SOME AMPLIFIER CHOICES PART 1

AES Los Angeles 2014
Product Design Track Event PD1

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The purpose of these circuits and measurements is to provide information about some types of amplifiers and how they will affect sonics. It is not a complete list

By careful choices one can design an amplifier to have a desired sound or avoid less desirable effects.

When negative feedback is applied the distortions and noise is reduced. But if one is looking for better than average audio quantity. Choosing amplifier designs that are distortion free or have desired distortions before feedback is applied allows sonic choices to be built into the design.

If you use an IC amplifier what type of output circuit does it have?, you should know, can it drive a load? What kind of load? How well?

If the load changes the performance of the amplifier can you predict the result?

In a studio it is not possible to predict what the load will be; Resistive, Capacitive, Inductive, Transformer, 200 feet of cable.

The most important measurement tool is your playback system and ears.

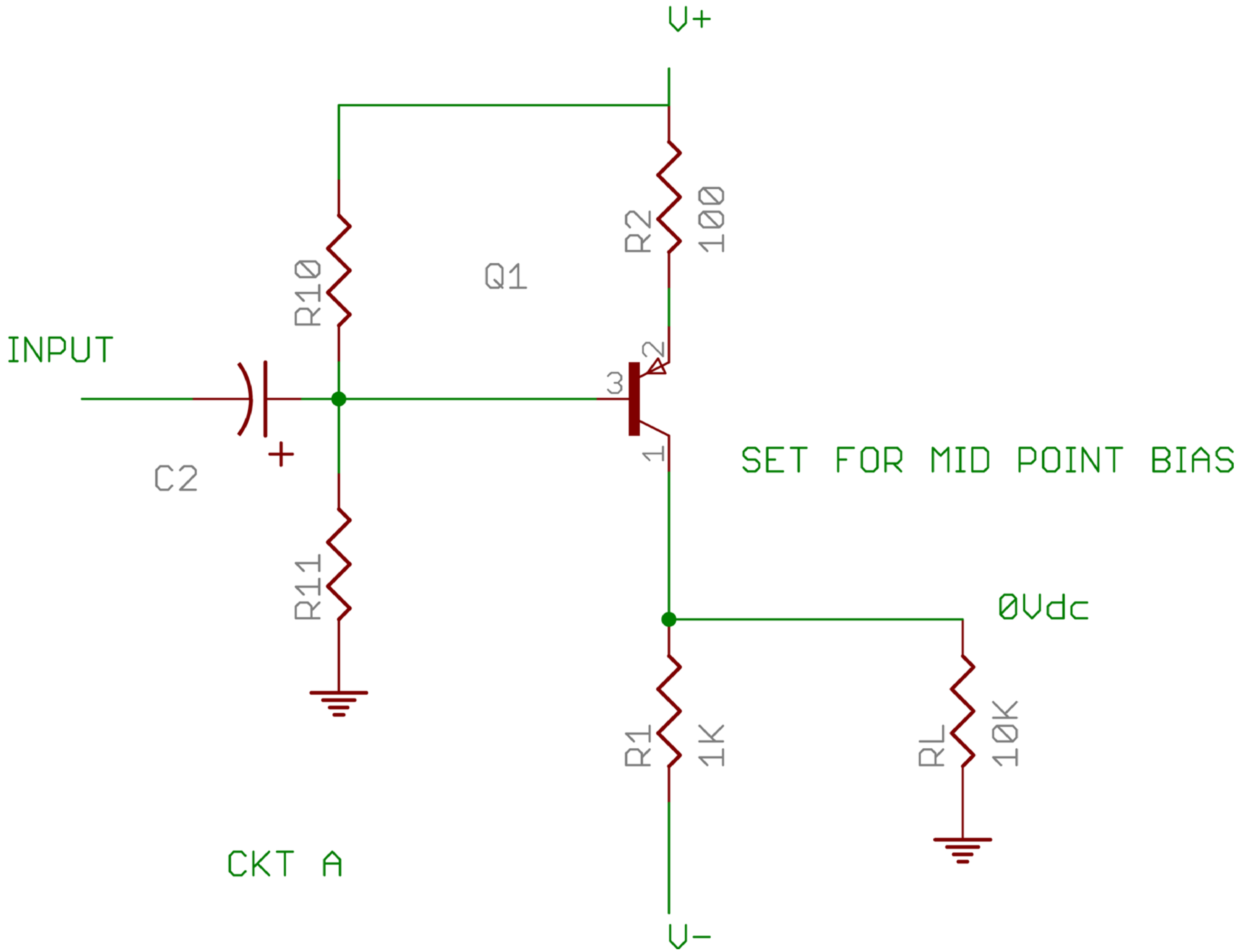
These measurements were made with a Tektronix AA5001, SG505 MOD WR, 2465B scope and a Stanford SR1. There was a buffer amp in between the DUT and the measurement gear Running the analog measurement in parallel with the digital system provides insights.

Other useful things;

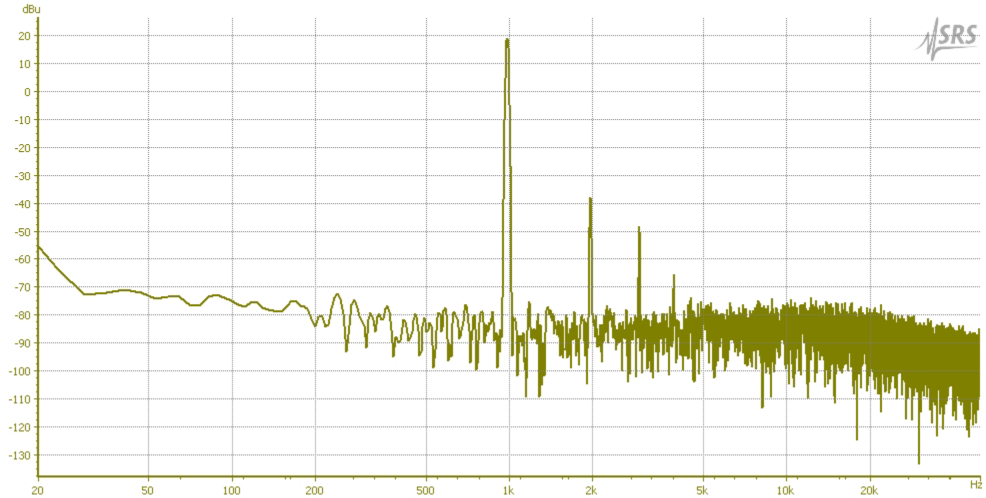
In testing output amplifier designs have a 200 foot cable to connect between the amplifier and the load to verify performance. Having both a cable of something like Belden 8451 and a high end audio cable can be useful.

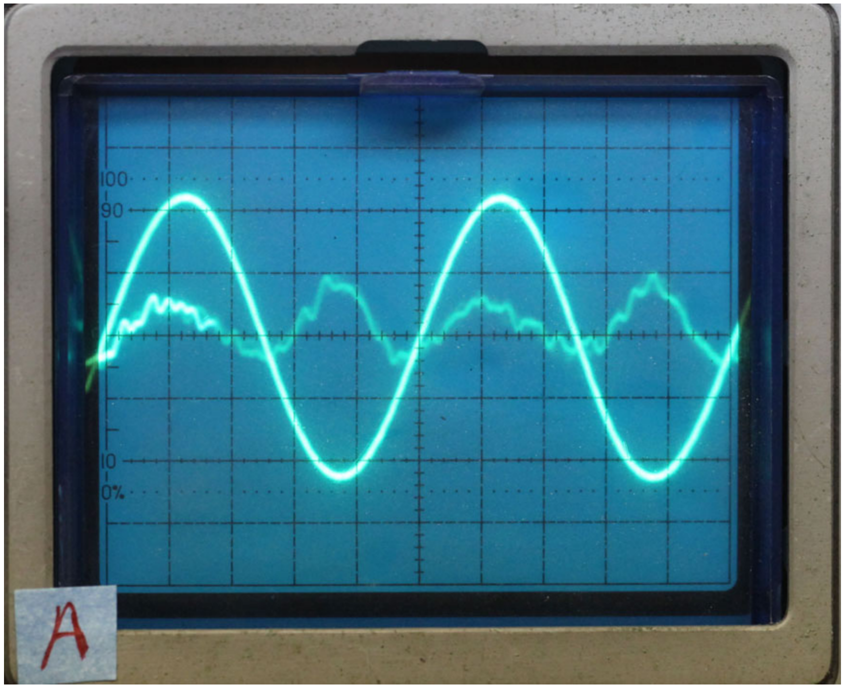
Learn to hear how different distortions change sound
Learn to think differently. Not copy
Analog design can be improved.

Note: In the following measurements low level distortion wave forms have noise
There was no attempt to reduce noise, there is some randomness in repeatability in these circuits, trim pots were used for bias settings. In the analog measurement higher order harmonics will result in sharper edges in the distortion waveform. Some of the part values are not accurate in the drawings.



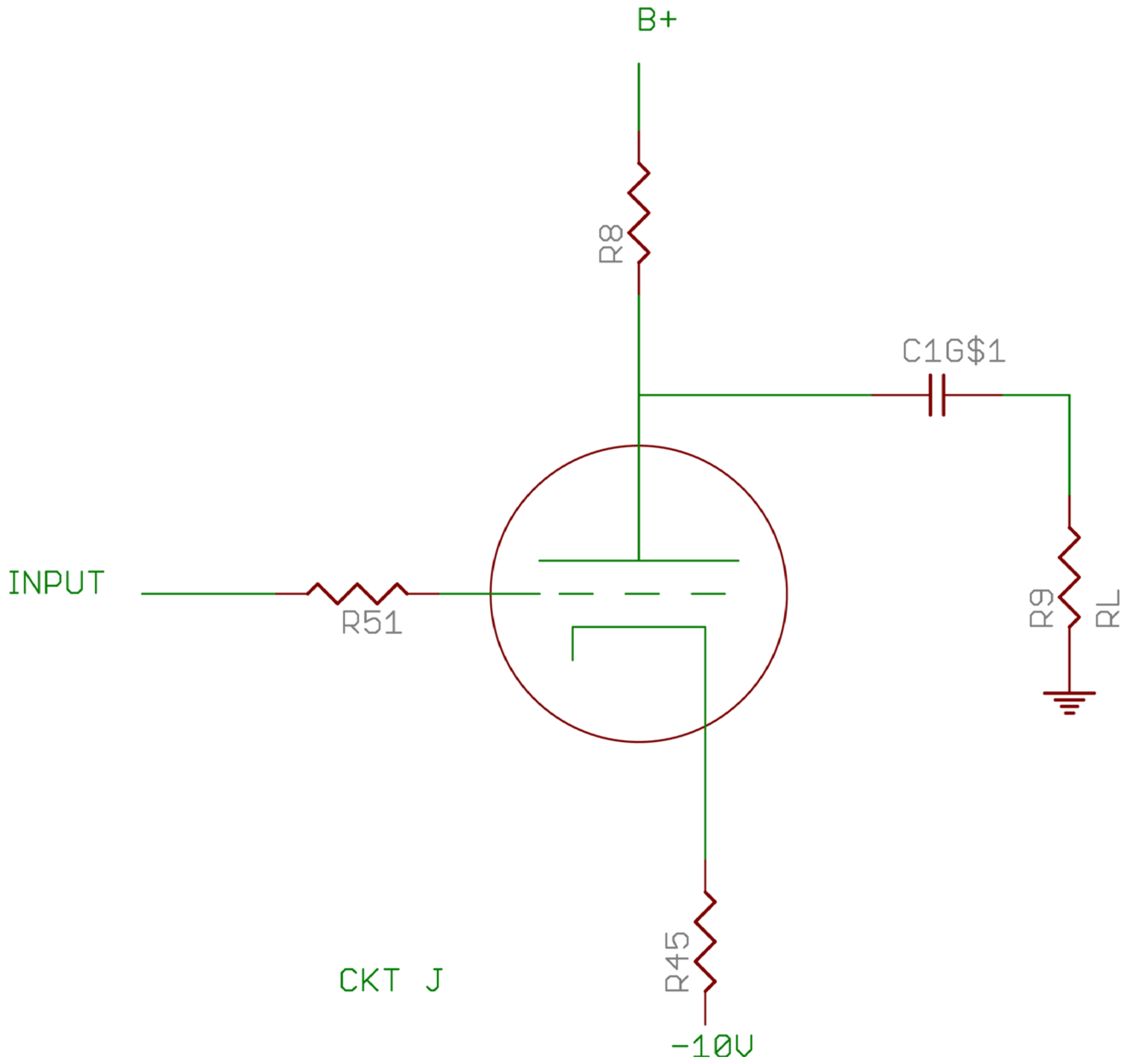
V+
R2
100
R10
Q1
INPUT
2
3
1
C2
+
SET FOR MID POINT BIAS
R11
0Vdc
R1
1K
RL
10K
CKT A
V-



