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A simple discrete one-watt amplifier

by [Wattnik](#) · [① 2024-11-20 7:43 pm](#)[1](#) [2](#) [3](#) ... [18](#)[Jump to Latest](#)

W

Wattnik
Member
Joined 2024

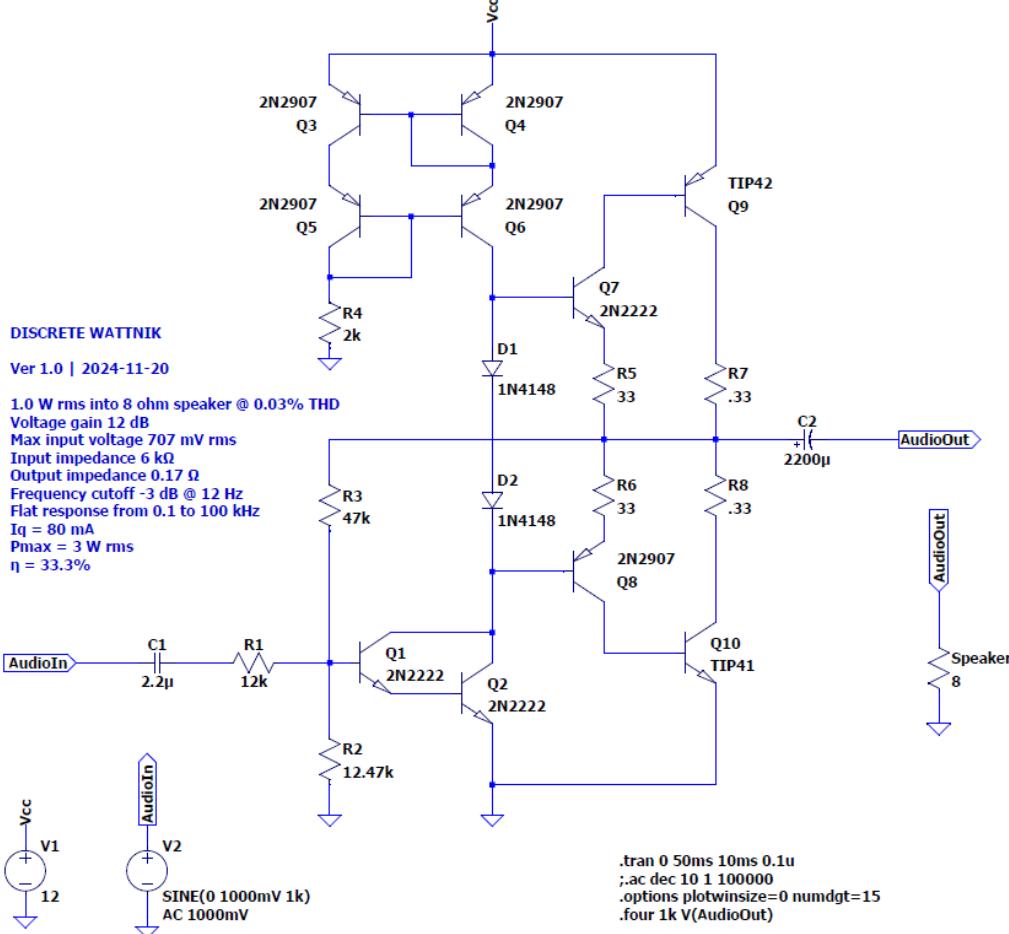
2024-11-20 7:43 pm

#1

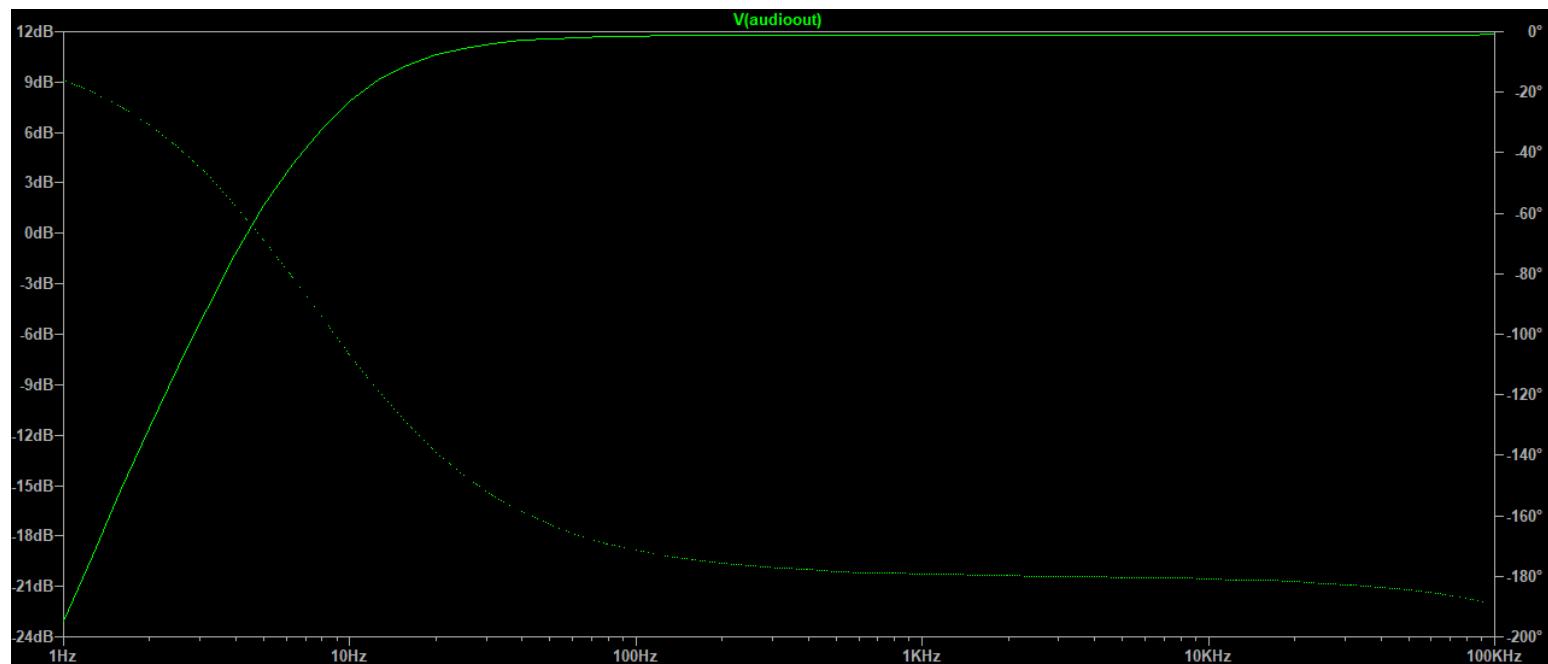
Being a pretty much beginner in audio amplifier building scene, here is a simple discrete amplifier I designed in Ltspice. I have not yet built it, but will plan to do so as soon as I have a free weekend (or two). There are most likely many technical inaccuracies concerning this design, so if there is something I should change in the schematics or do differently, I would be glad to hear your suggestions.

The component selection is based on what I have on hand.

The schematics, only one channel shown 😊



I ran some simulations as well, here is the response curve...



... and the THD data at full power. It gets down to 0.002% and less at smaller output power levels.

```

Fourier components of V(audioout)
DC component:-0.000843794

Harmonic      Frequency      Fourier      Normalized      Phase      Normalized
Number        [Hz]          Component    Component     [degree]    Phase [deg]
1             1.000e+3       3.887e+0   1.000e+0   -90.76°     0.00°
2             2.000e+3       1.069e-3   2.749e-4   95.47°      186.23°
3             3.000e+3       4.295e-4   1.105e-4   -163.62°   -72.86°
4             4.000e+3       1.471e-4   3.784e-5   -90.04°     0.73°
5             5.000e+3       5.670e-5   1.459e-5   -8.01°      82.76°
6             6.000e+3       3.673e-5   9.448e-6   90.52°      181.28°
7             7.000e+3       2.188e-5   5.630e-6   176.30°     267.07°
8             8.000e+3       4.209e-6   1.083e-6   -101.98°   -11.22°
9             9.000e+3       3.176e-6   8.172e-7   55.23°      145.99°

Partial Harmonic Distortion: 0.029928%
Total Harmonic Distortion:  0.029930%
```

