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KT88 PP - Dotting the i's, crossing the t's

SSassen · 2022-02-22 6:33 am

SSassen
Member

2022-02-22 6:33 am

#1

Alright, the subject is pretty self explanatory, I'm at that stage of a design where I'm dotting the i's and crossing the t's. Below is the schematic which represents the status quo of the current prototype with an actual measurement of THD v.s. output power at 1kHz included. I've obviously tried just about every trick in the book, hence the fact this is the 30th revision of the prototype schematics, some revisions were small just a resistor value change, some larger, and I am hoping to get some suggestions on how to improve THD > 20W, as currently the THD rises significantly after that point. I have the prototype on the bench, and the simulation running on the PC and interested to try suggestions, as I'm sure there's still room for improvement! Looking forward to your replies!

Attachments

[\(URL: /community/attachments/proto30_schematic-jpg.1027940/\)](/community/attachments/proto30_schematic-jpg.1027940/)

proto30_schematic.jpg

494.5 KB · Views: 199

[\(URL: /community/attachments/proto30_thd_vs_pow_1khz-jpg.1027941/\)](/community/attachments/proto30_thd_vs_pow_1khz-jpg.1027941/)

proto30_thd_vs_pow_1khz.jpg

193.4 KB · Views: 201

Mediocre is not my middle name.

B

baudouin0
Member

2022-02-22 7:03 am

#2

What's the UL tap at?

SSassen
Member

2022-02-22 7:08 am

#3

baudouin0 said: [\(URL: /community/goto/post?id=6949775\)](/community/goto/post?id=6949775)

What's the UL tap at?

A few Volts below the B+.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 7:23 am

🔗 📌 #4

Sorry what percentage UL?



SSassen
Member



2022-02-22 7:28 am

🔗 📌 #5

baudouin0 said: (URL: /community/goto/post?id=6949787)

Sorry what percentage UL?

40%, just your regular old UL transformer, nothing special really.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 7:33 am

🔗 📌 #6

Ok then because the transformer windings are tightly coupled then $L1 = L2 = (.40/2)^2 \cdot L_a$ and $L4 = L5 = (.60/2)^2 \cdot L_a$ where L_a is the total primary inductance.



SSassen
Member



2022-02-22 7:35 am

🔗 📌 #7

Oh wait, I should've mentioned that, don't mind the transformer values in the LTspice schematic, those are anything but accurate.

Mediocre is not my middle name.



petertub
Member



2022-02-22 8:08 am

🔗 📌 #8

The LTP phasesplitter is inherently unbalanced as shown.



SSassen
Member



2022-02-22 8:11 am

🔗 📌 #9

petertub said: (URL: /community/goto/post?id=6949829)

The LTP phasesplitter is inherently unbalanced as shown.

Why is that? Both on the bench and in the simulator I see exemplary performance with the anodes being within a few 10s of mV of each other, unless you know something I don't?

Mediocre is not my middle name.

Bbaudouin0
Member

2022-02-22 9:38 am

#10

I think to analyze distortion you need a reasonably accurate match of the transformer - in particular the UL % position. I would also expect that without a CCS in the LTP tail the anode AC voltage swings would be different causing 2nd harmonic distortion. You can get round this by making the plate resistors non equal which will get the AC right and the DC wrong.

Bbaudouin0
Member

2022-02-22 9:39 am

#11

You could add a transistor current mirror there or maybe a ef86 would work?

SSassen
Member

2022-02-22 9:42 am

#12

I tried a CCS and a rather elaborate CCS for the LTP, but all of these attempts resulted in worse THD results, even with the operating conditions of the 6922 being exactly the same. What I haven't tried yet I now realize is a CCS with a series resistor on top, not sure whether that would make a big difference, but certainly something I can try.

Mediocre is not my middle name.

SSassen
Member

2022-02-22 9:46 am

#13

What's also interesting is that by looking at the idle current through the KT88s the distortion drops significantly from 50-60-70mA, see attached measurements, top is 50mA, middle 60mA and bottom 70mA. What doesn't change, which is what I was hoping for, is the point where the distortion starts to climb, around the 20W mark. I kind of hoped this would be the point the amplifier switched to class-B and thus a higher idle current would push that further out. It seems like this however is caused by the input section lacking the needed gain to correct the distortion at higher power.

Attachments

([URL: /community/attachments/proto32_bias_current_kt88-jpg.1028023/](/community/attachments/proto32_bias_current_kt88-jpg.1028023/))

proto32_bias_current_kt88.jpg

199.9 KB · Views: 30

Mediocre is not my middle name.

petertub
Member

2022-02-22 12:20 pm

#14

SSassen said: ([URL: /community/goto/post?id=6949833](/community/goto/post?id=6949833))

Why is that? Both on the bench and in the simulator I see exemplary performance with the anodes being within a few 10s of mV of each other, unless you know something I don't?

Reason is that amplification is not infinite, thus the right half will have lower plate swing. Some compensates with differing plate resistors, other uses a pot used to minimise dist (AC balance)
Better would be to use a concertina that is inherently balanced and needs no adjustment.

W

wg_ski
Member



2022-02-22 12:56 pm

< □ #15

A concertina is no *guarantee* of balance - I've had 12ax7's that were pretty darn unbalanced. And you cannot get as much voltage swing from one as you can with an LTP.

B

baudouin0
Member



2022-02-22 2:52 pm

< □ #16

Does your simulation show the same problem or is it different. Could you zip it up so we can take a look please.



SSassen
Member



2022-02-22 2:59 pm

< □ #17

baudouin0 said: ([URL: /community/goto/post?id=6949903](/community/goto/post?id=6949903))

I think to analyze distortion you need a reasonably accurate match of the transformer - in particular the UL % position. I would also expect that without a CCS in the LTP tail the anode AC voltage swings would be different causing 2nd harmonic distortion. You can get round this by making the plate resistors non equal which will get the AC right and the DC wrong.

I'm analyzing distortion with measurements on the prototype, at this point the simulation is merely used to check operating points and to try out ideas before modifying the prototype.

baudouin0 said: ([URL: /community/goto/post?id=6950211](/community/goto/post?id=6950211))

Does your simulation show the same problem or is it different. Could you zip it up so we can take a look please.

There's no problem, I'm merely asking for suggestions on improving this design further. Things I haven't thought of, stuff that can't be found in any of the tube design related books, i.e. practical tips that would show results on the bench. I'd be happy to zip up the simulation though and post it here.

Mediocre is not my middle name.



jhstewart9
Member



2022-02-22 3:04 pm

< □ #18

SSassen said: ([URL: /community/goto/post?id=6949756](/community/goto/post?id=6949756))

Alright, the subject is pretty self explanatory, I'm at that stage of a design where I'm dotting the i's and crossing the t's. Below is the schematic which represents the status quo of the current prototype with an actual measurement of THD v.s. output power at 1kHz included. I've obviously tried just about every trick in the book, hence the fact this is the 30th revision of the prototype schematics, some revisions were small just a resistor value change, some larger, and I am hoping to get some suggestions on how to improve THD > 20W, as currently the THD rises significantly after that point. I have the prototype on the bench, and the simulation running on the PC and interested to try suggestions, as I'm sure there's still room for improvement! Looking forward to your replies!

Looks a lot like a Mullard 5-20, a bullet proof design with a good record.
So what is the problem? Just build & expect good results. And enjoy.

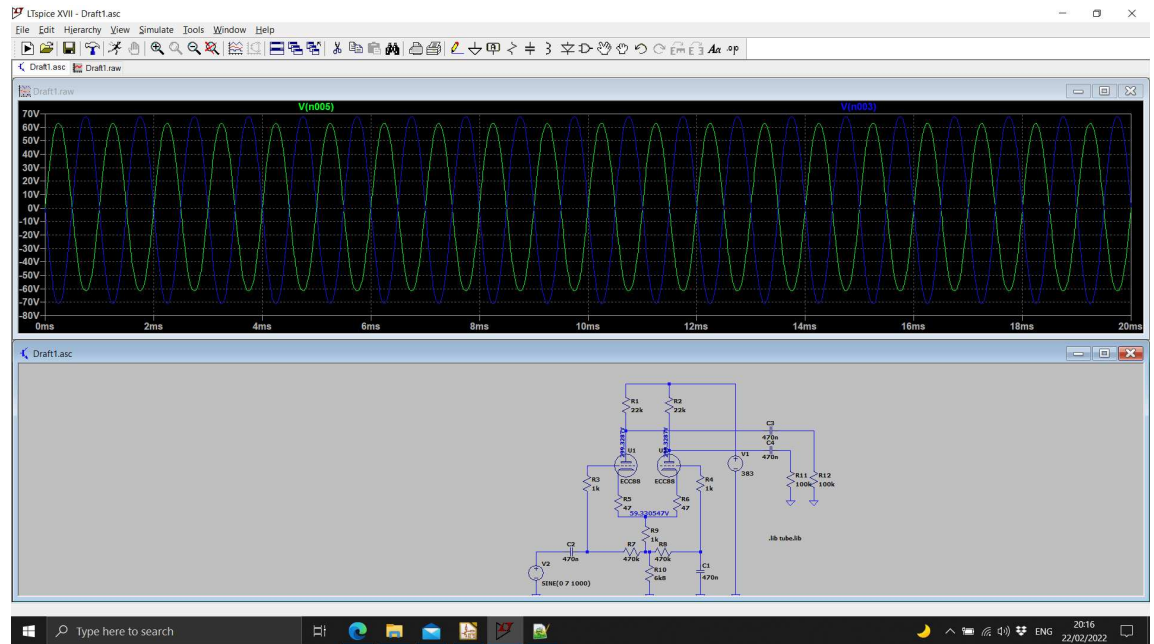
B

baudouin0
Member



2022-02-22 3:17 pm

#19



B

baudouin0
Member



2022-02-22 3:17 pm

#20

Don't think this is the problem but this shows the AC imbalance with such a setup.



