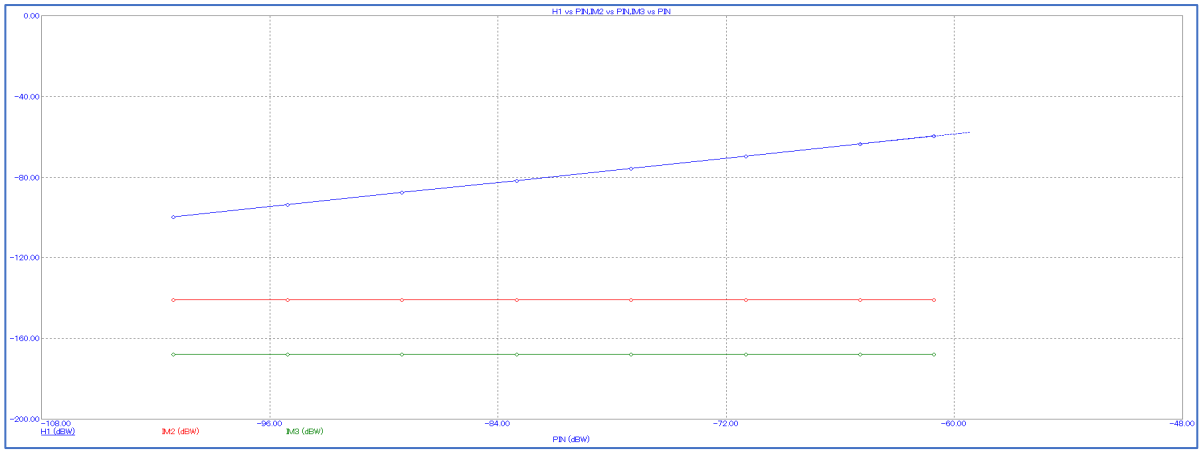
Crosstalk

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



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

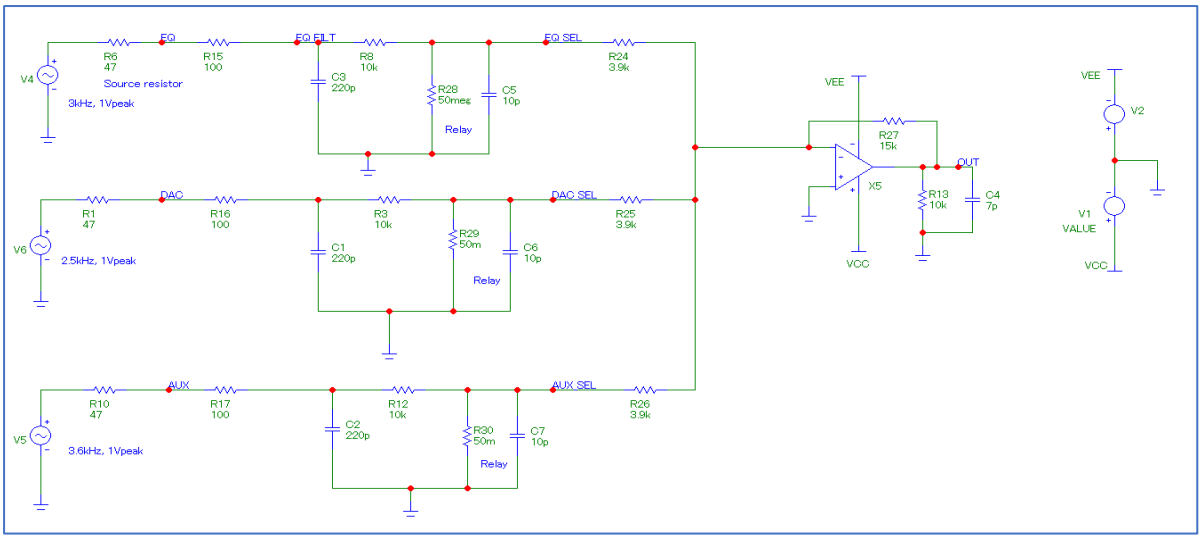
IMD