Airhead, NE WAY, TNT and 2 others



Bigun

Member
Joined 2009

2024-11-20 7:57 pm

#2

There's a lot of stuff that could be said but if you are going to actually build it then I'd hate to see a bunch of suggestions come flooding in which result in your going around the loop with simulations - getting something built is where it's at.

Parasitic oscillations can be a bear, current mirrors and Darlington topologies are not immune from this and you may want some small capacitors handy in case things don't quite behave. An r.f. filter on the input may also be wise - small cap to gnd after R1 etc.

Start with a dummy resistive load instead of a real speaker.

stenak

J

jxdking

Member
Joined 2009

2024-11-20 8:21 pm

#3

For beginners, I suggest to start from some simple projects such as single ended class A with a single transistor. I am sorry to say, there are so many problems with the circuit in OP that it doesn't make sense to fix them one by one.

Globulator and cumbb

M

MarcelvdG

Member
Joined 2003

2024-11-20 8:44 pm

#4

I think the quiescent current is rather unpredictable. You could give Q3 and Q4 emitter degeneration resistors and replace D1 and D2 with a V_{BE} multiplier to improve that somewhat.

G

gijser

Member
Joined 2016

2024-11-20 8:55 pm

#5

The outputs are sziklai pairs, and they like oscillate, for some reason unknown to me especially at around 7Mhz. Can be solved with two small capacitors.

sgrossklass



cumbb

Banned
Joined 2005

2024-11-21 9:50 am

#6

I would start very simply. A simple little single ended. One or at most two steps.

#1 is basically not an audio amplifier at all. And far too complex for the targeted 1 watt. Because electronic parts modulate current. Audible. And complementary transistors modulate audibly very differently. Unfortunately, this is not taught in any electronics training courses. Some noise may come out here, but compare it with the clean sound of a small 1 watt SE;-)

An audio related categorization would classify this as a 4-stage half-wave unsymmetrical complementary transistor push-pull amplifier. The most audio unsuitable category in the analog range.

If you still want to build it: bridge D1 and D2 with a very neutral and clean sounding capacitor > 100 uF.