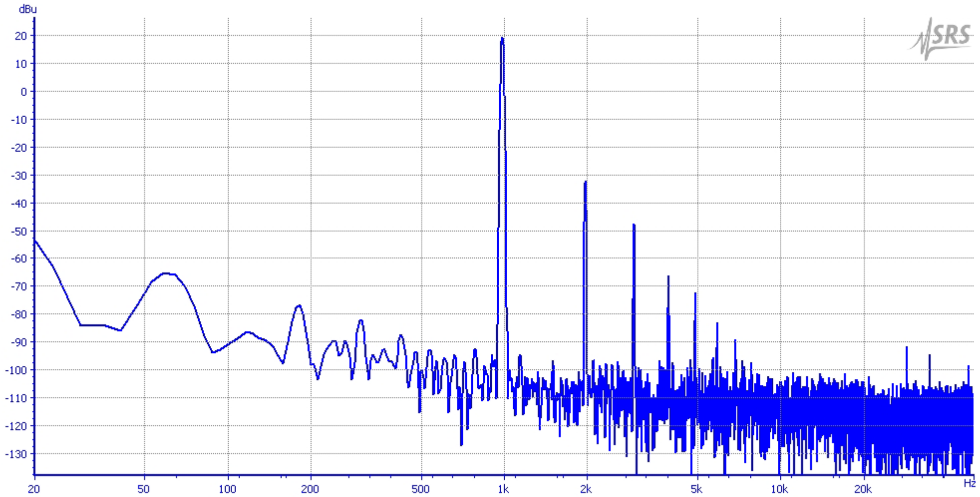


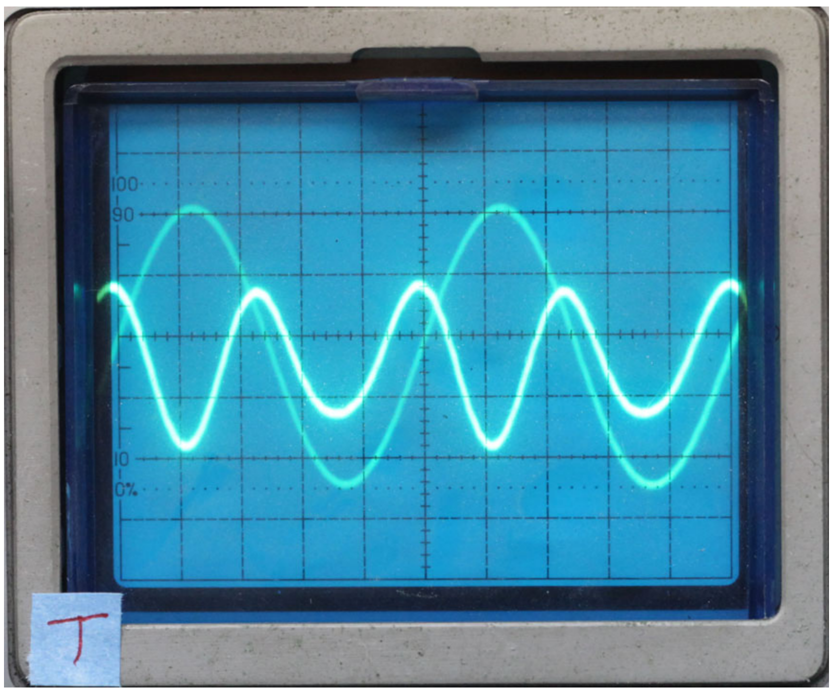
CKT A

10K load,   Av = 9 aprox
0.14 THD + Noise
Distortion does not change when the load changes, within reason. Circuit gain changes with a change in load
R1 can be replaced with a current source