*** Conclusion**

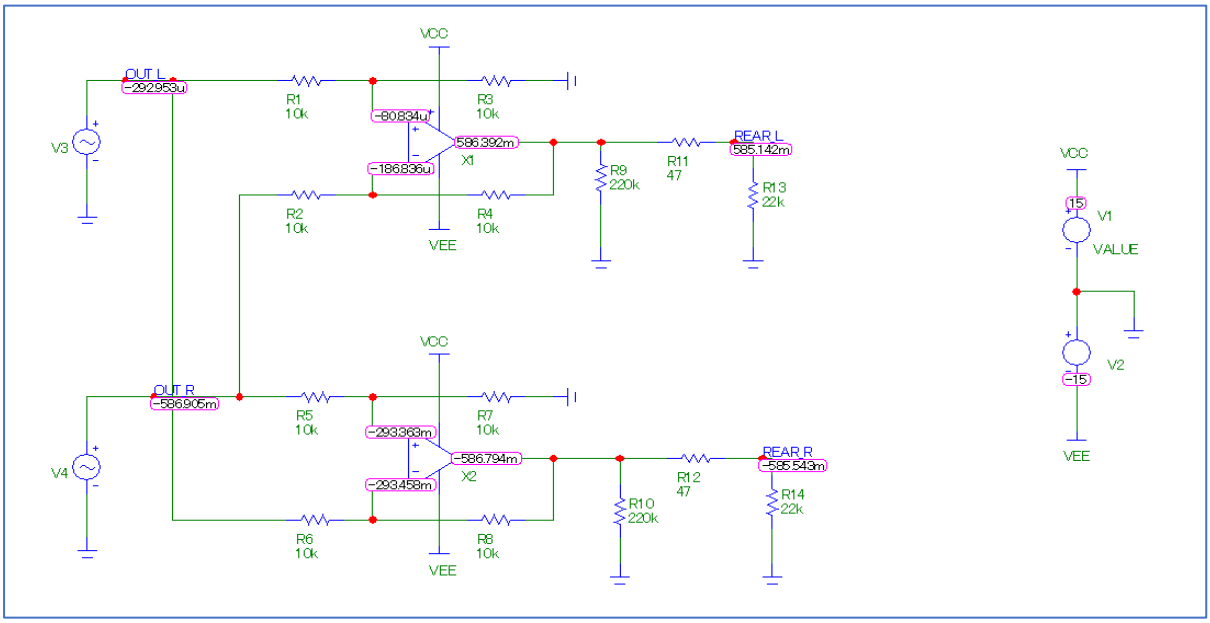
Relay + Adder is the best solution!

Final circuit



Simulation of Matrix

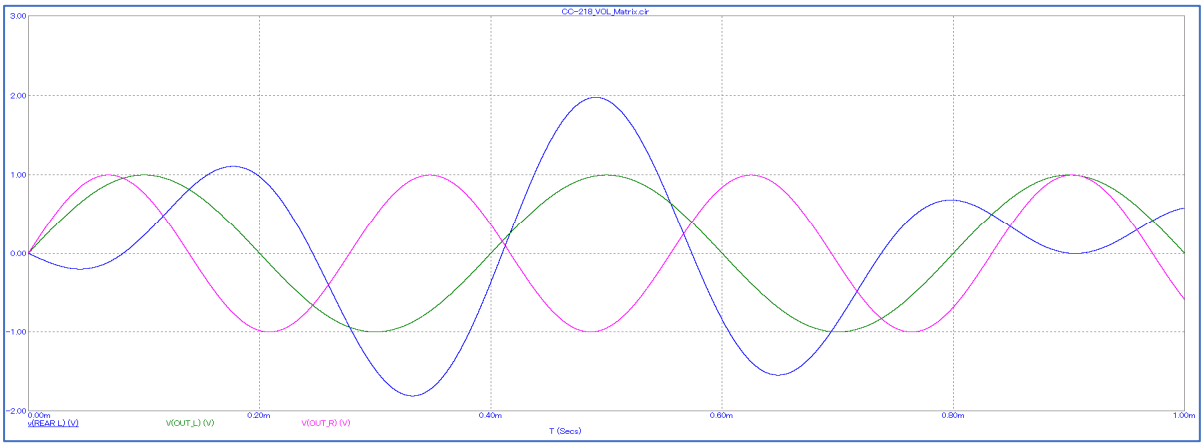
*** Schematics for simulation**



Op amp: LME49860 (similar to LME49720)