W

Wattnik

Member
Joined 2024

2024-11-21 10:58 am

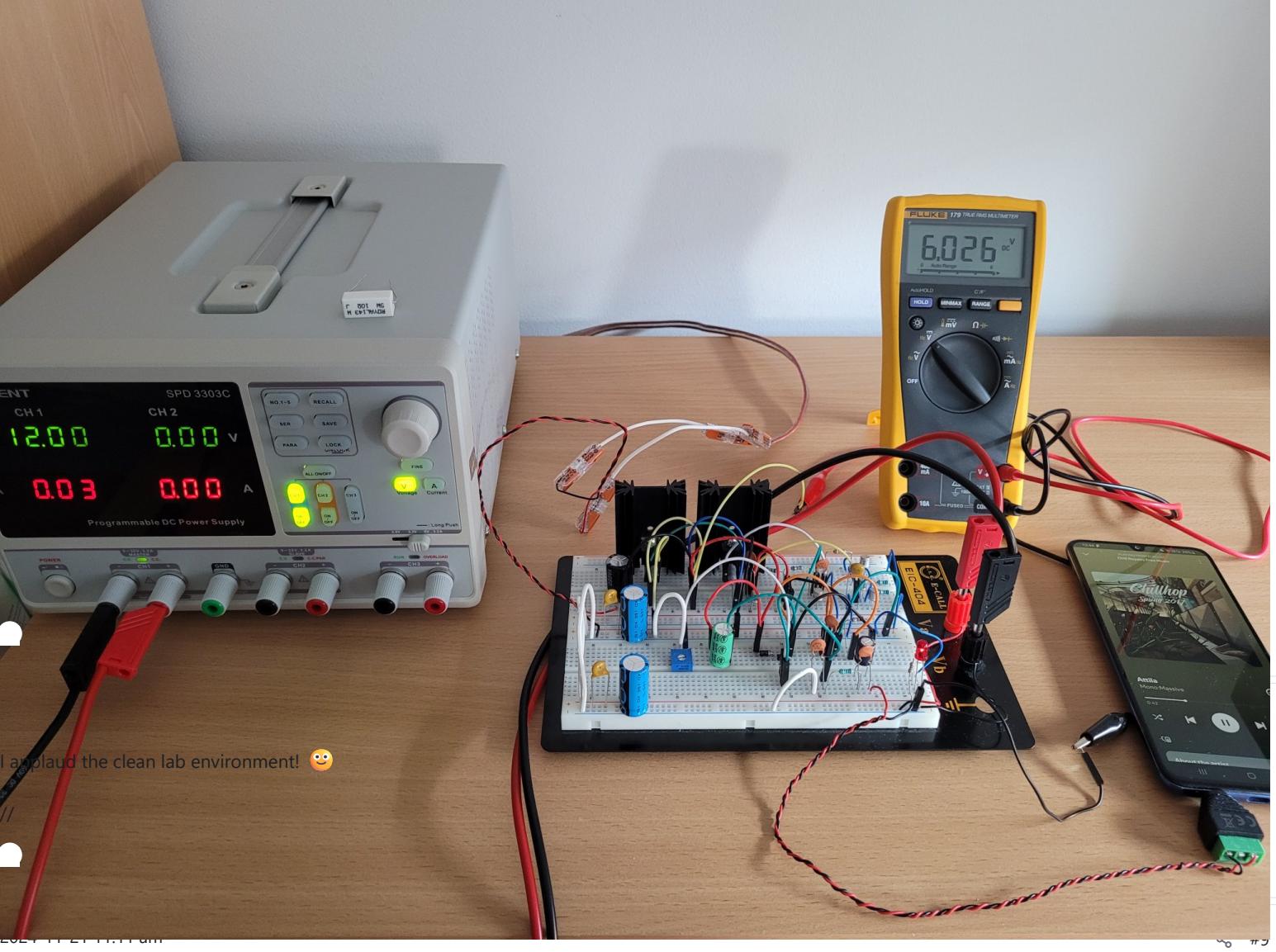
#7

Many thanks for suggestions and advice, I actually built it and added additional emitter resistors to the current source plus made some other tweaks.

Yes, it is not a "simple" amplifier as Jxdking and Cumbb have pointed out and not quite beginner friendly.

Of course, it oscillated like crazy, but then I added 100pF bypass capacitors between the push pull final stage driver transistors bases and collectors, and removed one stage of the darlington pair. And got it to work! Well, it actually sounds very good in comparison to my other amp projects (well, maybe the OPA2132 based headphone amp sounds better...), and consumes surprisingly little power when idle.

Now gotta break out the o'scope and do some performance testing...



I applaud the clean lab environment! 😊

LSK489
lineup
Member
Joined 2005

Nice project.
Wattnik

cumbb
Banned
Joined 2005

2024-11-21 11:33 am #10

I only see TO-18/-39 transistors (except for the TIPs). These are among those with the lowest sonic potential. I would try the TO-92 types. Unless you have any multi-way speakers that tend to sound rather dark sound rather dark and leave a lot on the way.

Wattnik
Member
Joined 2024

2024-11-21 1:16 pm #11

I will try to find some TO-92 packaged 2n2907 transistors and swap these in, the local distributor only had those metal can versions on stock when I ordered them.