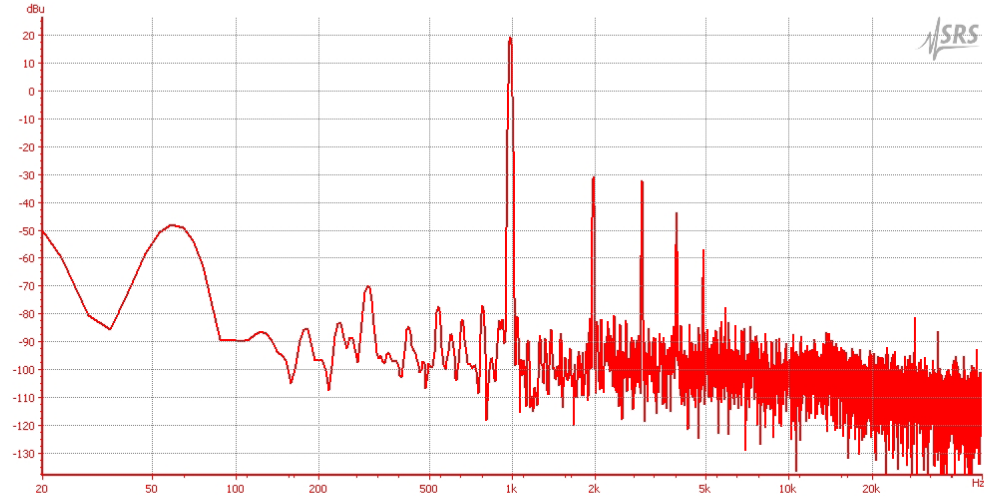

B+
R8
C1G$1
INPUT
R51
R9
RL
CKT J
R45
-10V

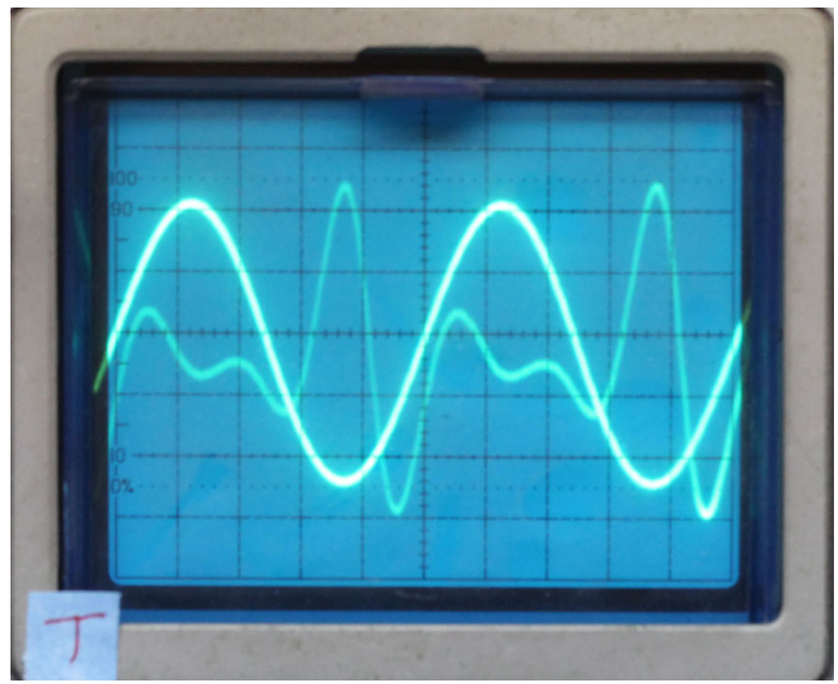
Low Z Drive Impedance





Hi Z Drive Impedance





CKT J

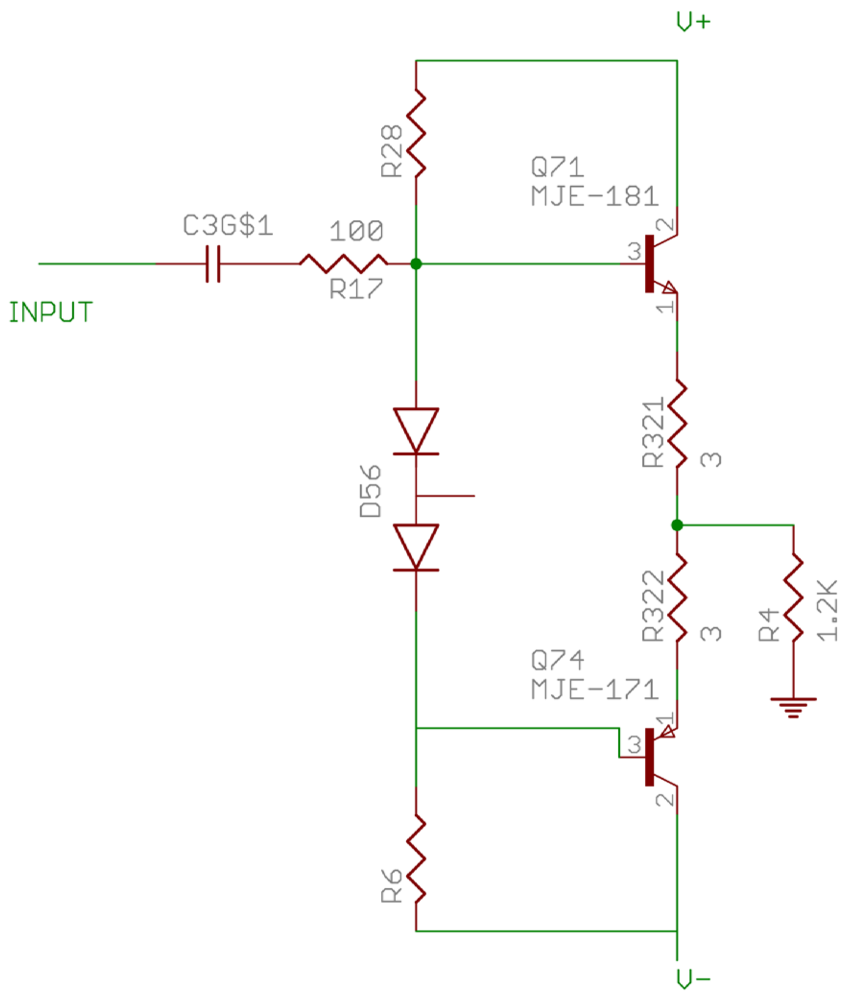
Tube amp for reference

Both load and source impedance will have an effect on the performance

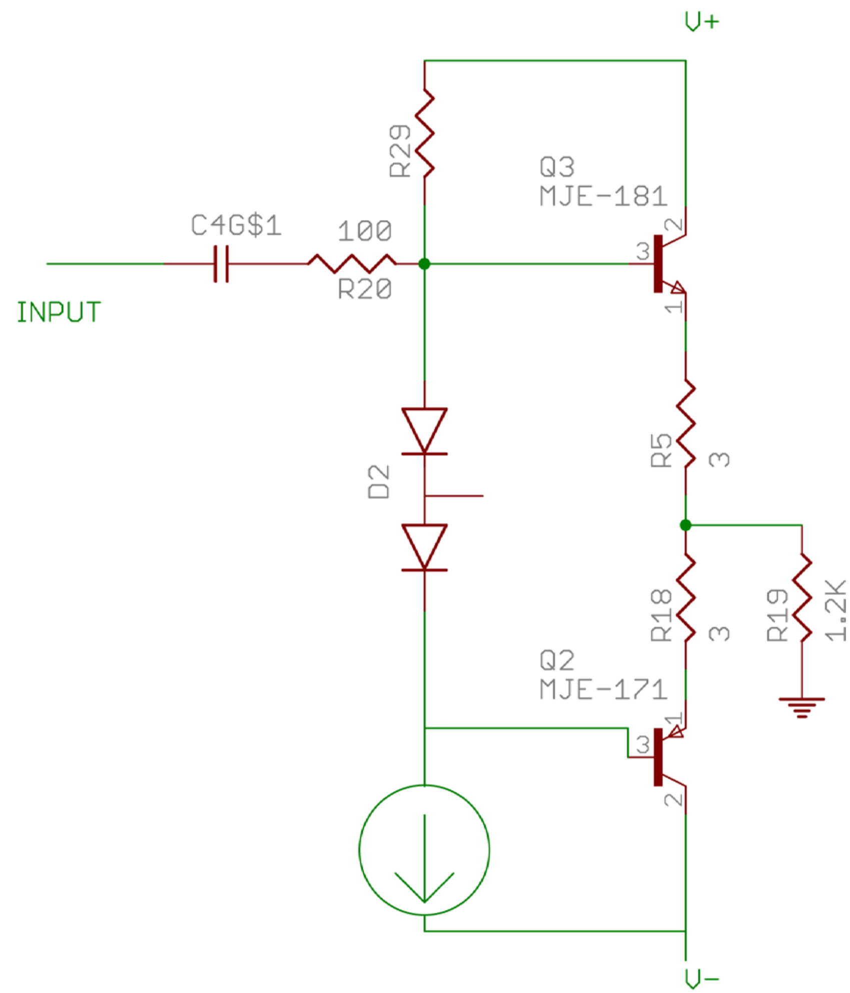
Low Z drive THD + Noise = 0.24%

Hi Z drive THD + Noise = 0.3%

Compare this measurement to ckt A

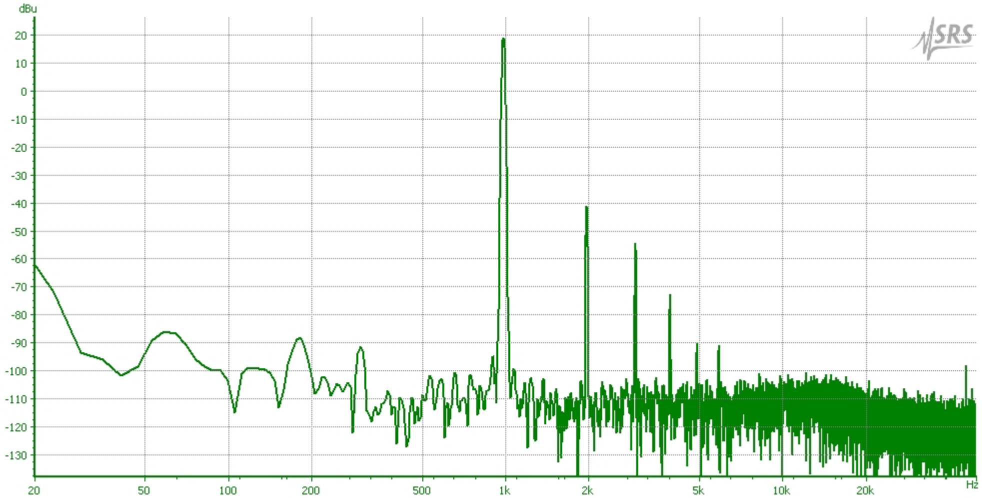

V+
Q71
MJE-181
R28
C3G$1
100
R17
INPUT
R321
3
D56
R322
3
R4
1.2K
Q74
MJE-171
R6
V-

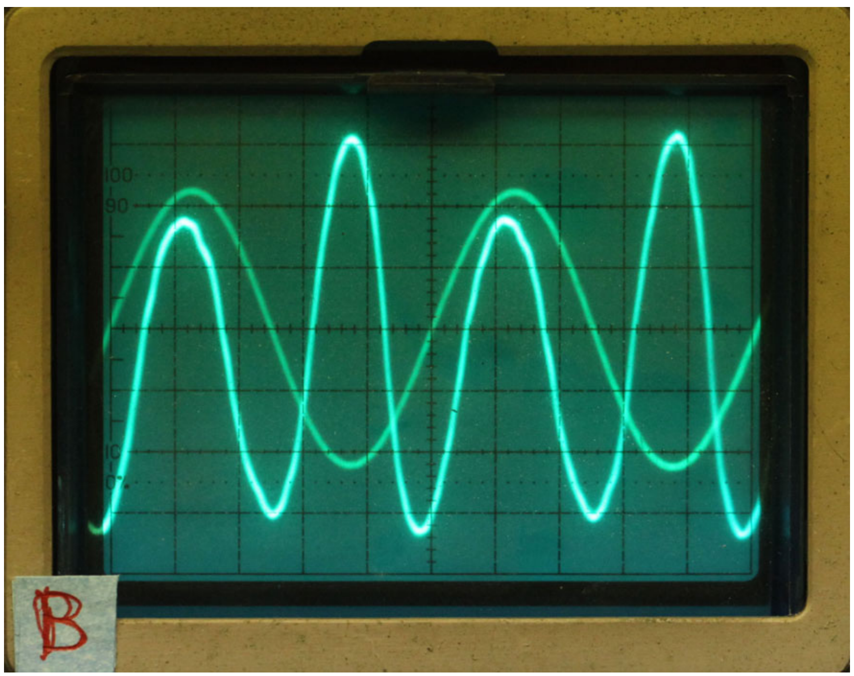
CKT B


V+
Q3
MJE-181
R29
C4G$1
100
R20
INPUT
R5
3
D2
R18
3
R19
1.2K
Q2
MJE-171
V-

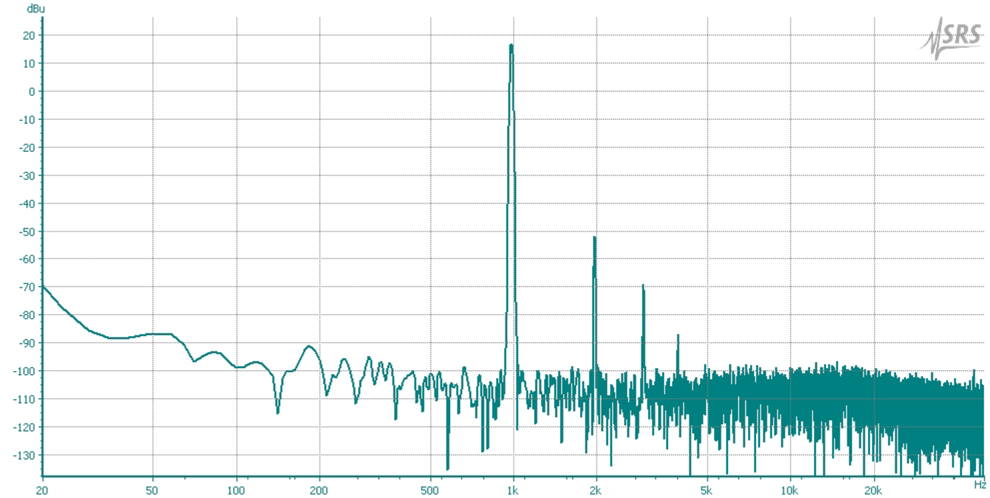
CKT C

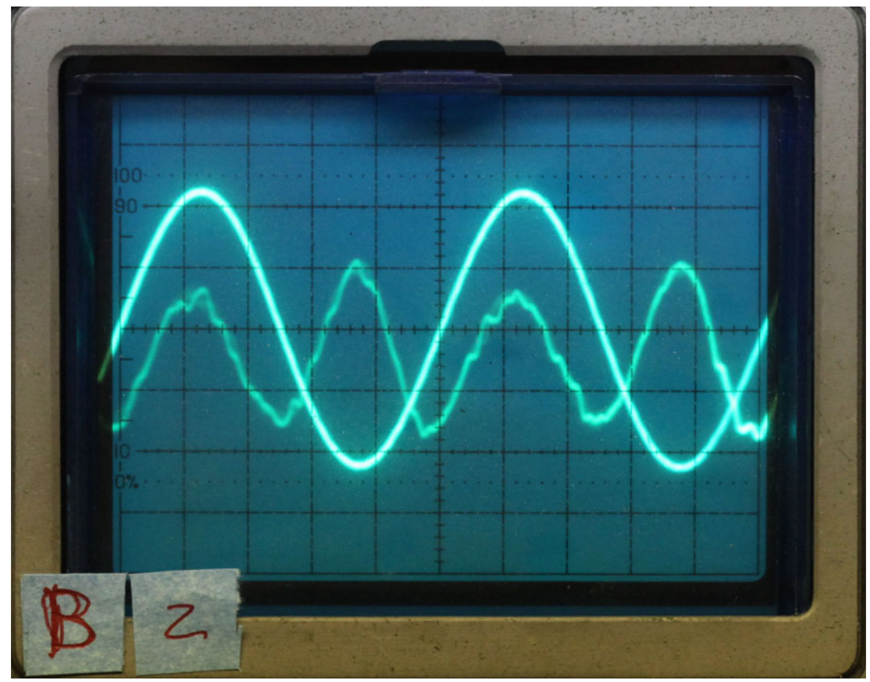
R6, R28 = 15K





R6, R28 = 5K



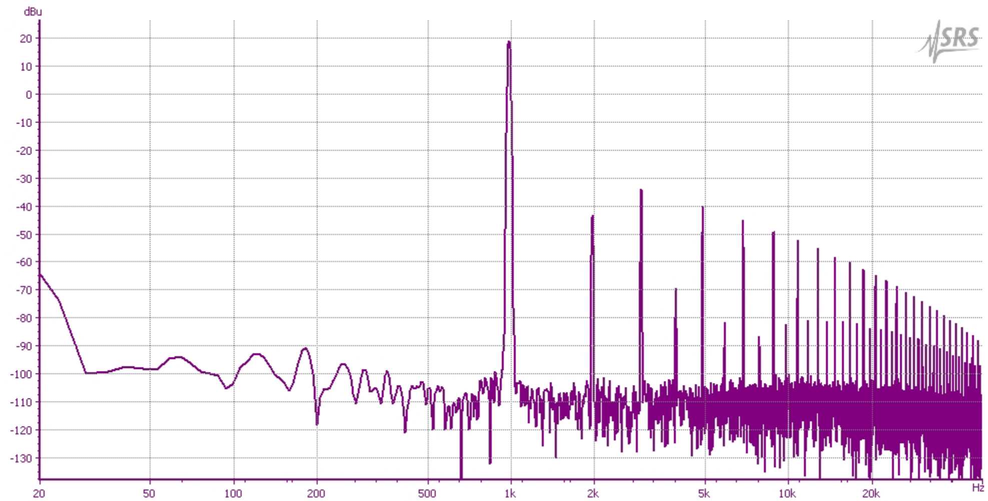


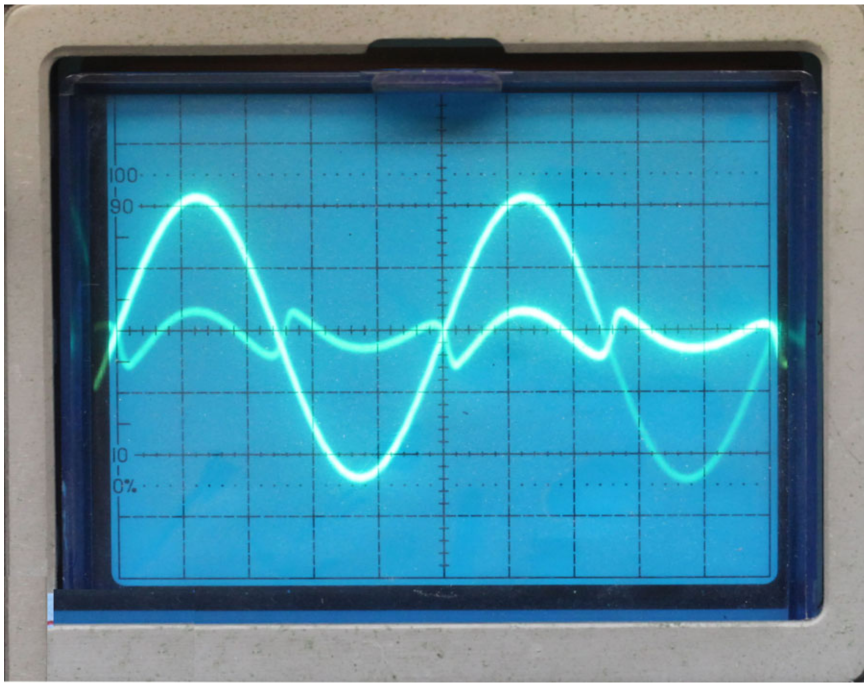
CKT B

Bias current has a large effect on distortion; this circuit can be made to operate in Class A mode with higher currents