SSassen
Member



2022-02-22 3:27 pm

#21

jhstewart9 said: ([URL: /community/goto/post?id=6950229](https://community.goto/post?id=6950229))

Looks a lot like a Mullard 5-20, a bullet proof design with a good record.
So what is the problem? Just build & expect good results. And enjoy.

It doesn't, it is nowhere near what I've shown in the first post. How do I know? Because that's one of the 1st designs I prototyped just to have a baseline.

Mediocre is not my middle name.



SSassen
Member



2022-02-22 3:30 pm

#22

baudouin0 said: ([URL: /community/goto/post?id=6950241](https://community.goto/post?id=6950241))

Don't think this is the problem but this shows the AC imbalance with such a setup.

Thanks! Yes, I am aware of that, on the prototype the right 22K anode resistor actually has a 5K trimmer in series which is used to make sure both outputs match to within a few mV.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 3:32 pm

↩ 📌 #23

This would be my version with a bit more swing.

Attachments

([URL: /community/attachments/screenshot-109-png.1028151/](/community/attachments/screenshot-109-png.1028151/))

Screenshot (109).png

40.3 KB · Views: 50

B

baudouin0
Member



2022-02-22 3:35 pm

↩ 📌 #24

Anyway you wanted i dotting and t crossing. Still don't know why the distortion suddenly increases. You would expect it move with bias as class B will be later.



SSassen
Member



2022-02-22 3:42 pm

↩ 📌 #25

baudouin0 said: ([URL: /community/goto/post?id=6950253](/community/goto/post?id=6950253))

This would be my version with a bit more swing.

Thanks! I tried that, and without the large tail resistor distortion is at least a factor 4x worse. My take on this is that the distortion profile of the LTP set up in the way I have it configured must be the inverse of the output section as when the global loop closes they, partially, cancel out.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 3:48 pm

↩ 📌 #26

You are correct in saying that the rounding of the peaks of the waveform in the LTP actually does compensate for the distortion in the output stage. Sort of distortion cancellation. In fact if you look at the drive to the output devices you will find the NFB has rounded the drive waveforms. However I am not sure such distortion cancellation can be relayed upon and in my view its better to design linear. I don't know if 43% UL may be a bit high.

B

baudouin0
Member



2022-02-22 3:51 pm

↩ 📌 #27

I think when I looked at this before two 6550's in parallel at 430V was more linear than a KT88 at 530V.



SSassen
Member



2022-02-22 4:02 pm

↩ 📌 #28

baudouin0 said: ([URL: /community/goto/post?id=6950258](/community/goto/post?id=6950258))

Anyway you wanted i dotting and t crossing. Still don't know why the distortion suddenly increases. You would expect it move with bias as class B will be later.



Yes, please look at the measurements with the different current settings for the KT88s I posted earlier, you'd expect the point where the amplifier enters class-B to move with the current setting (i.e. lower current it shifts to the left, higher current shifts to the right). The fact that it doesn't and the point where the distortion starts to increase is the same for all, hence the cause for this lays elsewhere.

My take on what causes this is that the LTP runs out of headroom, which I plan to test tomorrow by providing it with a higher supply voltage, to see if this point moves.

Mediocre is not my middle name.



jhstewart9
Member



2022-02-22 4:02 pm

< □ #29

SSassen said: ([URL: /community/goto/post?id=6950248](/community/goto/post?id=6950248))

It doesn't, it is nowhere near what I've shown in the first post. How do I know? Because that's one of the 1st designs I prototyped just to have a baseline.

Proto 30 is definitely the basic Mullard 5-20, of which there are many iterations since its introduction in 1956.

66 yrs ago. Shew us where your cct Proto 30 is significantly different. I'm curious.

Attachments

([URL: /community/attachments/mullard-520-200-dpi_0001-jpg.1028158/](/community/attachments/mullard-520-200-dpi_0001-jpg.1028158/))

Mullard 520 200 dpi_0001.jpg

614.4 KB · Views: 35

([URL: /community/attachments/mullard-520-200-dpi_0002-jpg.1028159/](/community/attachments/mullard-520-200-dpi_0002-jpg.1028159/))

Mullard 520 200 dpi_0002.jpg

532.8 KB · Views: 36

([URL: /community/attachments/mullard-520-200-dpi_0003-jpg.1028160/](/community/attachments/mullard-520-200-dpi_0003-jpg.1028160/))

Mullard 520 200 dpi_0003.jpg

644.5 KB · Views: 32

([URL: /community/attachments/mullard-520-200-dpi_0004-jpg.1028161/](/community/attachments/mullard-520-200-dpi_0004-jpg.1028161/))

Mullard 520 200 dpi_0004.jpg

233.8 KB · Views: 24

B

baudouin0
Member



2022-02-22 4:08 pm

< □ #30

Yes rounding to tops of the waveform with the LTP plate voltage could easily lead to early clipping - but still don't think that's it. Your not overloading the distortion measurement.



SSassen
Member



2022-02-22 4:13 pm

< □ #31

jhstewart9 said: ([URL: /community/goto/post?id=6950290](/community/goto/post?id=6950290))

Proto 30 is definitely the basic Mullard 5-20, of which there are many iterations since its introduction in 1956.

66 yrs ago. Shew us where your cct Proto 30 is significantly different. I'm curious.

Look at the THD vs. output power measurement I included, now show me a Mullard 5-20 design that

does the same or better. They don't, I looked at them in great detail in the simulator and have built a few variations to get a handle on what they're capable of and they don't offer this level of THD performance. But am welcome to try any suggestions you might have as you have far more experience than I do, I'm just a nitpicking perfectionist that bites down on something and won't let go until I have extracted every last bit of performance from it.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 4:15 pm

< □ #32

If you fancy pre-distorting the signal look at this sort of thing

Hybrid amplifiers and soft-clipping circuit (URL: <https://www.tubecad.com/2006/05/blog0066.htm>)



SSassen
Member



2022-02-22 4:15 pm

< □ #33

baudouin0 said: (URL: </community/goto/post?id=6950297>)

Yes rounding to tops of the waveform with the LTP plate voltage could easily lead to early clipping - but still don't think that's it. Your not overloading the distortion measurment.

Yes, I'm not sure yet either, would love to hear your thoughts though, and/or try to get a handle on the mechanism at play here if you have suggestions for things to try?

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 4:17 pm

< □ #34

I think I would ask - does anything move that nee point.



SSassen
Member



2022-02-22 4:22 pm

< □ #35

baudouin0 said: (URL: </community/goto/post?id=6950306>)

If you fancy pre-distorting the signal look at this sort of thing

Hybrid amplifiers and soft-clipping circuit (URL: <https://www.tubecad.com/2006/05/blog0066.htm>)

On that note, one thing that puzzled me is that decoupling the 10R kathode resistors for the KT88s reduced distortion across the board. I didn't expect that as effectively, without the decoupling, they see a little local feedback so the net distortion for the output stage should be lower without decoupling. So there's certainly a distortion cancellation mechanism at play here, which, consequently, only shows with a 6922 (any brand, I tried EH, JJ and NOS), substitute for a ECC82/ECC99 and the distortion is much, much higher.

Mediocre is not my middle name.



2022-02-22 4:23 pm

< □ #36

SSassen
Member



baudouin0 said: (URL: /community/goto/post?id=6950309)

I think I would ask - does anything move that nee point.

Nothing I've tried thusfar seems to, I plan on increasing the supply voltage to the LTP in 20V increments tomorrow to see what that does.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-22 4:25 pm

< □ #37

Does it shift with frequency?

B

baudouin0
Member



2022-02-22 4:26 pm

< □ #38

Yes I think you've got some distortion cancellation taking place. It will be more obvious with the NFB disconnected.



SSassen
Member



2022-02-22 4:29 pm

< □ #39

baudouin0 said: (URL: /community/goto/post?id=6950321)

Does it shift with frequency?

Marginally, repeating the same THD vs. output power measurement at 100Hz shows pretty much the same result, at 10kHz the knee starts earlier but that's mostly due to the fact THD at 10kHz is higher to begin with.

Mediocre is not my middle name.



SSassen
Member



2022-02-22 4:37 pm

< □ #40

baudouin0 said: (URL: /community/goto/post?id=6950309)

I think I would ask - does anything move that nee point.

P.s. if I swap the OPT for any of the others (similar specs.) I have I basically get the same result, which tells me the OPT is not a contributing factor in all this, or at least not specific to one type/model.

Mediocre is not my middle name.



jhstewart9
Member



2022-02-22 9:20 pm

< □ #41

Problem solved, follow the examples. The Mullard long tailed inverter has no problem driving the output.

The 2nd sim shews your long tailed pair, looks OK driven by One Volt.

In the 3rd 2V starts to shew some clipping, not enough p-p to drive the output.

The 4th shews 2.5V, overload.

The 5th is biased up like the Mullard & easily drives the output. The balance is also a little better.

There are other ways to get here, but this works well.