Some torture tests are now ready and the amp is capable of producing 1.5 W with 1kHz sine wave into 8 ohm load just before the clipping starts.

The problem is the distortion I still receive. I am not very familiar with the FFT math on my Siglent 1104X-E, so there may be some inaccuracies, but I calculated the THD to be 0.17% at full power, but still 0.10 - 0.12% at lower powers. Mostly 2nd to 6th harmonics at -70...-80 dBV when main 1kHz signal is at -6dBV. Not good, not terrible, I assume...
Last edited: 2024-11-21 1:45 pm

cumbb

cumbb
Banned
Joined 2005

2024-11-21 2:22 pm #12

Another audio elektronics tip: Your Sziklais each consist of a complementary pair. Since complementary transistors sound enormously different, it is possible to use a complementary pair here. For reasons of harmony. Each half-wave is then amplified by two equally different tonal characters. Example: TIP41/TIP42 and TIP42/TIP41. Components retain their sound character at every point of their use and function, whether as power or driver or psu or diode or whatever.

Fear not the distortions. Connect and listen first. The ear is very gracious towards THD, almost careless;-) The ear does not like noise, all kinds of noise;-)
There is no program for determining and calculating these;-)
Last edited: 2024-11-21 2:27 pm

grindstone and alain98

 Bigun
Member Joined 2009

2024-11-21 3:03 pm #13

Watnik said:
Many thanks for suggestions and advice, I actually built it and added additional emitter resistors to the current source plus made some other tweaks.
Yes, it is not a "simple" amplifier as Jxdking and Cumbb have pointed out and not quite beginner friendly.

Click to expand...

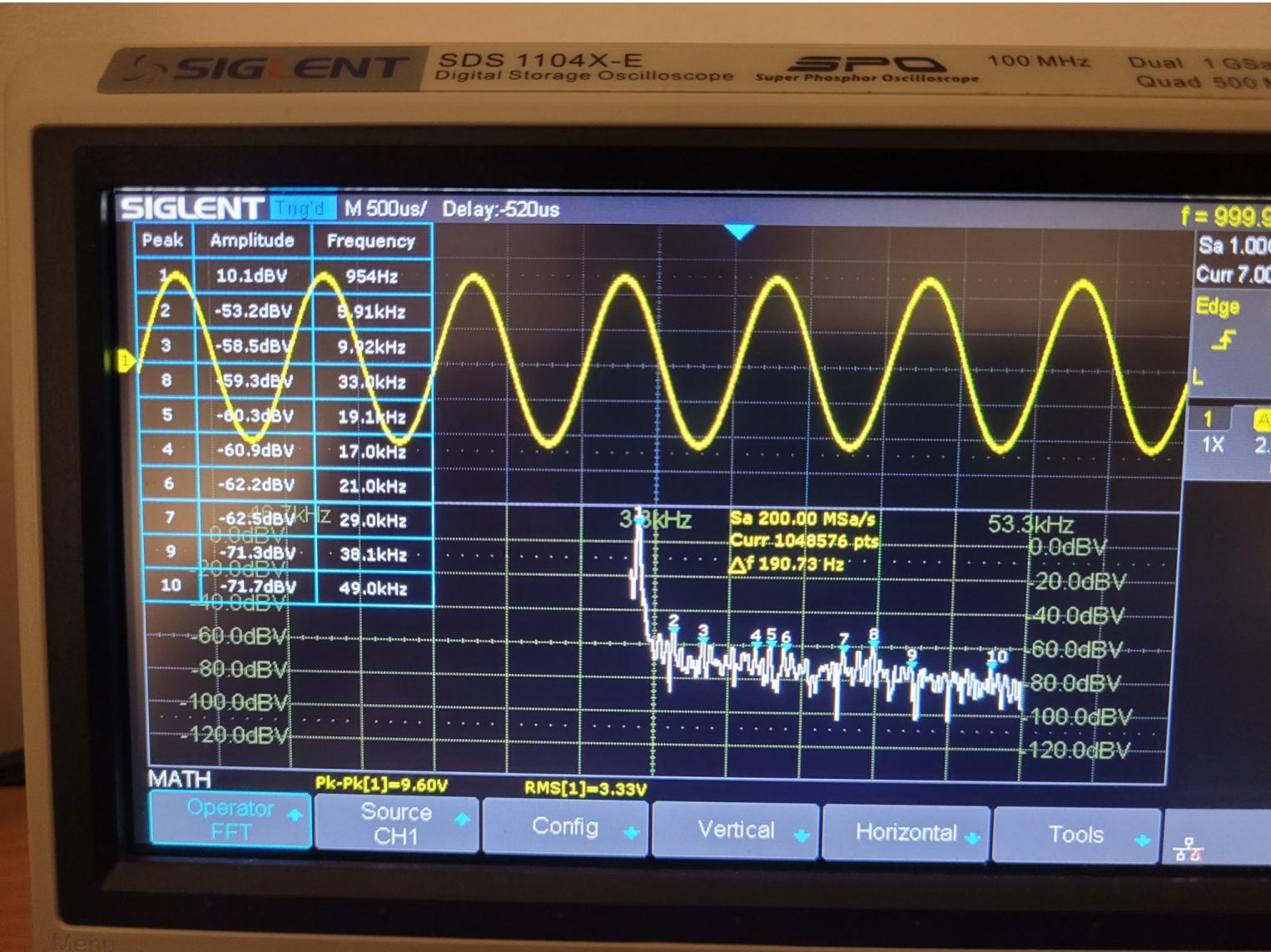
Well done - a man of action !