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

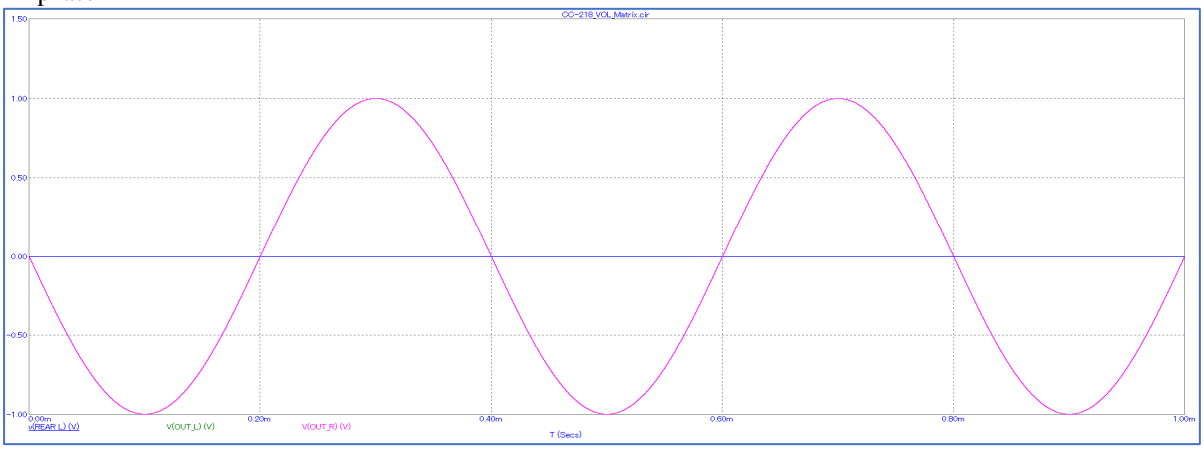
*** Transient - sine wave**



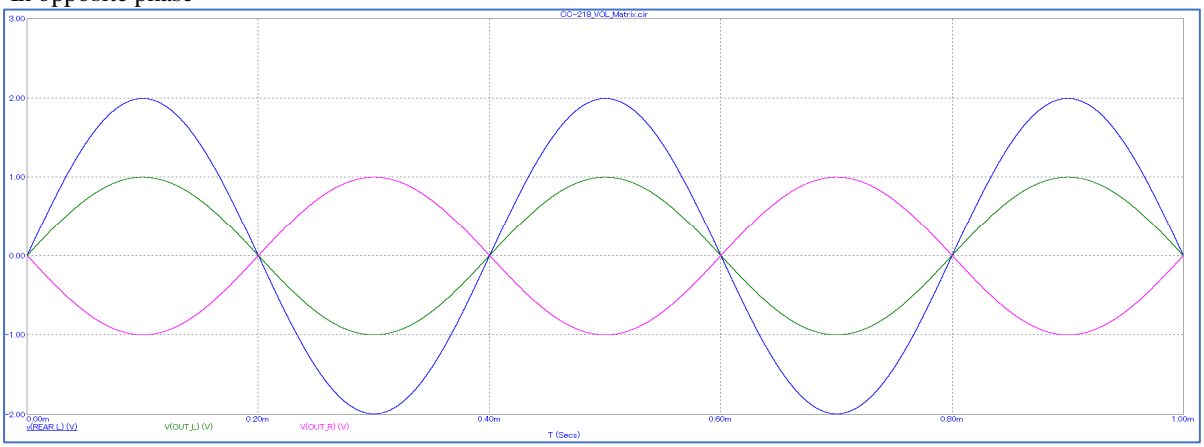
V3 (OUT_L): 2.5kHz, 1V_{peak}

V4 (OUT_R): 3.6kHz, 1Vpeak

In phase

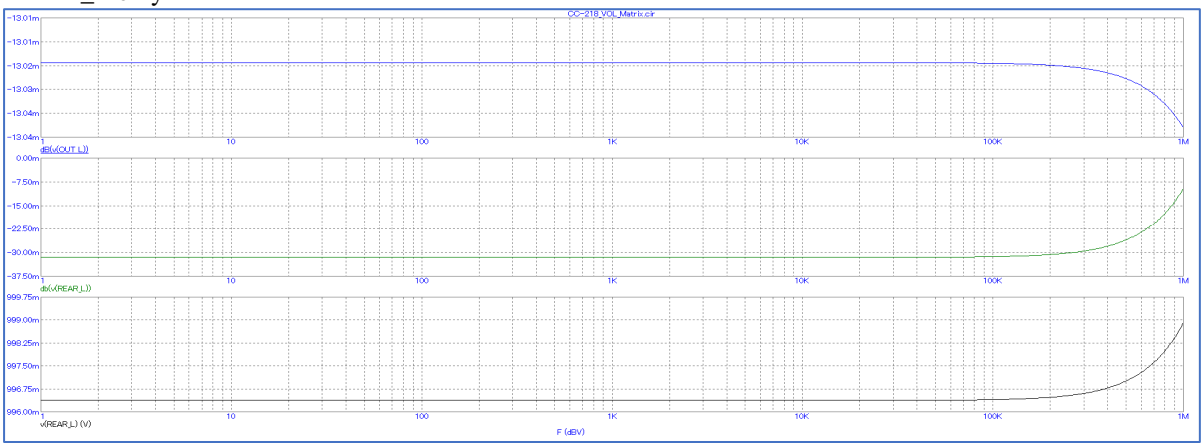


In opposite phase