Attachments

([URL: /community/attachments/mullard-520-long-tailed-pair-jpg.1028246/](/community/attachments/mullard-520-long-tailed-pair-jpg.1028246/))

Mullard 520 Long Tailed Pair.JPG

61.4 KB · Views: 51

([URL: /community/attachments/proto-a-jpg.1028247/](/community/attachments/proto-a-jpg.1028247/))

Proto A.JPG

60.3 KB · Views: 44

([URL: /community/attachments/proto-b-jpg.1028248/](/community/attachments/proto-b-jpg.1028248/))

Proto B.JPG

63.6 KB · Views: 41

([URL: /community/attachments/proto-c-jpg.1028249/](/community/attachments/proto-c-jpg.1028249/))

Proto C.JPG

57.3 KB · Views: 45

([URL: /community/attachments/proto-e-jpg.1028250/](/community/attachments/proto-e-jpg.1028250/))

Proto E.JPG

60 KB · Views: 46

Z

zintolo
Member



2022-02-23 4:34 am

◀ ◻ #42

SSassen said: ([URL: /community/goto/post?id=6949802](/community/goto/post?id=6949802))

Oh wait, I should've mentioned that, don't mind the transformer values in the LTspice schematic, those are anything but accurate.

I agree with you on the reliability of most if not all OPT models, but using a different voltage ratio between anode and screens and a different reflected impedance will change alot the behaviour of the output tubes, so at least I would put it right in the simulation. The OPT is a 4k-8 Ohm (based on the 22.3 ratio written as note).

I'd suggest you to set the data based on the OPT you'll use just to give the right voltage ratio to screens and load to the output tubes:

With your current 3 to 1 ratio (15 and 5H), UL ratio is 36.6% and primary inductance 150 H, so you should have 300 mH on the 8 Ohm secondary tap.

With 100 mH on 8 Ohm on the secondary, reflected impedance is 12k.

E.G. with a primary inductance of 427 H (I've used Toroidy's value) a 40% tap will be:

$L1 = L2 = 427 \text{ H} \times 0.2^2 = 17.08 \text{ H}$

$L4 = L5 = 427 \text{ H} \times 0.3^2 = 38.43 \text{ H}$

$L3 = 427 \text{ H} \times (8 / 4000) = 854 \text{ mH}$

B

baudouin0
Member



2022-02-23 5:58 am

◀ ◻ #43

Couple of other suggestions. Take a look at the driver waveforms on the grids of the output tubes. This is what the NFB is having to do to correct the distortion. Sometimes you can get HF instability which only occurs when the signals get larger. If you see this often reducing the resistor on the dominate pole (R37) helps a lot.



SSassen
Member



2022-02-23 6:01 am

< □ #44

zintolo said: (URL: /community/goto/post?id=6950713)

I agree with you on the reliability of most if not all OPT models, but using a different voltage ratio between anode and screens and a different reflected impedance will change alot the behaviour of the output tubes, so at least I would put it right in the simulation. The OPT is a 4k-8 Ohm (based on the 22.3 ratio written as note).

Click to expand... (URL:)

Thanks! I dusted off the R&S LCR bridge and took some measurements of the Ogonowski LO-PP80-1 OPT, here's what I found, these values may seem low, but take note these are at 1kHz as that's the frequency I'm using in the simulator for modelling the amplifier, so it seemed wrong to use 50Hz measurement data. Also the LCR bridge tops out at 1.5Vpp, which may not be enough to get an accurate measurement. I'm measuring the OPT without anything connected between the Anode, UL and B+ connections, so I'm measuring one half of the PP transformer.

Primary LO-PP80-1

Anode to UL > 1.88H > Rdc=36.3 Ohm

UL to B+ > 1.2H > Rdc=23.6 Ohm

Secondary LO-PP80-1

8 Ohm winding > 67mH > Rdc=0.5 Ohm

I also measured parasitic inductance, which is the parasitic part of the primary winding that's not coupled to the secondary. I measured parasitic inductance by shorting the secondary 8 Ohm winding leaving the 4 Ohm winding open and measured between Anode and B+ on the OPT.

Parasitic inductance

5.8mH

Since I had the tools out I also wanted to take a look at parasitic capacitance. Which I measured by shorting the Anode, UL and B+ on the primary side and the 8 Ohm winding on the secondary side individually and subsequently measuring the capacitance between these shorted primary and secondary windings.

Parasitic capacitance

3.4nF

I added these in the schematic, see attached, and ran some simulations, but I get the distinct impression this still doesn't accurately reflect reality?

Attachments

(URL: /community/attachments/proto33_schematic-jpg.1028341/)

proto33_schematic.jpg

486.5 KB · Views: 27

Mediocre is not my middle name.

B

2022-02-23 6:06 am

< □ #45

Nop the leakage inductance sets the coupling factor. The primary capacitance is just across the total



primary.
Here's an example

```
* Model of 100PP2K2S transformer
.SUBCKT 100PP2K2S 100 102 104 106 108 204 202 200
.PARAM Lp=670 ; TOTAL PRIMARY L (FROM SPECS).
.PARAM Rp=190 ; TOTAL PRIMARY R (FROM SPECS).
.PARAM Tap=.35
.PARAM Leak=3.8e-3
.PARAM Rs=.08 ; SECONDARY R (FROM SPECS).
.PARAM Rs2=.07 ; SECONDARY R (FROM SPECS).
.PARAM Lrat={4/2200} ; INDUCTANCE RATIO: (4 OHMS)/(PRIMARY).
.PARAM Cp=345p
.PARAM QFCTR={Lp/Leak} ; Q-FACTOR
L10 100 101 {Lp*(1-Tap)(1-Tap).25}
R10 101 102 {Rp*(1-Tap)*.5}
L11 102 103 {Lp*Tap*Tap*.25}
R11 103 104 {Rp*Tap*.5}
L12 104 105 {Lp*Tap*Tap*.25}
R12 105 106 {Rp*Tap*.5}
L13 106 107 {Lp*(1-Tap)(1-Tap).25}
R13 107 108 {Rp*(1-Tap)*.5}
C10 100 108 {Cp}
L20 200 201 {Lp*Lrat}
R20 201 202 {Rs}
L21 202 203 {Lp*Lrat*1.412}
R21 203 204 {Rs2}
K1 L10 L11 L12 L13 L20 L21 {1-1/(2*QFCTR)}
.ENDS
```

Some of the * keep getting deleted but its obvious

Last edited: 2022-02-23 6:12 am

B



2022-02-23 6:07 am

< □ #46

Symbol:

```
Version 4
SymbolType CELL
LINE Normal -19 -160 -47 -160
LINE Normal -19 -64 -48 -64
LINE Normal -19 0 -48 0
LINE Normal -19 64 -48 64
LINE Normal -19 160 -48 160
LINE Normal -1 163 -1 -163 1
LINE Normal 1 163 1 -163 1
LINE Normal 48 48 19 48
LINE Normal 48 80 19 80
LINE Normal 48 64 19 64
ARC Normal -27 0 -10 16 -19 16 -19 0
ARC Normal -27 16 -10 32 -19 32 -19 16
ARC Normal -27 32 -10 48 -19 48 -19 32
ARC Normal -27 48 -10 64 -19 64 -19 48
ARC Normal -27 -64 -10 -48 -19 -48 -19 -64
ARC Normal -27 -48 -10 -32 -19 -32 -19 -48
ARC Normal -27 -32 -10 -16 -19 -16 -19 -32
ARC Normal -27 -16 -10 0 -19 0 -19 -16
```

ARC Normal -27 -80 -10 -64 -19 -64 -19 -80
ARC Normal -27 64 -10 80 -19 80 -19 64
ARC Normal 27 48 10 64 19 48 19 64
ARC Normal 27 64 10 80 19 64 19 80
ARC Normal -27 -144 -10 -128 -19 -128 -19 -144
ARC Normal -27 -128 -10 -112 -19 -112 -19 -128
ARC Normal -27 -112 -10 -96 -19 -96 -19 -112
ARC Normal -27 -96 -10 -80 -19 -80 -19 -96
ARC Normal -27 -160 -10 -144 -19 -144 -19 -160
ARC Normal -27 80 -10 96 -19 96 -19 80
ARC Normal -27 96 -10 112 -19 112 -19 96
ARC Normal -27 112 -10 128 -19 128 -19 112
ARC Normal -27 128 -10 144 -19 144 -19 128
ARC Normal -27 144 -10 160 -19 160 -19 144
WINDOW 3 16 -144 Left 2
WINDOW 0 16 -112 Left 2
SYMATTR Value 100PP2K2S
SYMATTR Prefix X
PIN -48 -160 NONE 8
PINATTR PinName Blu
PINATTR SpiceOrder 1
PIN -48 -64 NONE 8
PINATTR PinName Blu/Yel
PINATTR SpiceOrder 2
PIN -48 0 NONE 8
PINATTR PinName Red
PINATTR SpiceOrder 3
PIN -48 64 NONE 8
PINATTR PinName Brn/Yel
PINATTR SpiceOrder 4
PIN -48 160 NONE 8
PINATTR PinName Brn
PINATTR SpiceOrder 5
PIN 48 48 NONE 8
PINATTR PinName Grn/Yel
PINATTR SpiceOrder 6
PIN 48 64 NONE 8
PINATTR PinName Grn/Yel1
PINATTR SpiceOrder 7
PIN 48 80 NONE 8
PINATTR PinName Blk/Yel
PINATTR SpiceOrder 8



SSassen
Member



2022-02-23 6:15 am

↩ 📌 #47

Can't seem to get that running, here's the .asc and the relevant libs, perhaps you could have a look at the transformer model?