stv and Watnik

 Watnik
Member Joined 2024

2024-11-21 3:51 pm #14

I had some 2N3904 and 2N3906 in TO-92 form factor laying around, so I replaced the 2N2222 and 2N2907 transistors with those, the sound is, how I would say, "cleaner".
The THD levels magically improved as well, measured at full power:



Peak	Amplitude	Frequency
1	10.1dBV	994Hz
2	-53.2dBV	9.91kHz
3	-58.5dBV	9.92kHz
8	-59.3dBV	33.0kHz
5	-60.3dBV	19.1kHz
4	-60.9dBV	17.0kHz
6	-62.2dBV	21.0kHz
7	-62.5dBV	29.0kHz
9	-71.3dBV	38.1kHz
10	-71.7dBV	49.0kHz

Last edited: 2024-11-21 4:00 pm
aroS3, Globulator and cumbb

 wg_ski
Member Joined 2007

2024-11-21 4:13 pm #15

2N3904,6 start running out of gain pretty badly above 20 mA. By the full rated 200 mA it is all but gone. The 2222/2907 gain holds up much better at high current.

 lineup
Member Joined 2005

2024-11-21 6:01 pm #16

Watnik said:
Many thanks for suggestions and advice, I actually built it and added additional emitter resistors to the current source plus made some other tweaks.
Yes, it is not a "simple" amplifier as Jxdking and Cumbb have pointed out and not quite beginner friendly.

Click to expand...

Could you show a new schematic including your tweaks?
There are a few points I would do different in such a circuit.