R=15K THD = 0.1%

R=5K THD = 0.03%



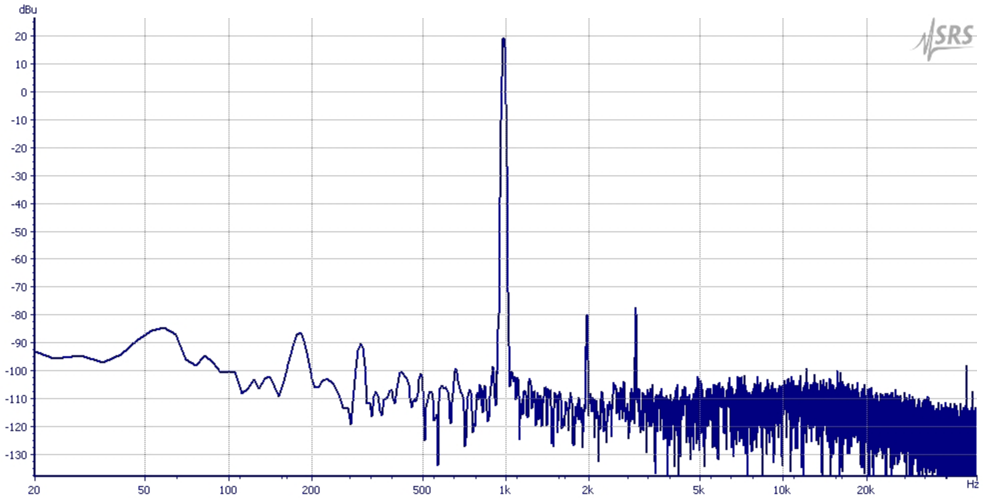


CKT B

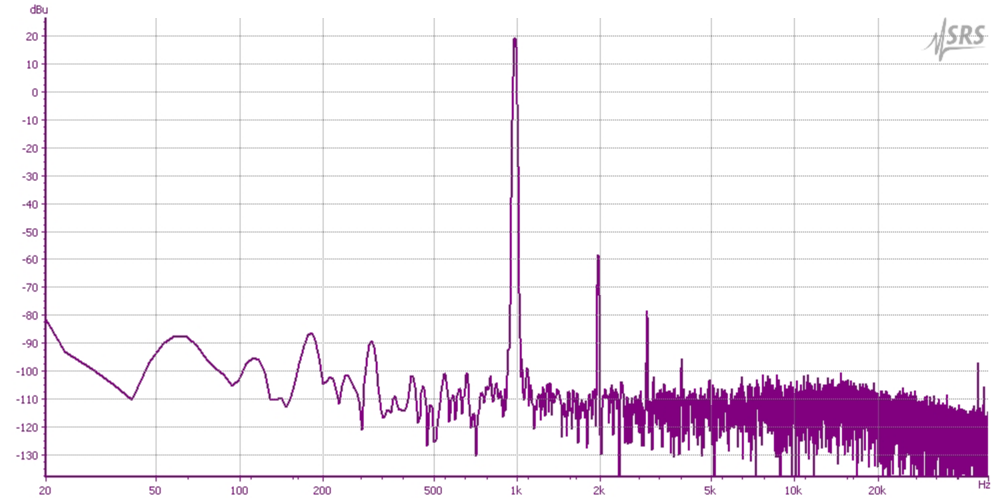
If under biased crossover distortion / (zero crossing distortion) will be high

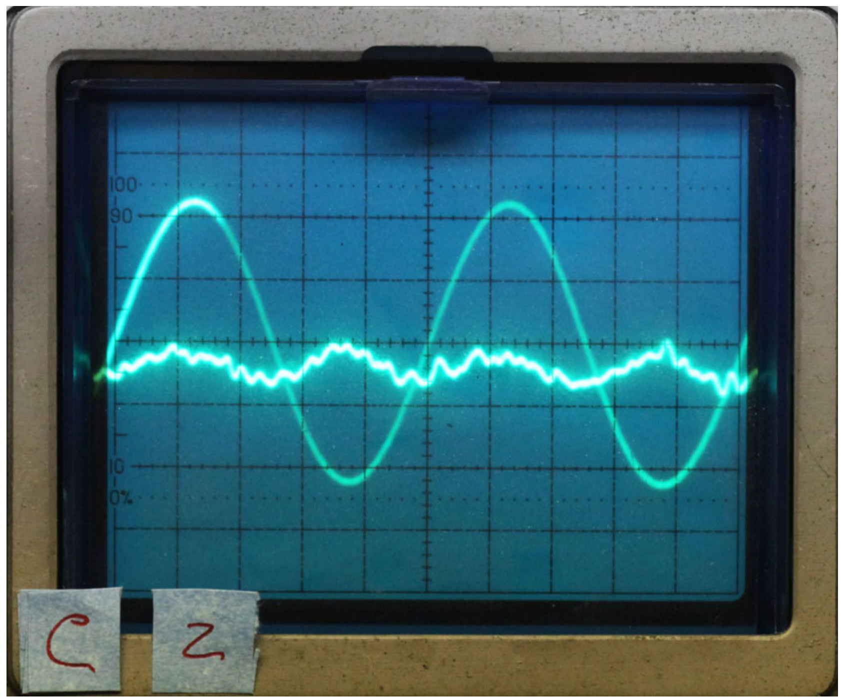
Note the large amount of higher order harmonics and the sharp edge in the distortion waveform

No Load



1.2K Load



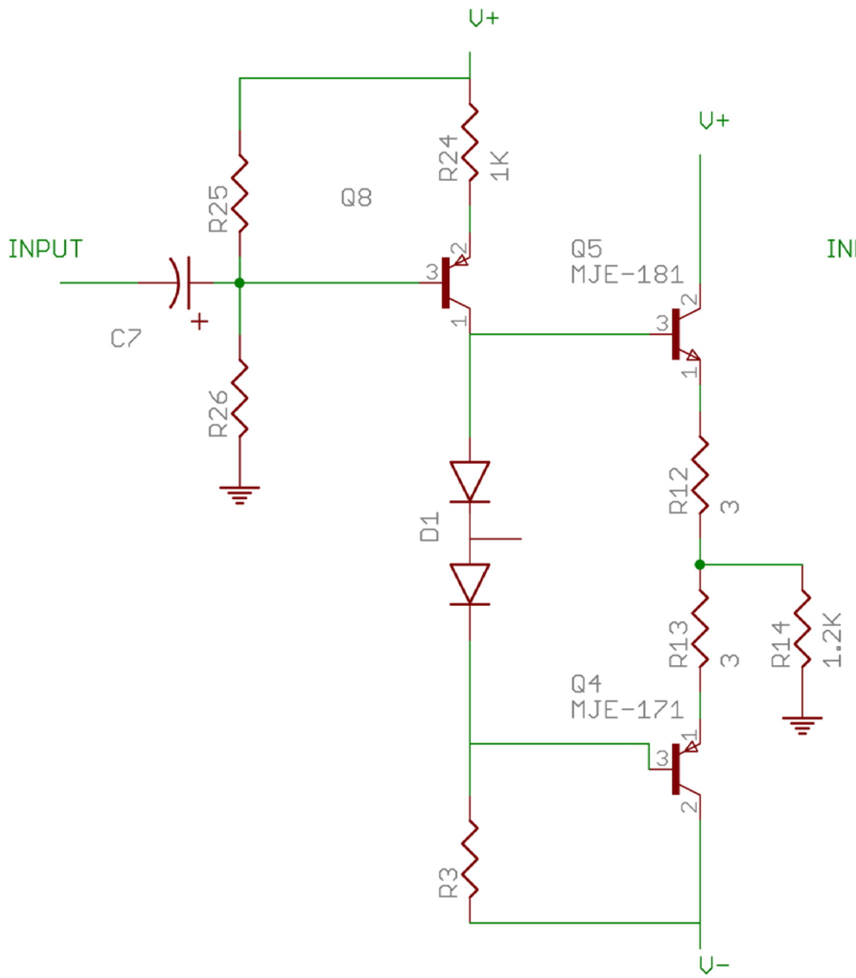


Note: noise in distortion wave form

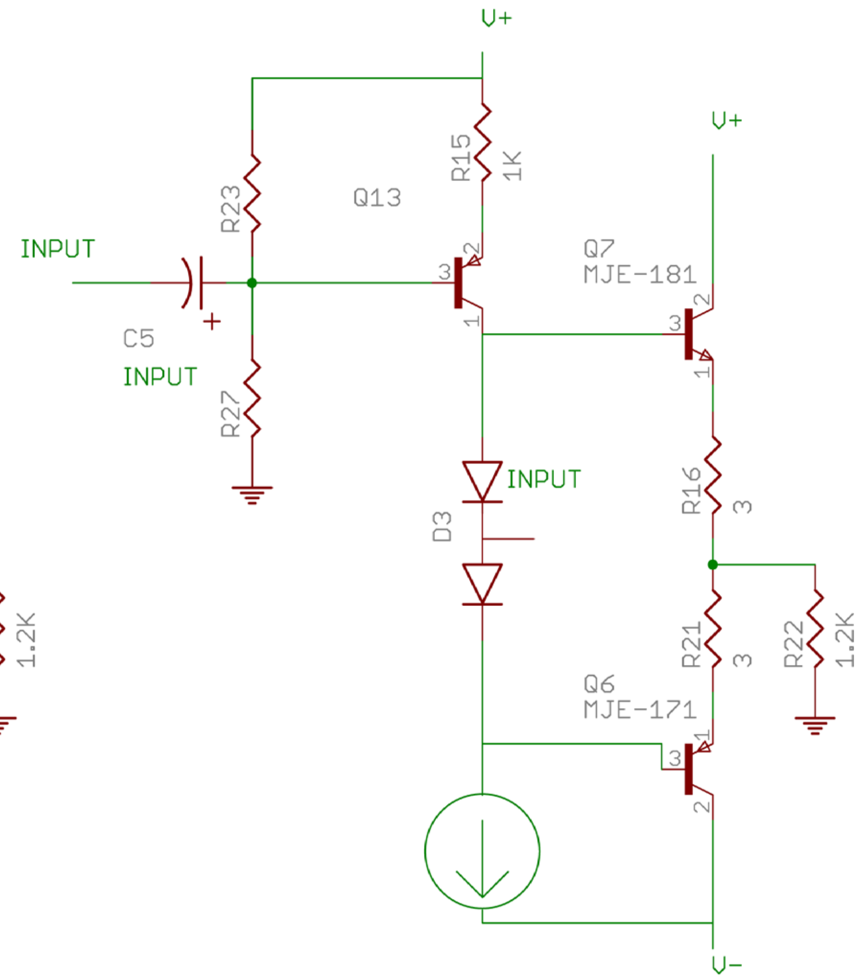
CKT C

Replacing the lower resistor with a current source will result in lower distortion
With the upper R29 = 5K, THD with the no load = 0.004%
THD with the load = 0.006%.
compare the loaded version to CKT B 0.03%