B

baudouin0
Member



Attachments



(URL: /community/attachments/kt88_pp_amp_033-zip.1028342/)



Let me zip it up as there seems to be an issue with cut and paste. The code is in trans.lib

Attachments



(URL: </community/attachments/vamp3-zip.1028343/>)

vamp3.zip

39.2 KB · Views: 12

B

baudouin0
Member



2022-02-23 6:25 am



#49

If your struggling still I can look later today.



SSassen
Member



2022-02-23 7:34 am



#50

baudouin0 said: (URL: </community/goto/post?id=6950753>)

If your struggling still I can look later today.

Thanks! I think I got most of it up and running, but for an odd squiggle in the gain plot. Would certainly appreciate it if you could check whether I'm not doing something monumentally stupid though. I have a pair of Hammond 1650R sitting on the shelf, so seemed logical to use that model so I can check the simulation with data from the actual prototype. Screenshot and zip archive with the latest (and greatest?) attached.

Attachments



(URL: /community/attachments/kt88_pp_amp_034-zip.1028366/)

kt88_pp_amp_034.zip

48.1 KB · Views: 14

(URL: /community/attachments/proto34_schematic_plot-jpg.1028367/)

proto34_schematic_plot.jpg

308.2 KB · Views: 26

SSassen
Member

2022-02-23 7:50 am

#51

jhstewart9 said: ([URL: /community/goto/post?id=6950532](/community/goto/post?id=6950532))

Problem solved, follow the examples. The Mullard long tailed inverter has no problem driving the output.

The 2nd sim shews your long tailed pair, looks OK driven by One Volt.

In the 3rd 2V starts to shew some clipping, not enough p-p to drive the output.

The 4th shews 2.5V, overload.

The 5th is biased up like the Mullard & easily drives the output. The balance is also a little better.

There are other ways to get here, but this works well.

Thanks John! I tried your suggestion, but it doesn't result in a working amplifier, the lower half of the sine is compressed, resulting in distortion levels measured to be >5%. In one of my earlier prototypes I tried a similar configuration which also didn't fare too well, please see attached.

Attachments

([URL: /community/attachments/proto27_schematic-jpg.1028374/](/community/attachments/proto27_schematic-jpg.1028374/))

proto27_schematic.jpg

506 KB · Views: 19

Mediocre is not my middle name.

SSassen
Member

2022-02-23 8:29 am

#52

SSassen said: ([URL: /community/goto/post?id=6950795](/community/goto/post?id=6950795))

Thanks John! I tried your suggestion, but it doesn't result in a working amplifier, the lower half of the sine is compressed, resulting in distortion levels measured to be >5%. In one of my earlier prototypes I tried a similar configuration which also didn't fare too well, please see attached.

Okay John, I took another stab at it, by raising the value of the tail resistor R26 to 18K (from 10K) this results in a working amplifier, however the performance is not at the same level as the configuration I originally posted, please see attached. I think this shows that another mechanism is at play that causes for the THD to rise when Pout>20W, do you perhaps have any other suggestions?

Attachments

([URL: /community/attachments/proto34_jhstewart_thd_vs_pow_1khz-jpg.1028389/](/community/attachments/proto34_jhstewart_thd_vs_pow_1khz-jpg.1028389/))

proto34_jhstewart_thd_vs_pow_1khz.jpg

190.7 KB · Views: 25

([URL: /community/attachments/proto34_jhstewart_schematic_plot-jpg.1028390/](/community/attachments/proto34_jhstewart_schematic_plot-jpg.1028390/))

proto34_jhstewart_schematic_plot.jpg

482.9 KB · Views: 25

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-23 10:32 am

< □ #53

I would have concerns taking some of the NFB to the plate of the LPT. This is because when that output valve goes out of conduction in higher power - that part of the loop will no longer have any effect so may make for HF burst on that part of the cycle. Consider taking the NFB just to the first stage.



SSassen
Member



2022-02-23 10:45 am

< □ #54

baudouin0 said: (URL: /community/goto/post?id=6950930)

I would have concerns taking some of the NFB to the plate of the LPT. This is because when that output valve goes out of conduction in higher power - that part of the loop will no longer have any effect so may make for HF burst on that part of the cycle. Consider taking the NFB just to the first stage.

Yeah, that makes sense, I'm just playing with compensation at this point and this was one of the ideas that proved to be effective.

Mediocre is not my middle name.

W

wg_ski
Member



2022-02-23 11:03 am

< □ #55

It's not actually feedback from the output back to the 2nd stage plate, it's nested feedback from the 2nd stage plate to the summing node. It's the "tube" equivalent of taking the lead compensation from the output of the VAS rather than the speaker out. It's a trick you can use to get higher levels of NFB before it sings - I do it this way all the time on big solid state amps with massively parallel output stages. The idea is that high frequency feedback (above audio) comes back without the phase shift through the output stage, letting you get away with low fT output transistors. The voltage "gain" from the LTP through the output tubes and trafo is usually under unity for UL connection. Needs to be in order to work properly. It often takes experimentation to get it right. In a tube circuit, it may help you out with stability margin if your output trafo is rolling off a bit too fast for the level of NFB you want. Just another tool in the box.

B

baudouin0
Member



2022-02-23 12:10 pm

< □ #56

Could you zip your latest offering so I can take a look. I have an interest in looking at distortion too. Cheers.



SSassen
Member



2022-02-23 3:30 pm

< □ #57

baudouin0 said: (URL: /community/goto/post?id=6951030)

Could you zip your latest offering so I can take a look. I have an interest in looking at distortion too. Cheers.

Post #50 has the latest, including your transformer model. Thanks!

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-23 3:33 pm

↩ 📌 #58

Yes thats a large amount of NFB, I guess the series R C across the transformer primary is helping a lot.

B

baudouin0
Member



2022-02-23 3:38 pm

↩ 📌 #59

I tried dropping R33 to 390K to give bias of 100V to second stage but that's all I could find.



SSassen
Member



2022-02-23 4:40 pm

↩ 📌 #60

baudouin0 said: (URL: /community/goto/post?id=6951238)

Yes thats a large amount of NFB, I guess the series R C across the transformer primary is helping a lot.

To quote Bruno Putzeys: use Nfb and use lots of it ... 🤖

Mediocre is not my middle name.



SSassen
Member



2022-02-23 4:41 pm

↩ 📌 #61

baudouin0 said: (URL: /community/goto/post?id=6951247)

I tried dropping R33 to 390K to give bias of 100V to second stage but that's all I could find.

Thanks! I have something else on my mind, I'll try it out tomorrow and report back.

Mediocre is not my middle name.



jhstewart9
Member



2022-02-23 8:12 pm

↩ 📌 #62

The Sims of the Proto E6 series shew circuit conditions with & without signal for both 8K & 18K tail resistors. The input DC level has been adjusted to be compatible with the plate of the first pentode so that DC coupling may be used. One less LF problem.

The 8K tail sets the DC conditions correctly. But the drive voltages to the output stage are poorly matched. Clearly, another solution is needed.

In these Sims some of the scope traces are set at 100V/div while others are at 50V/div. All are DC connected so that the traces are offset by 300V so that they appear on screen.

The E8 series sims test a possible alternative using a SS device as a constant current. The SS could be an NPN transistor or a FET. This sim is running an idealized NPN transistor. Whatever is selected needs to run at ~125V. Some people have used an MJE340 in the Mullard 520.

Some builders use 3-terminal regulators set in the CC mode. And still others like me use a long resistor tail to -150V. And some simply set the plate resistors to ~10% different.

A simple vers takes current to drive the reference Zener from the cct cathodes. But that puts 100K in parallel with the CC device. A last cct derives Zener current from the 383V plate supply.

The SS tail provides a much better matched drive to the output tube grids. And a 3V signal at the input of this cct would drive the KT88 to full power.

On your last sim I see the voltage on the KT88 U2 to be +520V at the grid. And the plate -75V. Some simulators fail if there are too many parts to keep track of. U1 KT88 looks OK. That may be the cause of some of the results you are seeing.

Attachments

[\(URL: /community/attachments/proto-e6-8k-tail-no-signal-jpg.1028610/\)](/community/attachments/proto-e6-8k-tail-no-signal-jpg.1028610/)

Proto E6 8K Tail No Signal.JPG

54.6 KB · Views: 18

[\(URL: /community/attachments/proto-e6-8k-tail-jpg.1028611/\)](/community/attachments/proto-e6-8k-tail-jpg.1028611/)

Proto E6 8K Tail.JPG

56.5 KB · Views: 14

[\(URL: /community/attachments/proto-e6-18k-tail-no-signal-jpg.1028612/\)](/community/attachments/proto-e6-18k-tail-no-signal-jpg.1028612/)

Proto E6 18K Tail No Signal.JPG

55 KB · Views: 10

[\(URL: /community/attachments/proto-e6-18k-tail-jpg.1028613/\)](/community/attachments/proto-e6-18k-tail-jpg.1028613/)

Proto E6 18K Tail.JPG

54 KB · Views: 12

[\(URL: /community/attachments/proto-e8-ss-tail-10v-drive-jpg.1028614/\)](/community/attachments/proto-e8-ss-tail-10v-drive-jpg.1028614/)

Proto E8 SS Tail 10V Drive.JPG

59.3 KB · Views: 14

[\(URL: /community/attachments/proto-e8-ss-tail-8v-drive-jpg.1028615/\)](/community/attachments/proto-e8-ss-tail-8v-drive-jpg.1028615/)