*** Freq resp**

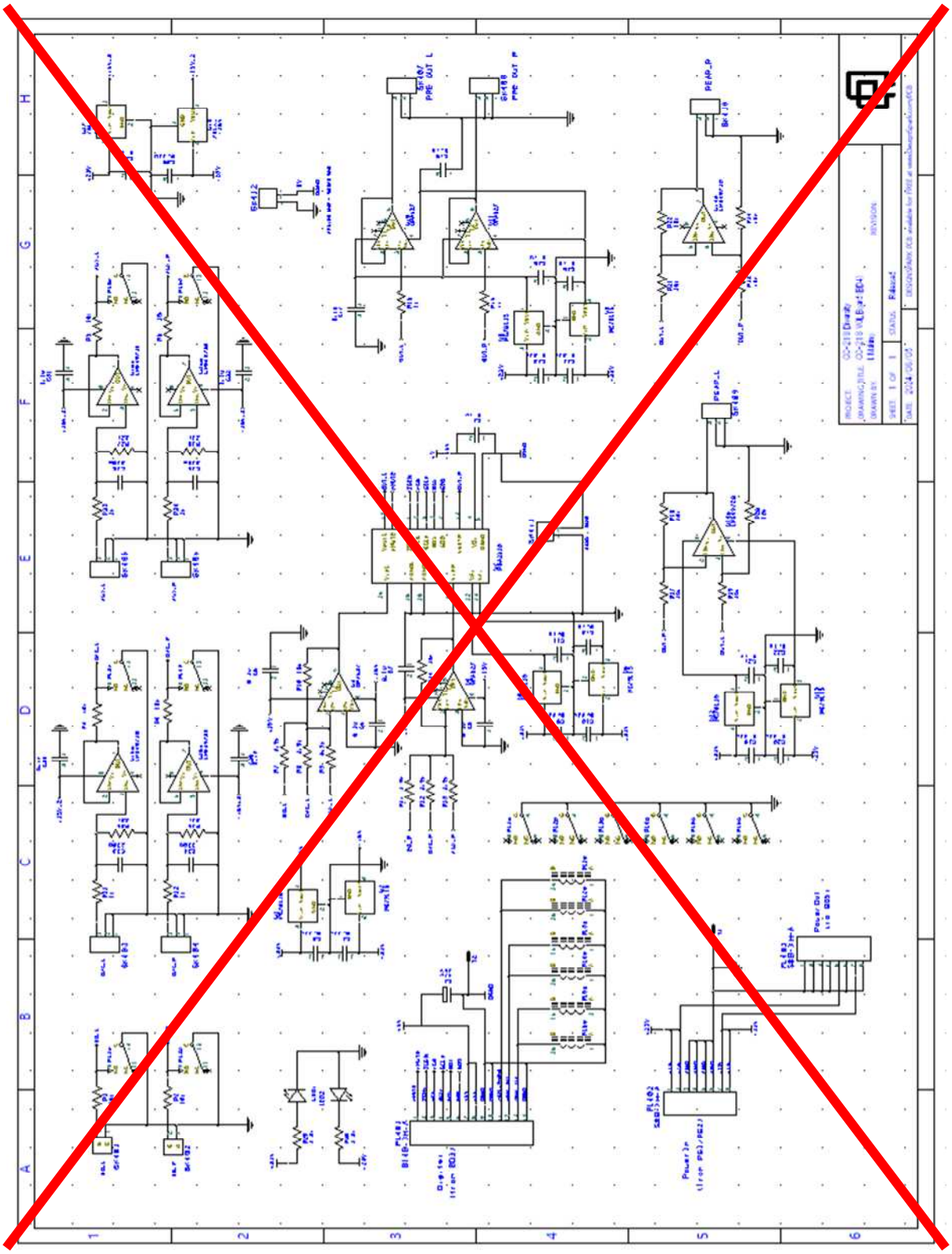
REAR_L only

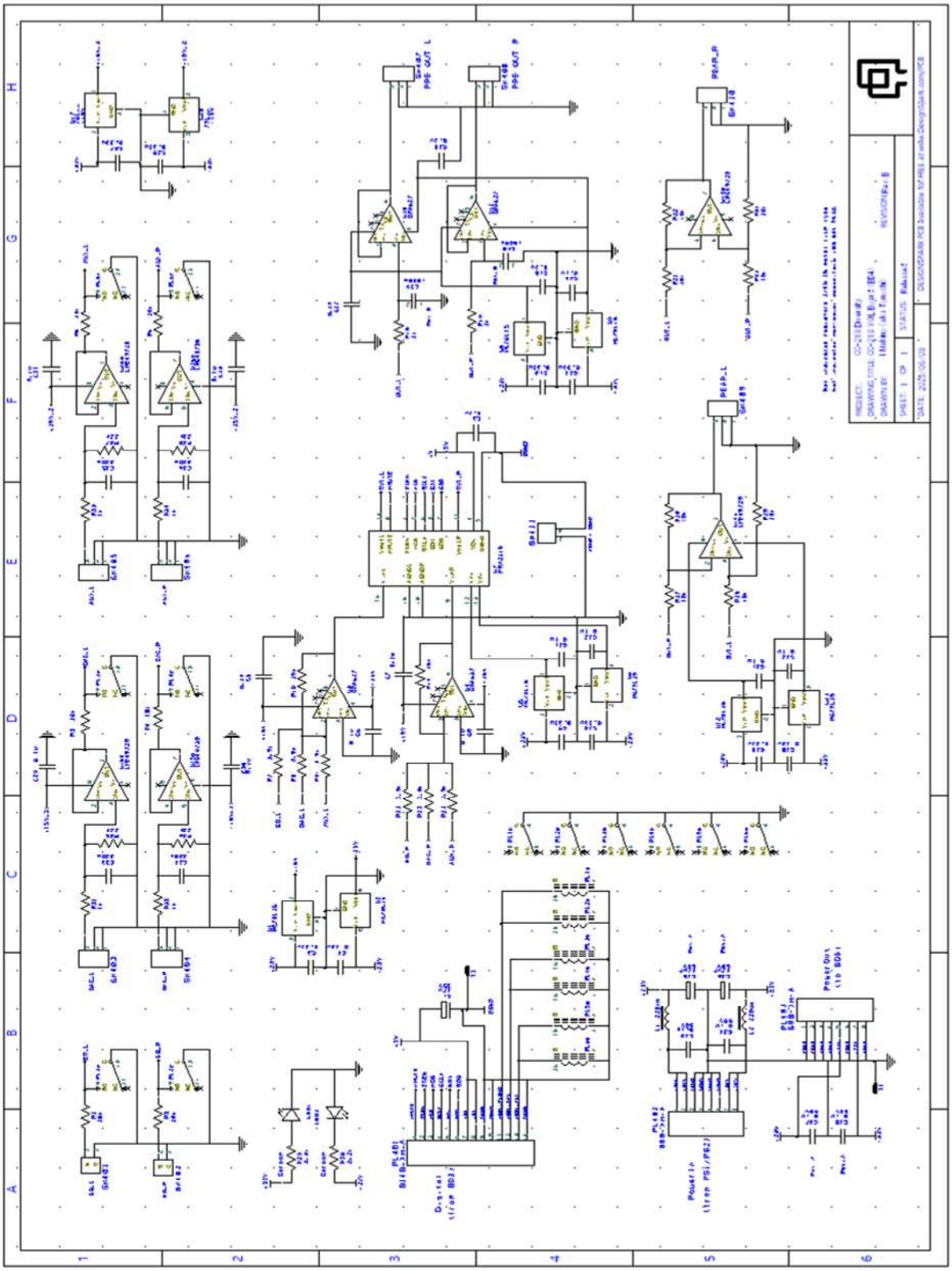


I quit simulation of Matrix here, because its SQ is not important.

Schematic

For the latest schematic, see ~~CC-218_VOL_Schematic.pdf~~CC-218_VOL_B - Schematic.pdf. 2025/03/21





Rev.A

LC 1st-order LPF added to DC power input:

L: 220uH (L1~2), C: 47uF (C35~36)

f_C = 1.5kHz

Rev.B

CR 1st-order LPF added to output buffer:

C: 1000pF (C39~40), R: 1k ohm (R15~16)

f_C = 160kHz

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

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