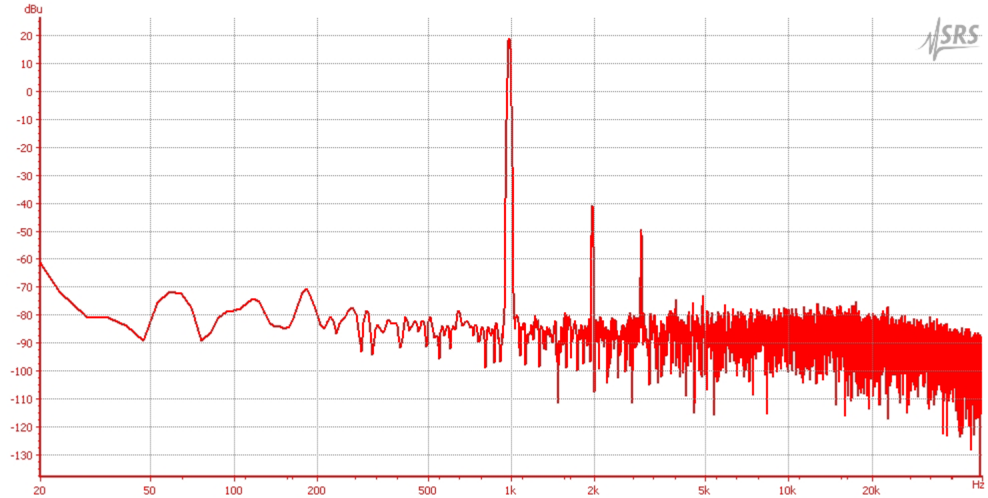
SET FOR MID POINT BIAS

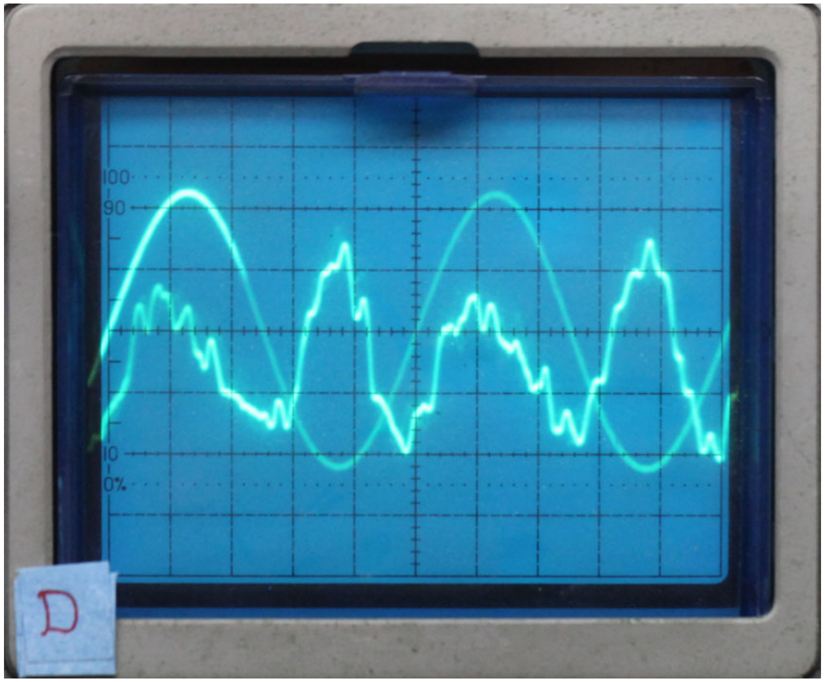


CKT D



CKT E



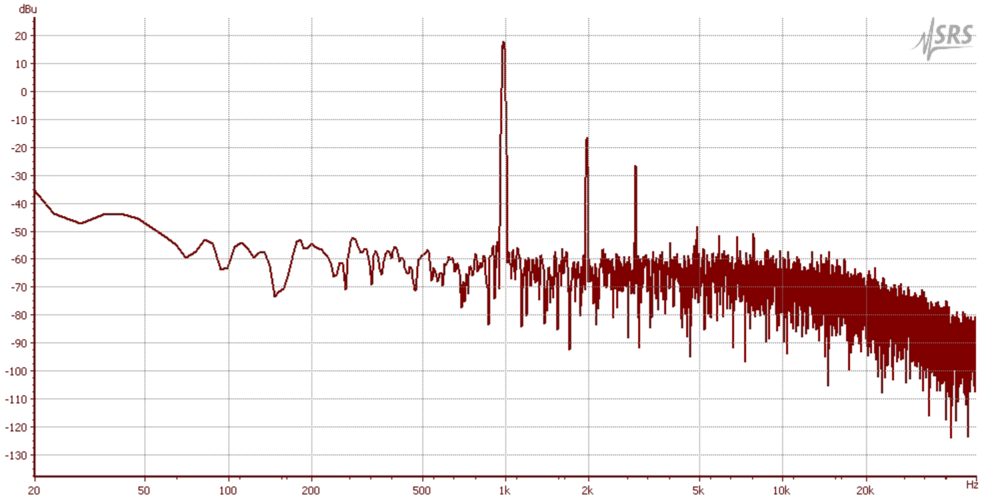


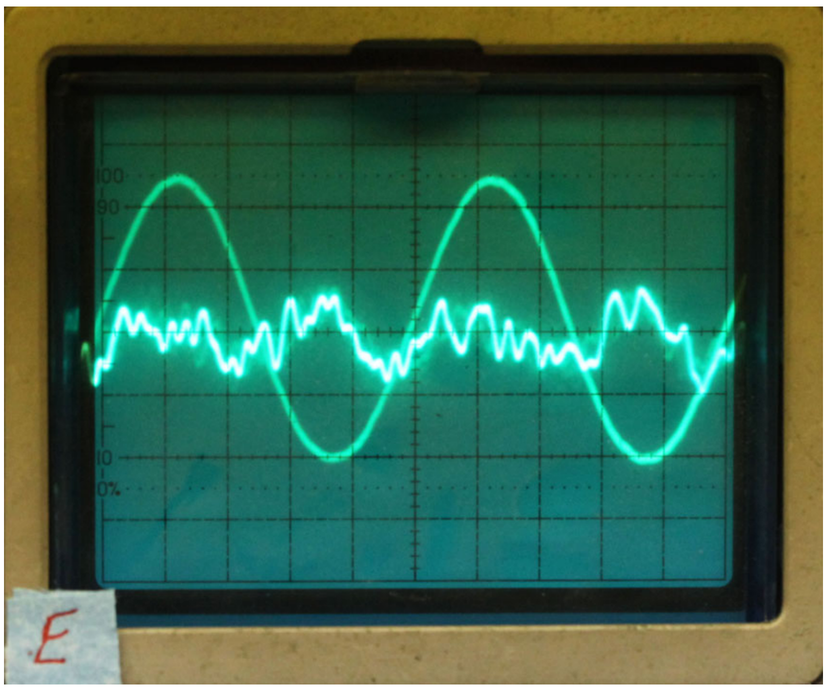
Note: lots of noise in distortion wave form

CKT D

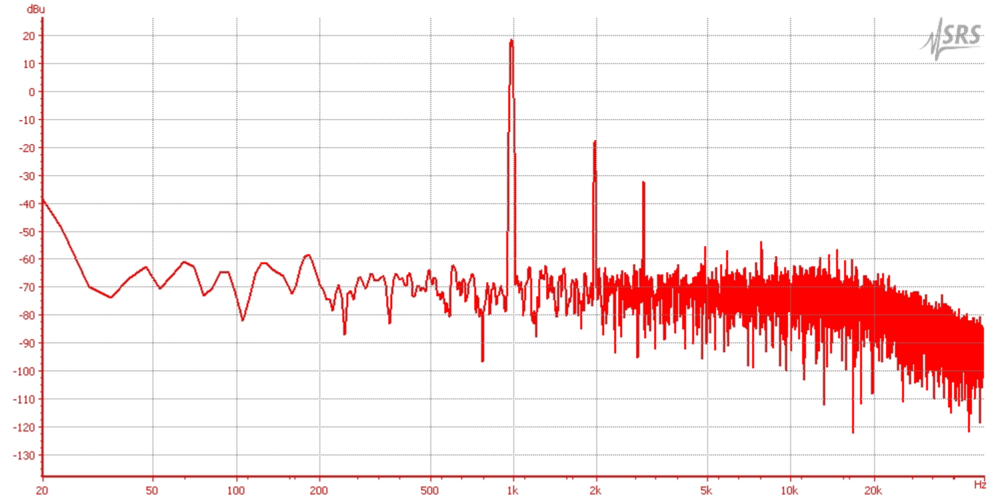
THD + Noise = 0.075% no load Gain = 3.6
THD + Noise = 0.085% with load Gain = 3.5
Distortion wave form has lots of noise in it,   R3= 5K