Proto E8 SS Tail 8V Drive.JPG

57.8 KB · Views: 13

[\(URL: /community/attachments/proto-e8-ss-tail-3v-drive-jpg.1028616/\)](/community/attachments/proto-e8-ss-tail-3v-drive-jpg.1028616/)

Proto E8 SS Tail 3V Drive.JPG

58.4 KB · Views: 15

[\(URL: /community/attachments/proto-e8-ss-tail-3v-drive-scope-50v-per-div-jpg.1028617/\)](/community/attachments/proto-e8-ss-tail-3v-drive-scope-50v-per-div-jpg.1028617/)

Proto E8 SS Tail 3V Drive Scope 50v per Div.JPG

56.6 KB · Views: 19

[\(URL: /community/attachments/proto-e8-ss-tail-3v-drive-scope-50v-per-div-zener-from-hv-jpg.1028618/\)](/community/attachments/proto-e8-ss-tail-3v-drive-scope-50v-per-div-zener-from-hv-jpg.1028618/)

Proto E8 SS Tail 3V Drive Scope 50v per Div Zener from HV.JPG

60.6 KB · Views: 20

B

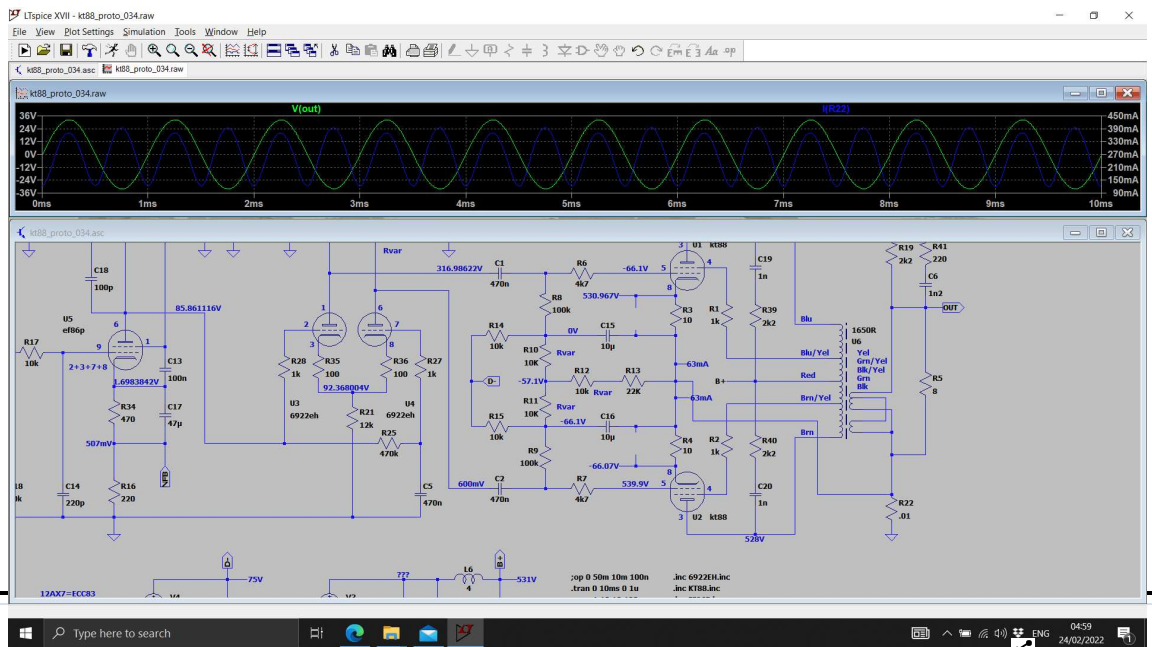
baudouin0
Member



2022-02-23 11:59 pm

← □ #63

Check that there is no way the ground currents from the output stage can get back into the input stage. Note the speaker - transformer ground is taken to the wrong place through a wire R22. At low levels the PP nature of the output stage keeps current in R22 constant but at high levels there is lots of 2nd harmonic.



B

baudouin0
Member



The SS tail Mr Stewart has another advantage. I like DC coupling of the first stage to the LPT as it makes the LF stability better. However the ef86 plate operating voltage is very variable from device to device. Adding a CCS in the second stage prevents the LPT plate voltages being a function of the ef86 plate voltage.

W

wg_ski
Member



2022-02-24 12:19 am

< > #65

baudouin0 said: (URL: /community/goto/post?id=6951603)

Check that there is no way the ground currents from the output stage can get back into the input stage. Note the speaker - transformer ground is taken to the wrong place through a wire R22. At low levels the PP nature of the output stage keeps current in R22 constant but at high levels there is lots of 2nd harmonic.

The speaker return side of the OPT should be connected directly (and only) to the grounded side of R16. I use shielded cable for the NFB, and that's the shield.

B

baudouin0
Member

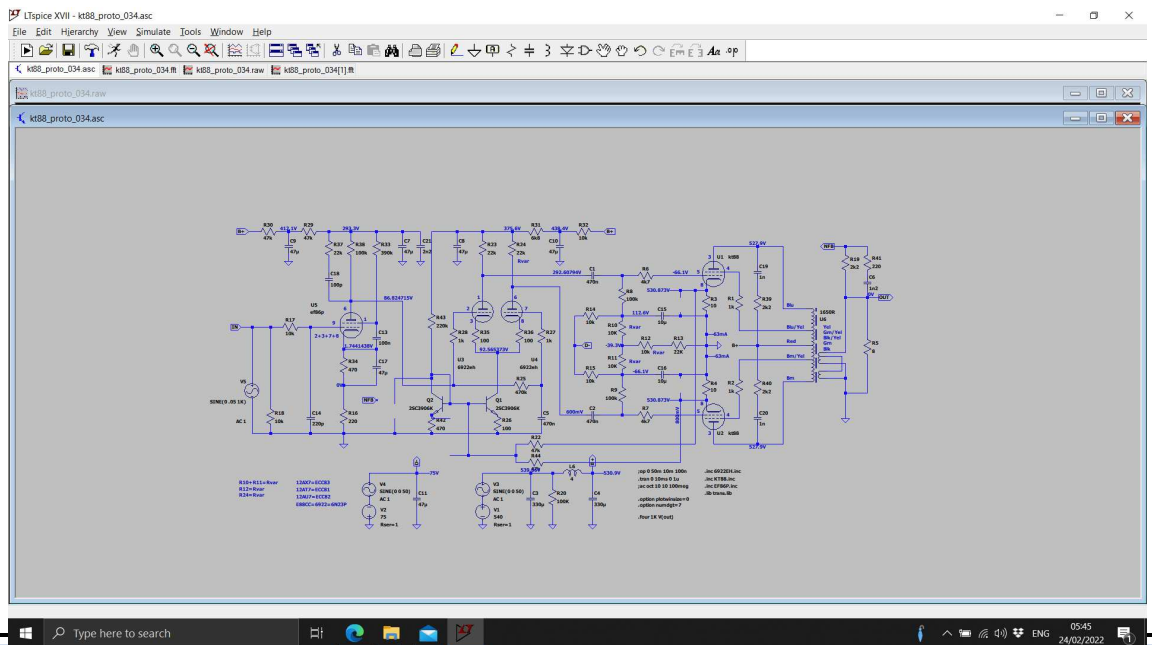


2022-02-24 12:36 am

< > #66

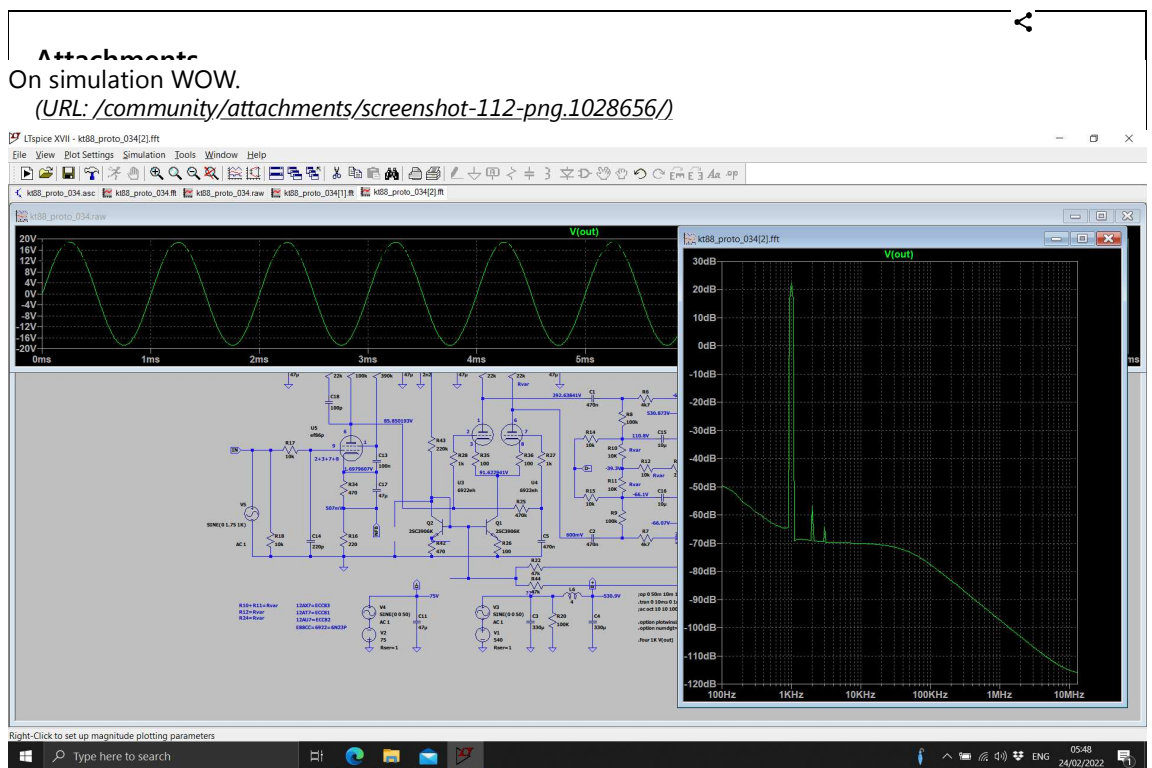
Yep agreed.

Here's my silly idea of the day. Take some of the current in the cathode resistors and use this to pre-distort the driver signal. Using a current mirror CCS its easy to do.



B

baudouin0
Member



SSassen
Member



2022-02-24 3:28 am

#68

baudouin0 said: (URL: /community/goto/post?id=6951623)

On simulation WOW.

View attachment 1028683 (URL: <https://www.diyaudio.com/community/attachments/1028683/>)

Ha! Nice idea! Tried that, see below schematics and measurements, doesn't seem to do much in reality?

Attachments

(URL: /community/attachments/proto35_schematic-jpg.1028711/)

proto35_schematic.jpg

512.8 KB · Views: 21

(URL: /community/attachments/proto35_35_alt_thd_vs_pow_1khz-jpg.1028712/)

proto35_35_alt_thd_vs_pow_1khz.jpg

197.3 KB · Views: 21

(URL: /community/attachments/proto35_alt_schematic-jpg.1028713/)

proto35_alt_schematic.jpg

518.9 KB · Views: 19

Mediocre is not my middle name.



SSassen
Member



2022-02-24 3:40 am

< □ #69

wg_ski said: (URL: /community/goto/post?id=6951609)

The speaker return side of the OPT should be connected directly (and only) to the grounded side of R16. I use shielded cable for the NFB, and that's the shield.

Yes, I actually use a continuous ground plane for the amplifier (not including the PSU obviously) and indeed hook the GND from the OPT directly to the grounded side of R16 via a shielded cable.

Mediocre is not my middle name.



SSassen
Member



2022-02-24 3:42 am

< □ #70

baudouin0 said: (URL: /community/goto/post?id=6951603)

The SS tail Mr Steward has another advantage. I like DC coupling of the first stage to the LPT as it makes the LF stability better. However the ef86 plate operating voltage is very variable from device to device. Adding a CCS in the second stage prevents the LPT plate voltages being a function of the ef86 plate voltage.

Yes, I'm going to try that next, expect an update today on how that worked out.

Mediocre is not my middle name.

Z

zintolo
Member



2022-02-24 3:46 am

< □ #71

Another option is to use a gyrator as load for the EF86, this way you can fix the output voltage to DC couple first and second stage.



SSassen
Member



2022-02-24 3:51 am

< □ #72

zintolo said: (URL: /community/goto/post?id=6951709)

Another option is to use a gyrator as load for the EF86, this way you can fix the output voltage to DC couple first and second stage.

You read my mind! That's on my todo list for today! Any suggestions?

SSassen
Member

2022-02-24 4:34 am

< □ #73

Okay, one thing I wanted to try and that's have the CCS also enforce balance by comparing the current through both anode resistors, please see attached schematic. The reasoning behind this is the following:

DC analysis

The two 220K resistors are equivalent to a single 110K resistance fed from the anodes of either section of the 6922.

AC analysis

If the two halves of the 6922 are perfectly balanced, one anode will be swinging more positive while the other is swinging more negative, and the combined AC voltage at the junction of the two 220k resistors will be zero, leaving only the DC component.

But when the two halves don't have identical Mu, and for example the input side has a higher gain than the feedback side of the pair, the voltage at the junction of the 220K resistors will be an AC signal, out of phase with the input signal. This causes an AC variation on the base voltage which in turn modulates the collector current in such a way as to place an AC signal on the cathodes in-phase with the input signal, of exactly the right amplitude to cancel out the excessive gain of the input side of the pair.

So consequently the AC balance of the LTP is now primarily dependent on the match of the two 220K resistors, and much less dependent on the intrinsic Mu or gain of each triode section. So now we have a self-balancing circuit without the need to balance the triode sections of the 6922, which also doubles as a very high impedance CCS and also a form of local feedback within this stage to improve balance.

How does this fare in practice? I don't see a direct improvement in the THD measurement, see attached measurement results nicely combined in one easy to read screenshot. Actually the 036 results are the top curve, which shows a slight rise in THD. Am I thus delusional and doesn't the above reasoning how this should work hold ground? Or am I simply measuring the wrong metric?

Attachments

(URL: /community/attachments/proto35_35_alt_036_thd_vs_pow_1khz-jpg.1028725/)

proto35_35_alt_036_thd_vs_pow_1khz.jpg

203 KB · Views: 22

(URL: /community/attachments/proto36_schematic-jpg.1028726/)

proto36_schematic.jpg

527.8 KB · Views: 22

Mediocre is not my middle name.

SSassen
Member

2022-02-24 6:01 am

< □ #74

Alright, I tried the alternative, simplified LTP that John suggested and baudouin0 simulated. Unfortunately there's very little wiggle room, I'll explain why from the schematic and the THD vs. output power measurements, see attached. The voltages listed in the measurement are the voltages at the collector of Q1, a MJE340, as the KSC1845 wouldn't tolerate such high voltages. At voltages <138V the distortion is >5%, simply because there's not enough voltage between the grid and the cathode of the 6922, so the triode is simply not conducting. At voltages >142V the distortion starts to rise again, and the anodes of the 6922 sit at >350V which is a fair bit over the 300V maximum. An optimum

seems to be around 138V. Take note that the calculated voltages in the schematic do not accurately reflect reality, that's why I've added voltages labeled with a *, these are the actual measured voltages.

Attachments

(URL: /community/attachments/proto37_voltages_thd_vs_pow_1khz-jpg.1028748/)

proto37_voltages_thd_vs_pow_1khz.jpg

202.2 KB · Views: 20

(URL: /community/attachments/proto37_schematic-jpg.1028749/)

proto37_schematic.jpg

516.4 KB · Views: 21

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-24 6:19 am

< □ #75

The AC balance of a CCS LPT is always good - as what goes up one plate does not go up the other - there is no where else for the current to go - does not depend on mu. Mu will affect gain however. The DC coupled approach does not actually save a coupling stage in the stability calculation - sorry. The other grid always tracks the first after a delay so the DC differential gain is zero - so its still the same as coupling the first stage to the LPT. I would make R1 R2 470R.

B

baudouin0
Member



2022-02-24 6:22 am

< □ #76

You can bias the grids right down to 0V with the current mirror as long as the worst case cathode AC voltage is enough to make the current mirror work. I think you are OK with E88CC.

B

baudouin0
Member



2022-02-24 6:23 am

< □ #77

I wonder if you would be better making your distortion measurements with the loop open. It should be easier to see whats occuring. You can make R39 and R40 quite small you only need about 300mV across them. This would get you current mirror down to <800mV on cathode. You could also bias the grids at say 10V if you need more headroom.

Last edited: 2022-02-24 6:30 am



jan.didden
Member



2022-02-24 6:24 am

< □ #78

SSassen said: (URL: /community/goto/post?id=6950317)

On that note, one thing that puzzled me is that decoupling the 10R kathode resistors for the KT88s reduced distortion across the board.

Sander, sorry to be late, but this caught my eye. To me that signifies that the distortion is not in the output stage. AC-removing the cathode resistors would increase output stage distortion but would also increase loop gain so the feedback can correct distortions anywhere in the loop. The fact that the result is lower distortion says that it originates before the output stage.

jan

B

baudouin0
Member



2022-02-24 6:26 am

< > #79

I think there was some distortion cancelation occurring between the LPT and the output stage. I would agree with what you say and not fit them.



jhstewart9
Member



2022-02-24 7:25 am

< > #80

Dissimilar plate resistors, the easy way out. This is what Mullard (And others) did.
The match does look rather good. And 3V at the cct input drives the KT88s all the way.

Attachments

(URL: /community/attachments/proto-e6-3v-dissimilar-plate-resisters-jpg.1028619/)

Proto E6 3V Dissimilar Plate Resistors.JPG

56.5 KB · Views: 23

Z

zintolo
Member



2022-02-24 7:33 am

< > #81

baudouin0 said: (URL: /community/goto/post?id=6951792)

I wonder if you would be better making your distortion measurements with the loop open.

I agree, it will make everything easier to be seen, then you can apply fbk to iron remaining harmonics.



SSassen
Member



2022-02-24 7:42 am

< > #82

zintolo said: (URL: /community/goto/post?id=6951836)

I agree, it will make everything easier to be seen, then you can apply fbk to iron remaining harmonics.

Open to suggestions, how would I best tackle that?

Mediocre is not my middle name.

Z

zintolo
Member



2022-02-24 7:49 am

< > #83

Cut the trace between NFB and C15.



jhstewart9

2022-02-24 7:59 am

< > #84

The SS tail Mr Steward has another advantage. I like DC coupling of the first stage to the LPT as it makes the LF stability better. However the ef86 plate operating voltage is very variable from device to device.

Member



Adding a CCS in the second stage prevents the LPT plate voltages being a function of the ef86 plate voltage.