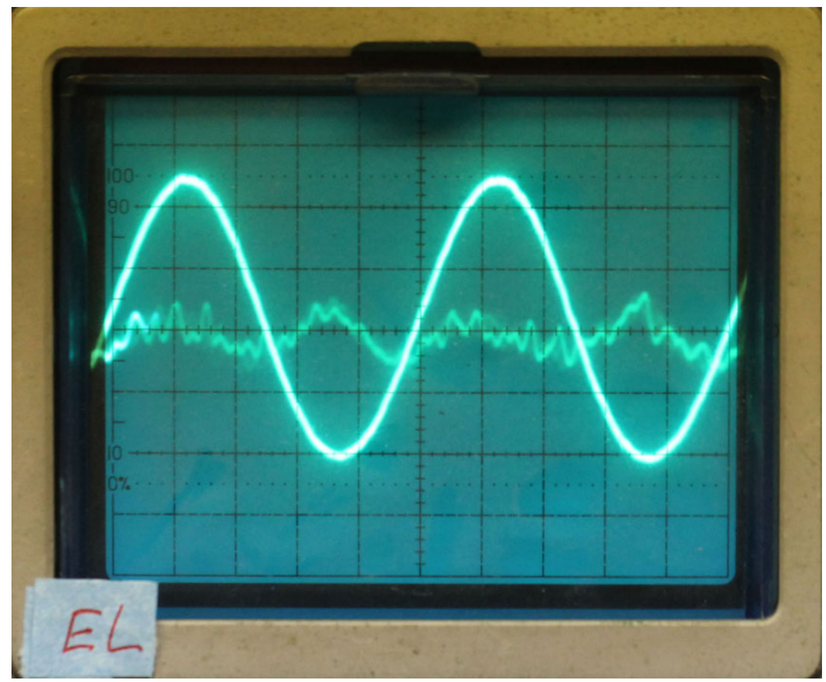
No Load





1.2K Load

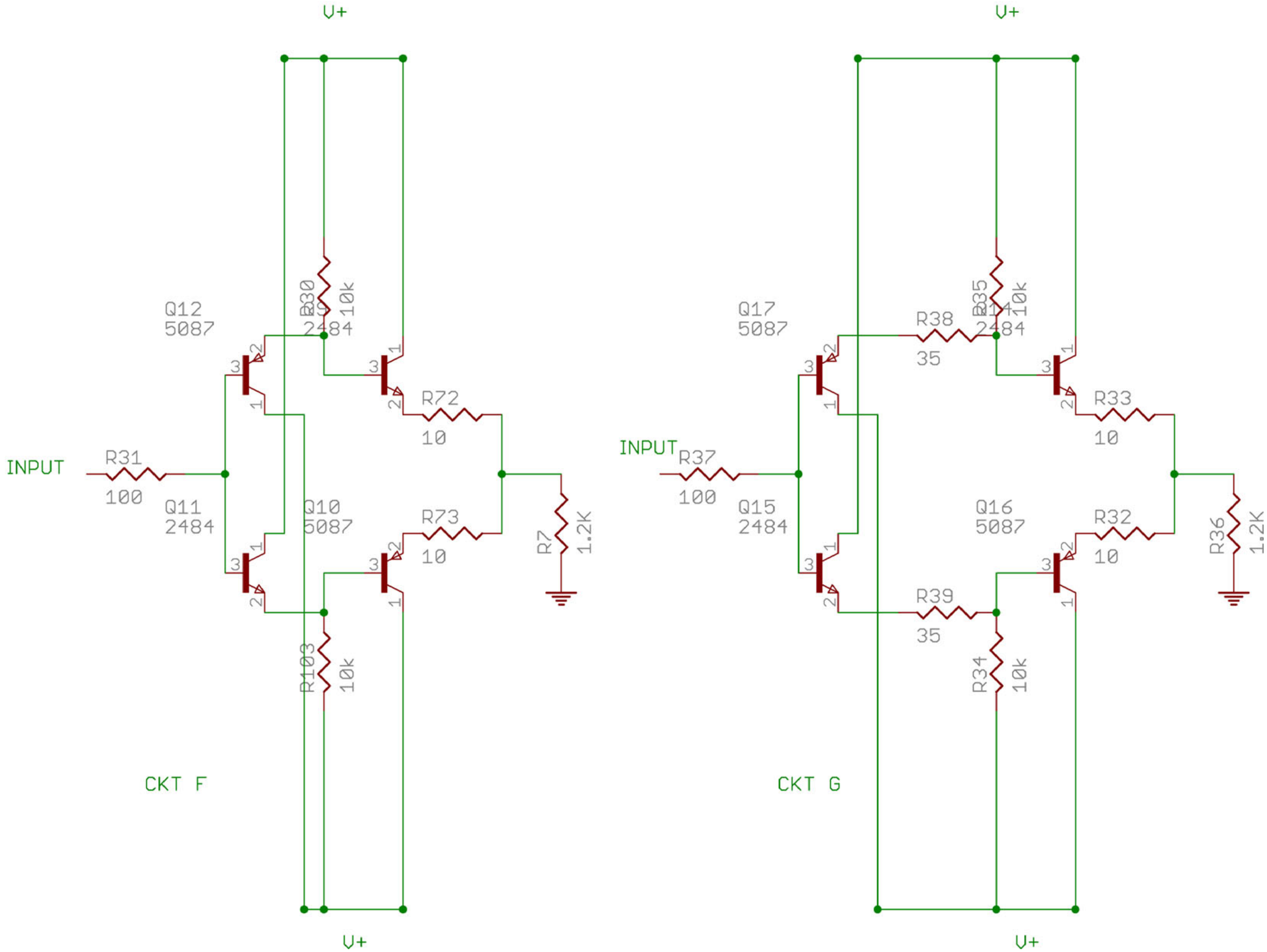




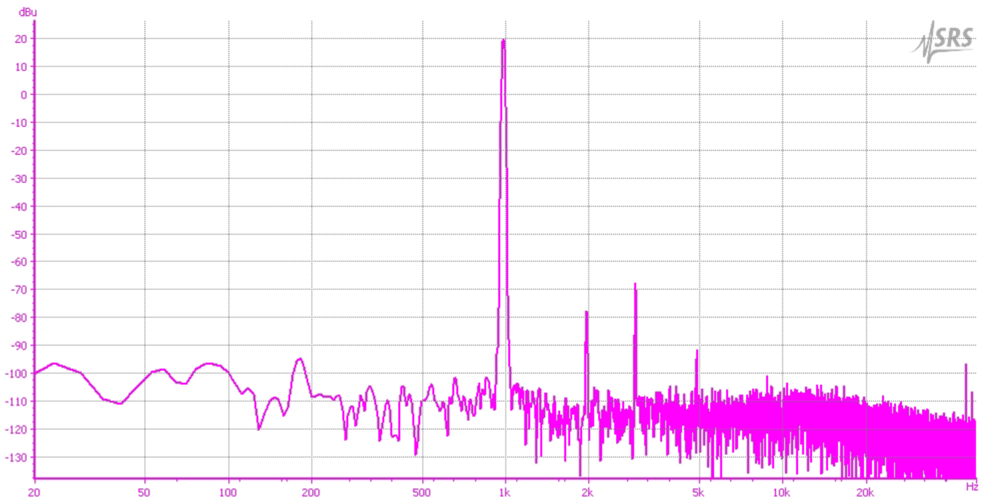
CKT E

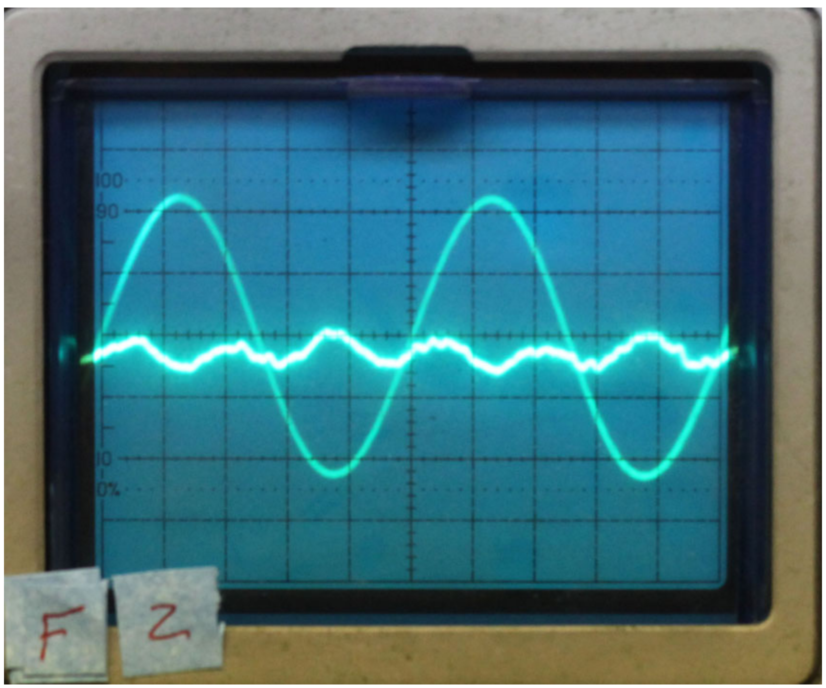
With no load
Av = 200
THD + Noise = 2.4%, dominated by noise
The FFT is 20 averages to help reveal the harmonic content

With Load
Av = 106
THD + Noise = 1.33%, dominated by noise
This is a large change in gain from no load to load

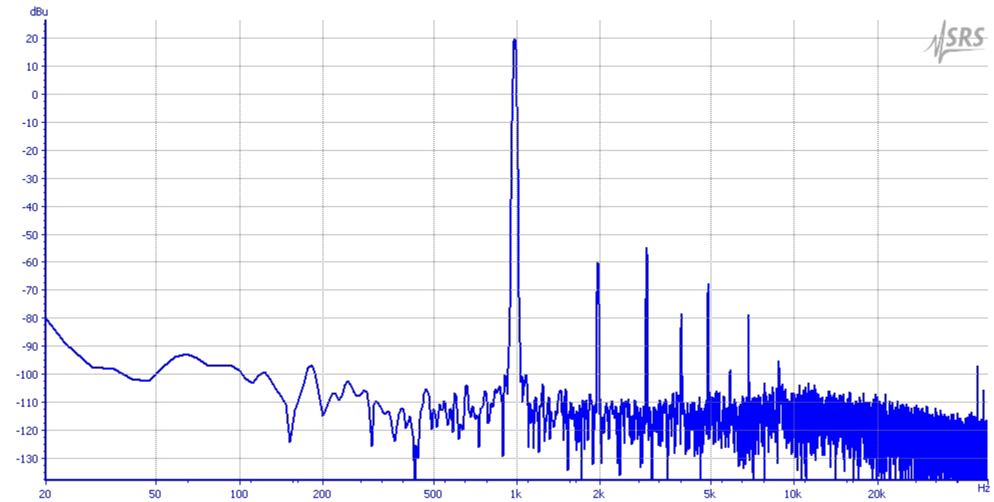

V+
Q12
5087
R30
10k
R72
10
INPUT
R31
100
Q11
2484
Q10
5087
R73
10
R7
1.2K
R103
10k
CKT F
V+
V+
Q17
5087
R35
10k
R38
35
R33
10
INPUT
R37
100
Q15
2484
Q16
5087
R32
10
R36
1.2K
R39
35
R34
10k
CKT G
V+