Thru previous work I found that there is ~10 db stabilization of the Q point of a small signal pentode by the screen resistance. The difference between the bypassed & unbypassed stage gain measured on the bench is the indicator. Further stabilization of the Q point is provided by the cathode resister.

Attachments



(URL: [/community/attachments/measure-step-size-caused-by-the-screen-bypassing-](/community/attachments/measure-step-size-caused-by-the-screen-bypassing-network-pdf.1028781/)

[network-pdf.1028781/](/community/attachments/measure-step-size-caused-by-the-screen-bypassing-network-pdf.1028781/))

Measure Step Size caused by the Screen Bypassing Network.pdf

55.7 KB · Views: 18



SSassen
Member



2022-02-24 8:01 am

< □ #85

jan.didden said: (URL: </community/goto/post?id=6951793>)

Sander, sorry to be late, but this caught my eye. To me that signifies that the distortion is not in the output stage. AC-removing the cathode resistors would increase output stage distortion but would also increase loop gain so the feedback can correct distortions anywhere in the loop.
The fact that the result is lower distortion says that it originates before the output stage.

jan

No worries Jan, you're here, that's all that matters! And yes, I didn't expect this either, although I need to revisit as I've obviously made changes to the prototype since then, so this may no longer be the case with the current iteration of the schematic.

Mediocre is not my middle name.



SSassen
Member



2022-02-24 8:03 am

< □ #86

zintolo said: (URL: </community/goto/post?id=6951849>)

Cut the trace between NFB and C15.

Yes, that part I understand, I'm just wondering what the best approach would be to measure the various sections in isolation?

Mediocre is not my middle name.



SSassen
Member



2022-02-24 8:21 am

< □ #87

jan.didden said: (URL: </community/goto/post?id=6951793>)

Sander, sorry to be late, but this caught my eye. To me that signifies that the distortion is not in the output stage. AC-removing the cathode resistors would increase output stage distortion but would also increase loop gain so the feedback can correct distortions anywhere in the loop.
The fact that the result is lower distortion says that it originates before the output stage.

jan

More on this, I'm trying out different ways of hooking up the cathode resistors on the KT88s. Have a look at the two configurations I just tried, and the resulting measurements. There's a clear difference, however *with* the bypass capacitors the distortion plot doesn't have the dip around 30W and is flattened out. Interesting, just not sure what sort of conclusions I can draw from this?

Attachments

(URL: /community/attachments/proto38_bypass_no_bypass-jpg.1028788/)

proto38_bypass_no_bypass.jpg

197.7 KB · Views: 21

(URL: /community/attachments/proto38_no_bypass-jpg.1028789/)

proto38_no_bypass.jpg

387.4 KB · Views: 25

(URL: /community/attachments/proto38_bypass-jpg.1028790/)

proto38_bypass.jpg

381.9 KB · Views: 22

Mediocre is not my middle name.



SSassen
Member



2022-02-24 9:09 am

< □ #88

Alright, this is where I'm at at the moment, and I am running out of ideas to further optimize things. I've reduced the parts count and simplified the circuit around the LTP without any adverse effect on performance, or at least as far as I can see/measure. I believe it was Albert Einstein who said: 'Everything should be made as simple as possible, but not simpler' and I couldn't agree more. Thanks guys for all the helpful suggestions thusfar!

Attachments

(URL: /community/attachments/proto38_schematic-jpg.1028814/)

proto38_schematic.jpg

499.7 KB · Views: 30

(URL: /community/attachments/proto38_thd_vs_pow_1khz-jpg.1028815/)

proto38_thd_vs_pow_1khz.jpg

194.5 KB · Views: 28

Mediocre is not my middle name.

T

tubes4all
Member



2022-02-24 9:17 am

< □ #89

What about reliability at 330Va?



SSassen
Member



2022-02-24 9:24 am

↩ 📌 #90

tubes4all said: ([URL: /community/goto/post?id=6951916](/community/goto/post?id=6951916))

What about reliability at 330Va?

Actual anode voltages on the 6922 are lower, around 300V, I forgot to add these to the schematic, please see an updated schematic below. The voltages noted with a * are the measured voltages. So there's no problem, Also many manufacturers (JJ and Tung-Sol for example) specify a 400V U_a -max for the 6922/E88CC so we're nowhere near the max, with about 100V of headroom.

Attachments

([URL: /community/attachments/proto38_schematic-jpg.1028820/](/community/attachments/proto38_schematic-jpg.1028820/))

proto38_schematic.jpg

501.6 KB · Views: 24

Mediocre is not my middle name.

T

tubes4all
Member



2022-02-24 10:30 am

↩ 📌 #91

This 400Va is only at $I_a = 0$, which is not the case here. Maximum at $P_a < 0,8W$ is 250V



SSassen
Member



2022-02-24 10:54 am

↩ 📌 #92

tubes4all said: ([URL: /community/goto/post?id=6951959](/community/goto/post?id=6951959))

This 400Va is only at $I_a = 0$, which is not the case here. Maximum at $P_a < 0,8W$ is 250V

I don't see the problem, the 6922 is routinely used, also in commercial designs, running at much larger current and anode voltages than I'm using here. If you worry about the longevity of the tube then I suggest you stay away from tube amplifiers as they all need their tubes replaced at some point, some more often than others.

Mediocre is not my middle name.

T

tubes4all
Member



2022-02-24 11:02 am

↩ 📌 #93

The 6922 is a long-life tube for 10.000h, in your amplifier a lot less with those voltages, it's your choice for less reliability.



SSassen
Member



2022-02-24 11:04 am

↩ 📌 #94

tubes4all said: ([URL: /community/goto/post?id=6951983](/community/goto/post?id=6951983))



The 6922 is a long-life tube for 10.000h, in your amplifier a lot less with those voltages, it's your choice for less reliability.

Nobody cares, least of all me.



jhstewart9
Member



Mediocre is not my middle name.
2022-02-24 12:01 pm

← □ #95

More on this, I'm trying out different ways of hooking up the cathode resistors on the KT88s. Have a look at the two configurations I just tried, and the resulting measurements. There's a clear difference, however with the bypass capacitors the distortion plot doesn't have the dip around 30W and is flattened out. Interesting, just not sure what sort of conclusions I can draw from this?

Here is an interesting read on that subject.

Attachments

([URL: /community/attachments/effect-of-cathode-capacitor-p1-jpg.1028849/](/community/attachments/effect-of-cathode-capacitor-p1-jpg.1028849/))

Effect of Cathode Capacitor p1.jpg

673.6 KB · Views: 37

([URL: /community/attachments/effect-of-cathode-capacitor-p2-jpg.1028850/](/community/attachments/effect-of-cathode-capacitor-p2-jpg.1028850/))

Effect of Cathode Capacitor p2.jpg

739.3 KB · Views: 37

([URL: /community/attachments/effect-of-cathode-capacitor-p3-jpg.1028851/](/community/attachments/effect-of-cathode-capacitor-p3-jpg.1028851/))

Effect of Cathode Capacitor p3.jpg

703.6 KB · Views: 32

([URL: /community/attachments/effect-of-cathode-capacitor-p4-jpg.1028852/](/community/attachments/effect-of-cathode-capacitor-p4-jpg.1028852/))

Effect of Cathode Capacitor p4.jpg

457 KB · Views: 34



SSassen
Member



2022-02-24 12:07 pm

← □ #96

jhstewart9 said: ([URL: /community/goto/post?id=6952026](/community/goto/post?id=6952026))

More on this, I'm trying out different ways of hooking up the cathode resistors on the KT88s. Have a look at the two configurations I just tried, and the resulting measurements. There's a clear difference, however with the bypass capacitors the distortion plot doesn't have the dip around 30W and is flattened out. Interesting, just not sure what sort of conclusions I can draw from this?

Here is an interesting read on that subject.

Thanks John, I'll be sure to give that a read!

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-24 2:08 pm

← □ #97

Umm its very good.

Z

zintolo
Member



2022-02-24 3:53 pm

↩ 📌 #98

About the cathode capacitors for output tubes, there's also VacuumState trick: use separate resistors for each output tube cathode, then use one capacitor for each output tube cathode, join the other side of the two capacitors together, then add a resistor with a value of 16% of R_k to ground. That proved to dramatically reduce IMD.



SSassen
Member



2022-02-24 3:58 pm

↩ 📌 #99

zintolo said: (URL: </community/goto/post?id=6952240>)

About the cathode capacitors for output tubes, there's also VacuumState trick: use separate resistors for each output tube cathode, then use one capacitor for each output tube cathode, join the other side of the two capacitors together, then add a resistor with a value of 16% of R_k to ground. That proved to dramatically reduce IMD.

Thanks! I'll whip that up tomorrow and see whether I see an improvement on the prototype.

Mediocre is not my middle name.



SSassen
Member



2022-02-24 3:59 pm

↩ 📌 #100

zintolo said: (URL: </community/goto/post?id=6952240>)

About the cathode capacitors for output tubes, there's also VacuumState trick: use separate resistors for each output tube cathode, then use one capacitor for each output tube cathode, join the other side of the two capacitors together, then add a resistor with a value of 16% of R_k to ground. That proved to dramatically reduce IMD.

P.s. any suggestions for a gyrator load for the EF86 you mentioned earlier? I mean I can cobble something together, but if you have a proven design you'd like to share I'd rather hit the ground running.

Mediocre is not my middle name.