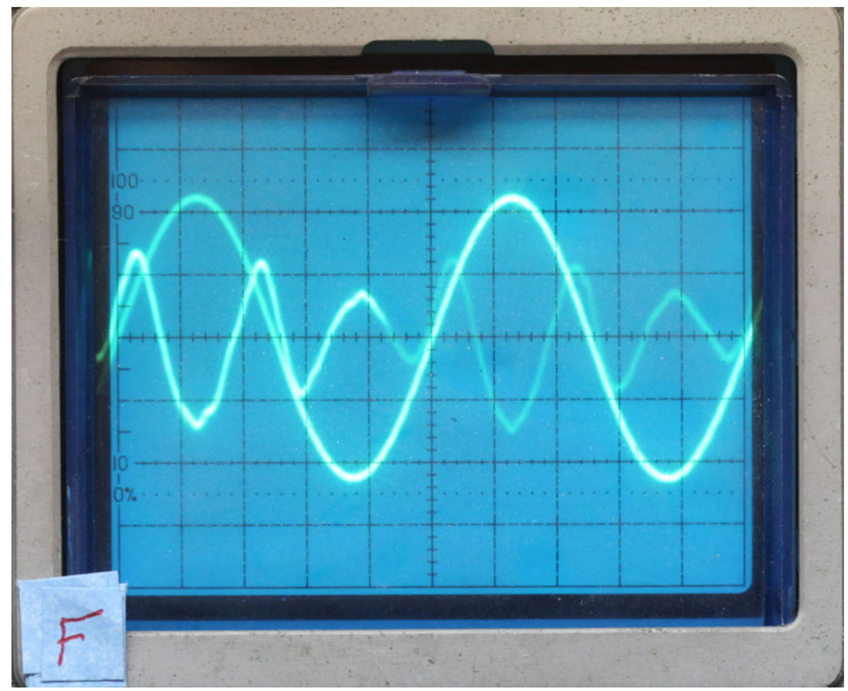
No Load





1.2K Load





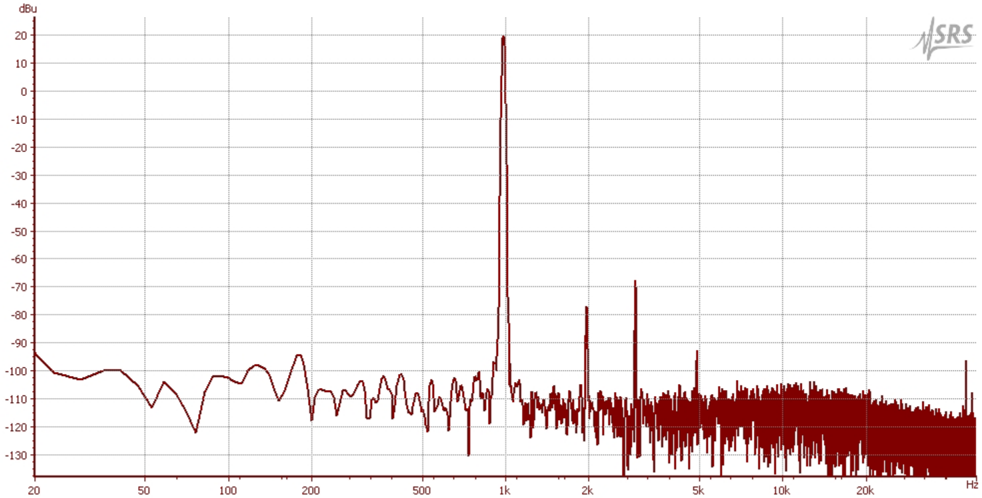
CKT F

THD with no load = 0.004%

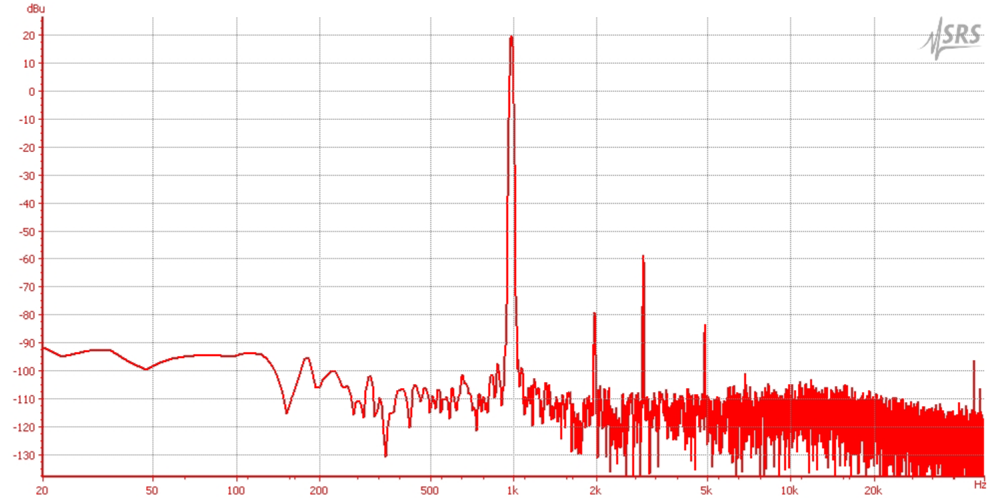
THD with load = 0.02%

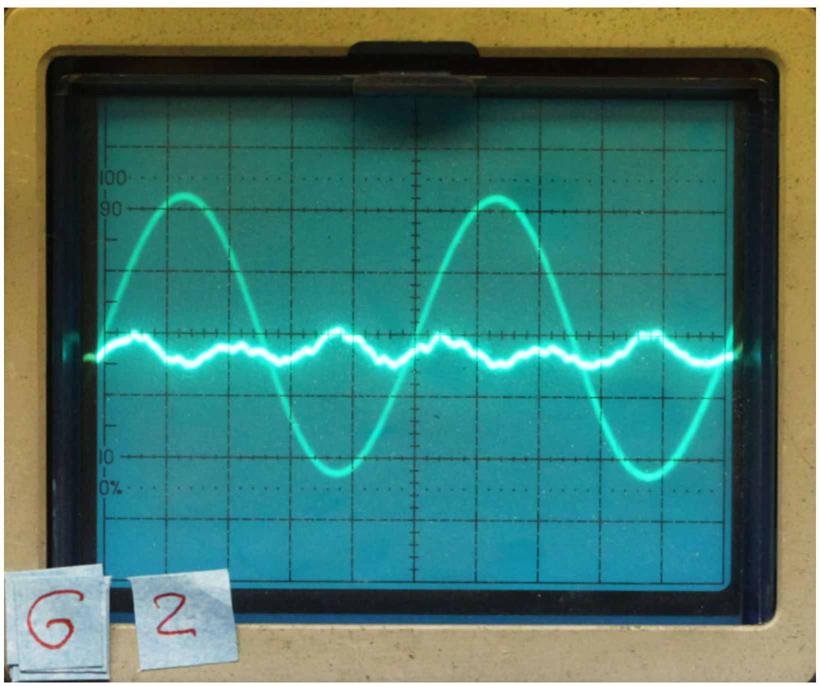
Note high order harmonics in loaded output

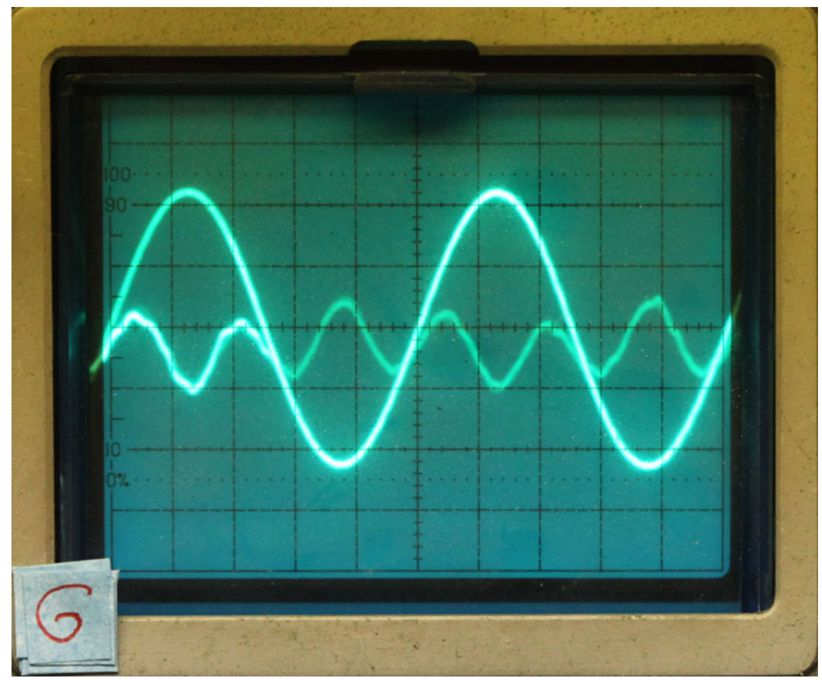
No Load



1.2K Load







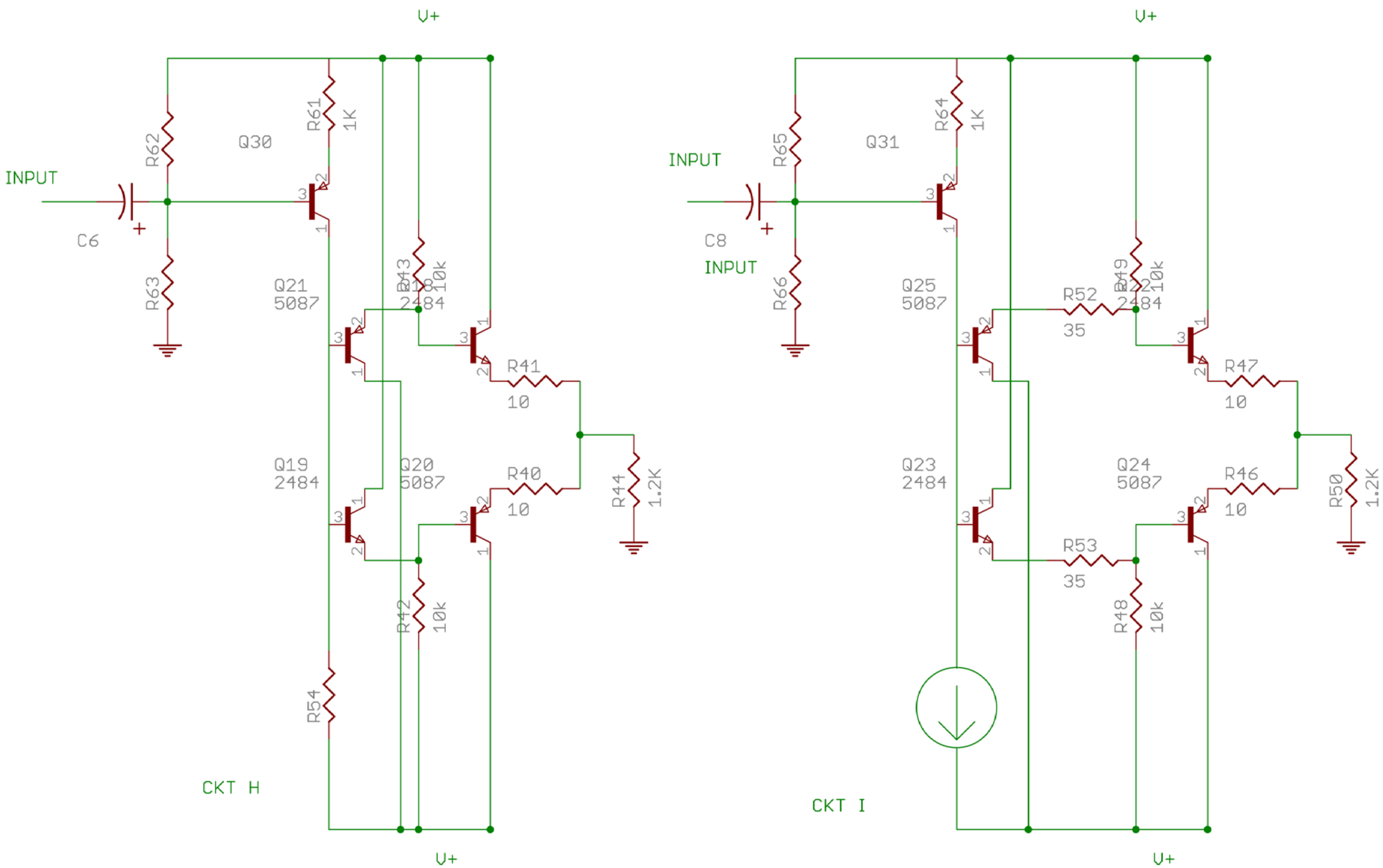
CKT G

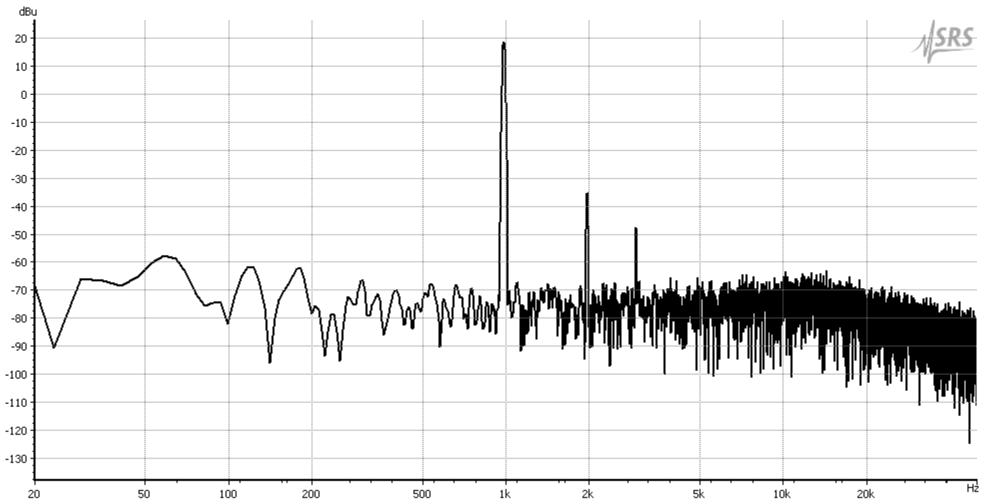
THD with no load = 0.004%

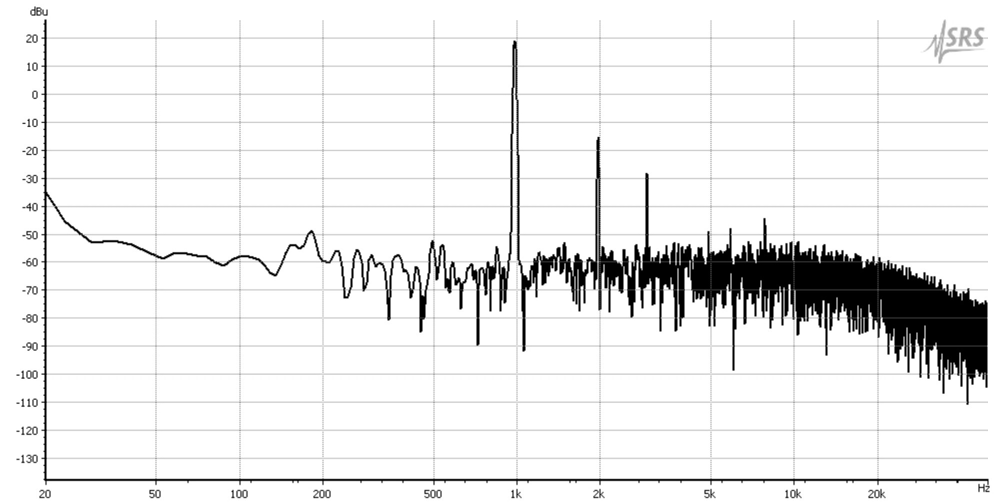
THD with load = 0.012%

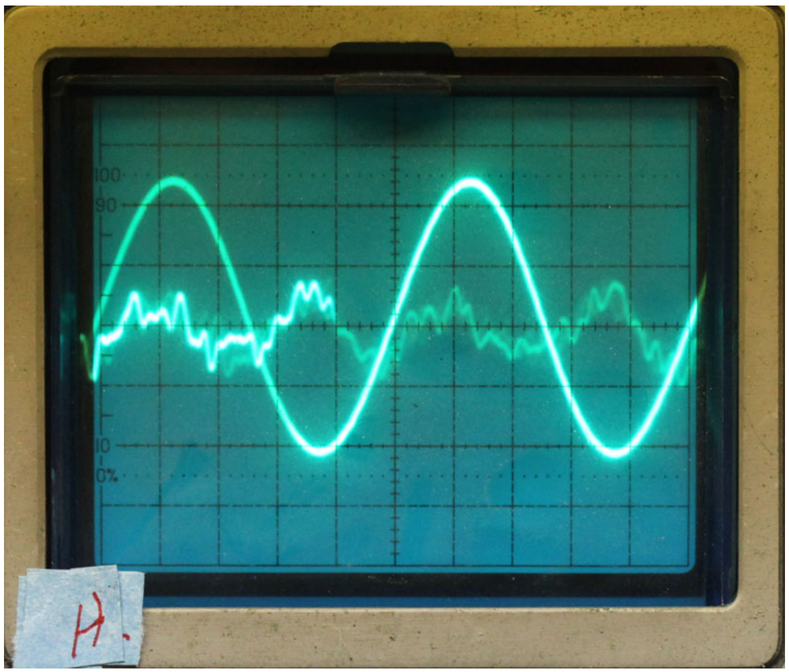
Note lack of high order harmonics in loaded output when compared to ckt F

SET FOR MID POINT BIAS

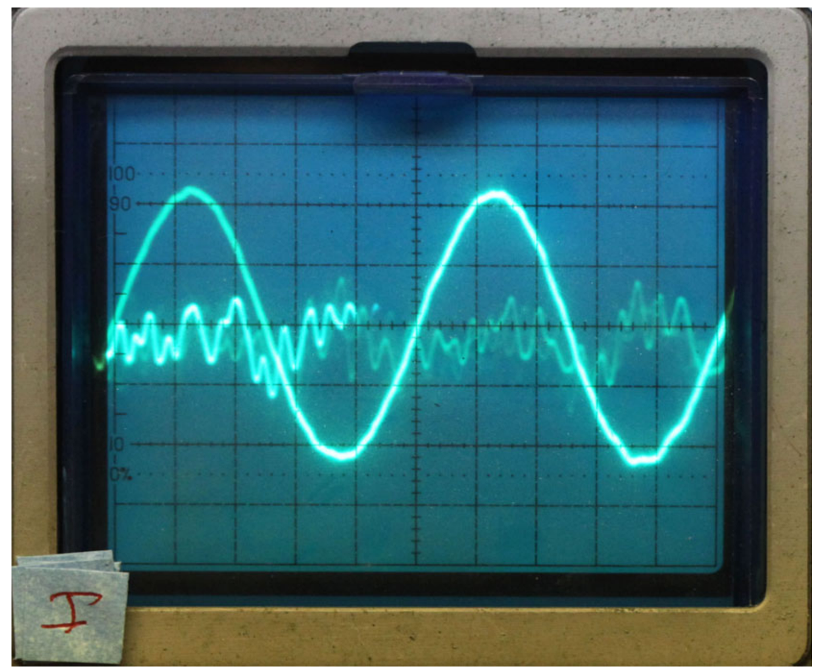








Note: noise in distortion wave form

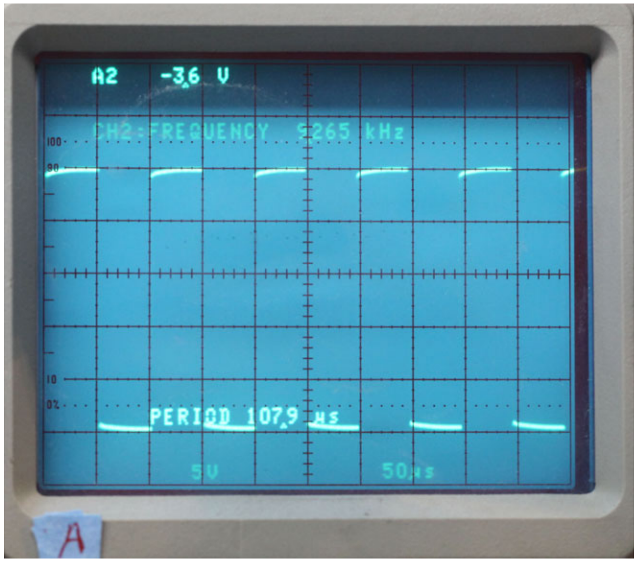


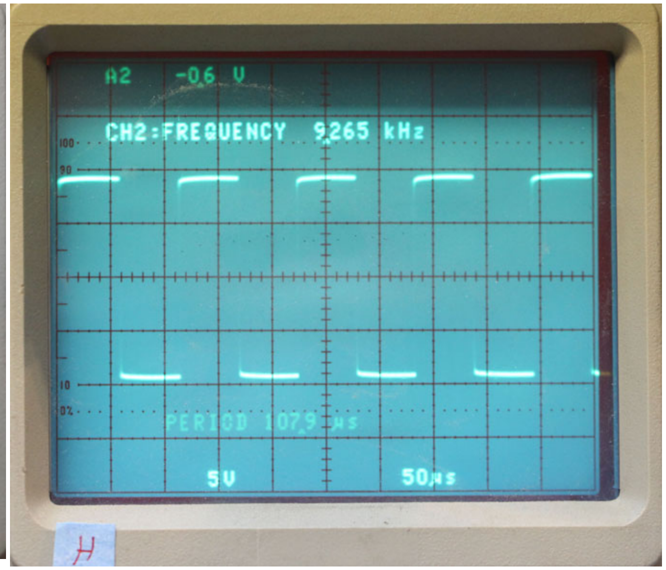
CKT H

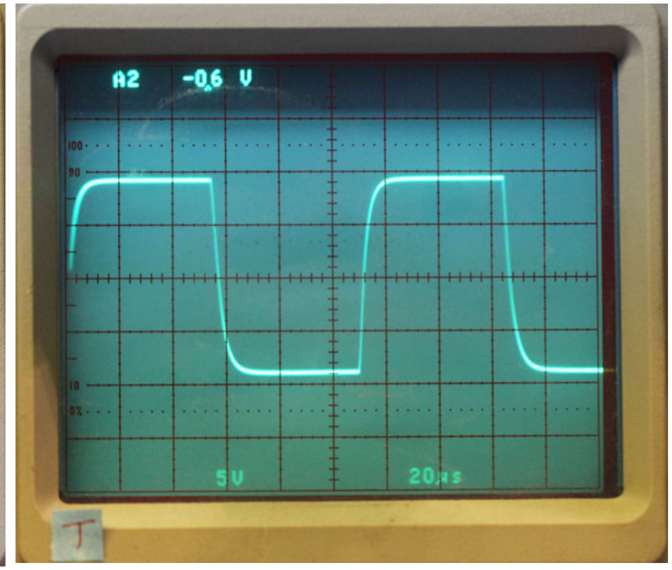
Very small change in gain with load to no load
Av = 12
THD + Noise = 0.2%
R54 = 15K

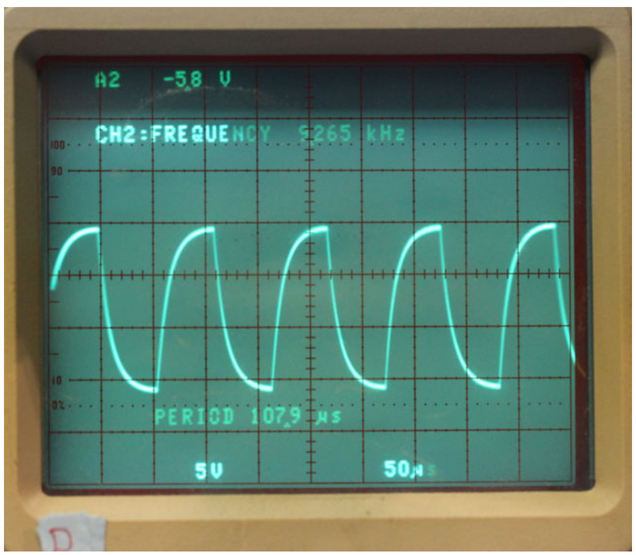
CKT I

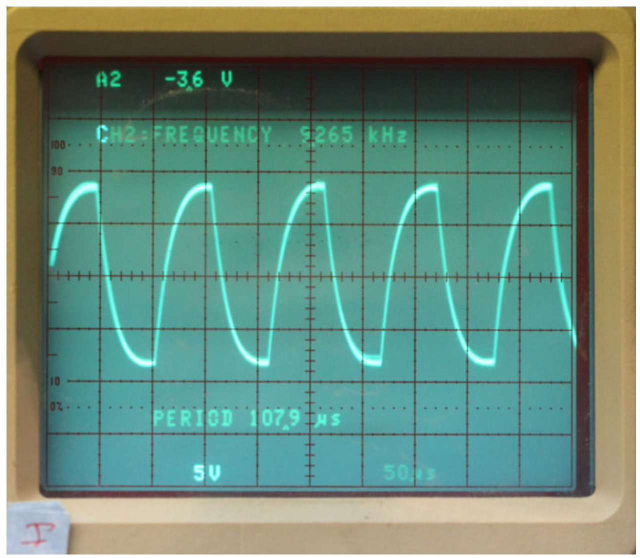
Very small change in gain with load to no load
Av = 330 with load   Av = 339 no load
THD + Noise is mostly noise
The FFT is 20 averages











Square wave measurements are reminder that there are more considerations than sine wave THD measurements. When negative feedback is applied in an amplifier time domain issues can result.

All measurements here are a 10KHz source (9.2KHz source) the frequency is not important