Z

zintolo
Member



2022-02-24 4:24 pm

↩ 📌 #101

SSassen said: (URL: </community/goto/post?id=6952248>)

Thanks! I'll whip that up tomorrow and see whether I see an improvement on the prototype.

EL84 Amp - Baby Huey (URL: <https://www.diyaudio.com/community/threads/el84-amp-baby-huey.7...>)

Here is my Baby Huey built in three modules: PS, Bias & CCS and Main. I just finished the modules wiring and I didn't test anything to see if it's working. I have a chassis recovered of an old nec inverter that I will try to use to assemble the amplifier. I'll use ECC803 and EL84 both from JJ. Photo...

www.diyaudio.com

Z

zintolo
Member

2022-02-24 4:26 pm

↩ 📌 #102

SSassen said: (URL: </community/goto/post?id=6952253>)

P.s. any suggestions for a gyrator load for the EF86 you mentioned earlier? I mean I can cobble



SSassen
Member



something together, but if you have a proven design you'd like to share I'd rather hit the ground running.

I just arrived back home, it's quite late here, I will search something tomorrow.

2022-02-24 4:27 pm

↩ 📌 #103

zintolo said: (URL: /community/goto/post?id=6952272)

I just arrived back home, it's quite late here, I will search something tomorrow.

Thanks! Have a good night!

Mediocre is not my middle name.

T

tubes4all
Member



2022-02-24 5:00 pm

↩ 📌 #104

SSassen said: (URL: /community/goto/post?id=6951986)

Nobody cares, least of all me.

Just you, I guess. Btw your product is just a show of what you can do, not that you would actually want to listen to a tube amp. Be happy with your Williams clone and especially the help others have given you. Without them, it would have died an early death.



SSassen
Member



2022-02-25 1:32 am

↩ 📌 #105

tubes4all said: (URL: /community/goto/post?id=6952304)

Just you, I guess. Btw your product is just a show of what you can do, not that you would actually want to listen to a tube amp. Be happy with your Williams clone and especially the help others have given you. Without them, it would have died an early death.

Would it? No it wouldn't! And may I suggest you refrain from making these kind of ad hominem posts unless you want your account suspended just like on the other forum where you kept harassing people.

Mediocre is not my middle name.



SSassen
Member



2022-02-25 9:30 am

↩ 📌 #106

Not much progress today, just a few minor changes, for example we gained a transistor and a resistor in order to add a cascode to the current source. At this point I get the feeling every reduction of a mere fraction of a percent of distortion is something that I need to fight for, but as long as there's progress, although slow, I'll keep chugging along.

Attachments

(URL: /community/attachments/proto40_thd_vs_pow_1khz-jpg.1029107/)

proto40_thd_vs_pow_1khz.jpg

202 KB · Views: 30

(URL: /community/attachments/proto40_schematic-jpg.1029108/)

proto40_schematic.jpg

506.6 KB · Views: 30

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-25 9:32 am

↩ 📌 #107

Care there you don't run out of volts on the CCS.



SSassen
Member



2022-02-25 9:58 am

↩ 📌 #108

baudouin0 said: (URL: /community/goto/post?id=6952847)

Care there you don't run out of volts on the CCS.

Yes, the cascode eats up a mere 1.5V from the available headroom which is not an issue.

Mediocre is not my middle name.

B

baudouin0
Member



2022-02-25 10:00 am

↩ 📌 #109

Yes I think its fine on the E88CC at full swing. For a 12AX7 I needed a slight negative supply on the CCS.

W

wg_ski
Member



2022-02-25 10:03 am

↩ 📌 #110

If there is a negative supply available for the CCS why not use it? Having a few volts of headroom might prevent you from hitting a hard voltage limit, but when VCE's get small capacitances start getting nonlinear. Things stay very linear with 20 volts or more on it. And you can use an emitter resistor with a lot of voltage on it instead of only a few tenths. Makes everything better.

B

baudouin0
Member



2022-02-25 10:06 am

↩ 📌 #111

You could take the negative supply with a zener and put more voltage across the emitter resistors saving the cascode. You could even run the whole CCS of the raw negative supply and use a zener CCS. Swings and roundabouts again



SSassen
Member



2022-02-25 10:12 am

↩ 📌 #112

wg_ski said: (URL: /community/goto/post?id=6952869)

If there is a negative supply available for the CCS why not use it? Having a few volts of headroom might prevent you from hitting a hard voltage limit, but when VCE's get small capacitances start getting nonlinear. Things stay very linear with 20 volts or more on it. And you can use an emitter resistor with a lot of voltage on it instead of only a few tenths. Makes everything better.

Could do, I'll have a look, remember when I said I wanted to keep things simple ...

Mediocre is not my middle name.

W

wg_ski
Member



2022-02-25 10:28 am

🔗 📌 #113

Could be even simpler - do away with the mirror and cascode if you bias the base with a 33 volt zener. With that much degeneration (39k emitter resistor) output resistance goes through the roof using *one* transistor.



SSassen
Member



2022-02-25 10:43 am

🔗 📌 #114

P.s. I also tried a gyrator instead of the 100K anode resi

wg_ski said: ([URL: /community/goto/post?id=6952893](/community/goto/post?id=6952893))

Could be even simpler - do away with the mirror and cascode if you bias the base with a 33 volt zener. With that much degeneration (39k emitter resistor) output resistance goes through the roof using *one* transistor.

How's that? I'm with you on the 33V zener, but with a 39K emitter resistor I can't make it work, no matter how large the voltage on the negative supply.

Attachments

([URL: /community/attachments/wg_ski_idea-jpg.1029127/](/community/attachments/wg_ski_idea-jpg.1029127/))

wg_ski_idea.jpg

253.5 KB · Views: 24

Mediocre is not my middle name.

W

wg_ski
Member



2022-02-25 10:48 am

🔗 📌 #115

Oh, 8.2k for 4 mA. Don't know how I got 39. Still orders of magnitude larger than the 6 ohms of intrinsic emitter resistance.

B

baudouin0
Member



2022-02-25 11:10 am

🔗 📌 #116

I tend to use a 6v8 zener returning the zener bias resistor back to 0V rather than HT. The transistor may need to dissipate more power or you can loose some in a collector resistor. Any old negative bias voltage will do its not fussy.



jhstewart9
Member



2022-02-25 3:54 pm

🔗 📌 #117

Here is another long tailed driver that fills the requirement to fully drive the PP KT88s. The error others have often made to realize a proper solution has to do with failing to consult the plate curves for the 6DJ8 & put a load line on it. Several have run much to small tail currents resulting in the 6DJ8 sitting up near the plate supply volts. On this Sim we can see the plates are running at ~150V, a result of enough tail current. There are several ways to get to a solution, this is simply one of them.

I've used this technique in the past, look up the threads where the 'Betty Crocker Special' is covered. Most often in a thread of Lingwendil in his thread 'Flea powered Amp'. I got involved, it looked to me the P-P OPT impedance selected was not high enough. So I covered PP versions of 6SN7, 6BL7, 6BX7 & 5998. The 5998 with a 280V supply managed an easy 10W in Class A. Without exceeding its dissipation ratings. All that series of amps used various versions of the long tail.

I'm playing with a PP 6EA7/6EM7 these daze. It uses a 120K long tail to -150V. And 7W at clipping, a bookshelf amp.

Do you have an objection to direct coupling to the input pentode? The removal of one LF rolloff from a NFB amp makes life a lot easier.

And we have seen a few posts back that it can be done successfully.

Attachments

(URL: </community/attachments/proto-e8b-npn-tail-to-20v-jpg.1029197/>)

Proto E8B NPN Tail to -20V.JPG

63.3 KB · Views: 25



jhstewart9
Member



2022-02-25 9:21 pm

← □ #118

zintolo said: (URL: </community/goto/post?id=6951709>)

Another option is to use a gyrator as load for the EF86, this way you can fix the output voltage to DC couple first and second stage.

Not a good idea, loading a high impedance pentode with a high impedance load. The operating point often become indeterminate, creating even more problems.

So the gyrator is OK with a triode. But not a pentode. Just adds another level of complication.



jhstewart9
Member



2022-02-25 11:19 pm

← □ #119

If you are not into bragging rights use a 6BQ7 for the long tail inverter. Check the specs, it plugs right in. And fully drives the KT88s.

Attachments

(URL: </community/attachments/proto-e8b-npn-tail-to-20v-6bq7s-jpg.1029279/>)

Proto E8B NPN Tail to -20V 6BQ7s.JPG

63.5 KB · Views: 16

W

wg_ski
Member



2022-02-26 12:13 am

← □ #120

Once you start using current sources for bias, and with sufficient voltage compliance, circuits tend to become "plug and play". Becoming tube and transistor type-agnostic. Even when they're direct coupled. Vgk doesn't matter. You just get a change in gain, depending on the mu and rp. Add degeneration and it matters even less.

I just bought 40 6BQ7's because they look like they show promise. More linear than 12AU7's for gain blocks and decent enough as followers.



jhstewart9
Member



Yesterday at 7:11 PM

↩ 📖 #121

Still spinning your wheels on that PP KT88 amplifier? Just curious.

› Tubes / Valves › KT88 PP - Dotting the i's, crossing the t's



SSassen
Member



Today at 3:08 AM

↩ 📖 #122

jhstewart9 said: (URL: /community/goto/post?id=6963713)

Still spinning your wheels on that PP KT88 amplifier? Just curious.

Thanks John, yes I am, work caught up with me the last few weeks though, but I plan to continue later this or early next week.

Mediocre is not my middle name.