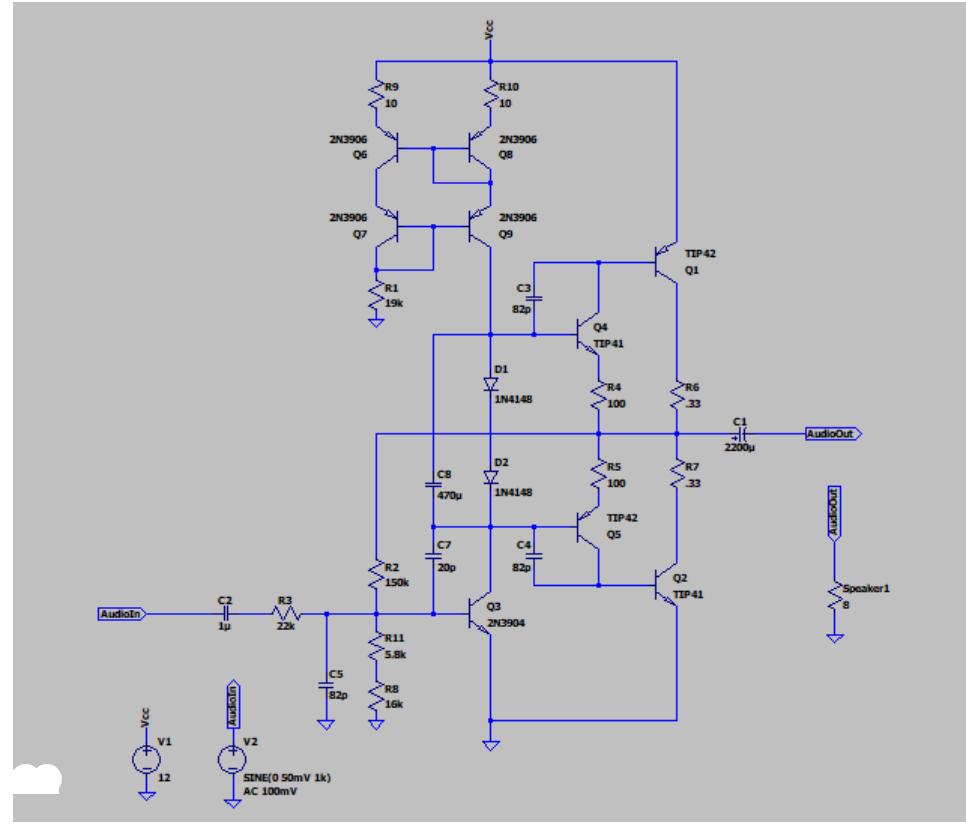
 Watnik
Member Joined 2024

2024-11-22 4:45 pm #17

lineup said:

Could you show a new schematic including your tweaks?
There are a few points I would do different in such a circuit.

Here's the final version. I followed Cumbb's advice to use complementary transistors in Sziklai's pairs. The amp sounds very clean and everything looks good on oscilloscope as well.



2024-11-22 6:30 pm

#18

I like it;-)

cumbb
Banned
Joined 2005

I would also have reduced Q1 and Q2 to just one transistor. PN transitions draw a technical, artificial, slightly cloudy and slowed-down curtain in the sound image. Diodes too. There are very few transistors and diodes where it is not very audible.

I would later combine Q6 - Q9 into just one transistor, including the one or two necessary resistors. Same reason.
A very clean-sounding electrolytic capacitor at its base would open up the stage enormously - a matter of taste and system.

I would replace D1 and D2 with a resistor at sometime. Practically use a trimmer here to set the ideal value. Or look for two very clean-sounding diodes. Because sound is also made here, modulated: the sonic cleanliness, but also the character of the components can be heard.
The best-sounding resistors are SMD film resistors or MELF.

R3 I would remove, just try and listen. C2 and C5 simply adapt as required.

R8 and R11 just one resistor. I assume you have determined an exact value here, but experience shows that the ear is more likely to pick out further material parts than a deviating conceptual value. Or use a trimmer, they sound a bit better than wired resistors.

After listening for a while, remove the capacitor C8 and listen;-)

The whole thing here is built without a board: this saves unnecessary paths and connections, which again has a positive effect on the sound.

Cool thing. In my experience, it hardly gets any better in the complementary transistors push-pull range. And the 1 paper watt sound at least like 10;-)

These TIPs are TO-220 transistors generally suitable for audio. I have a few batches that are all in the audio range - with transistors you can hear very clearly that each batch sounds different.

Much later, when you know the sound of this amp very well, make a cut in the TO-220 as shown. And report;-)

Attachments



DSCN0636[1].JPG



2024-11-22 8:03 pm

#19

@Wattnik

lineup
Member
Joined 2005

I have designed an 1Watt amp with 12V supply.

I have used only the transistors you use.

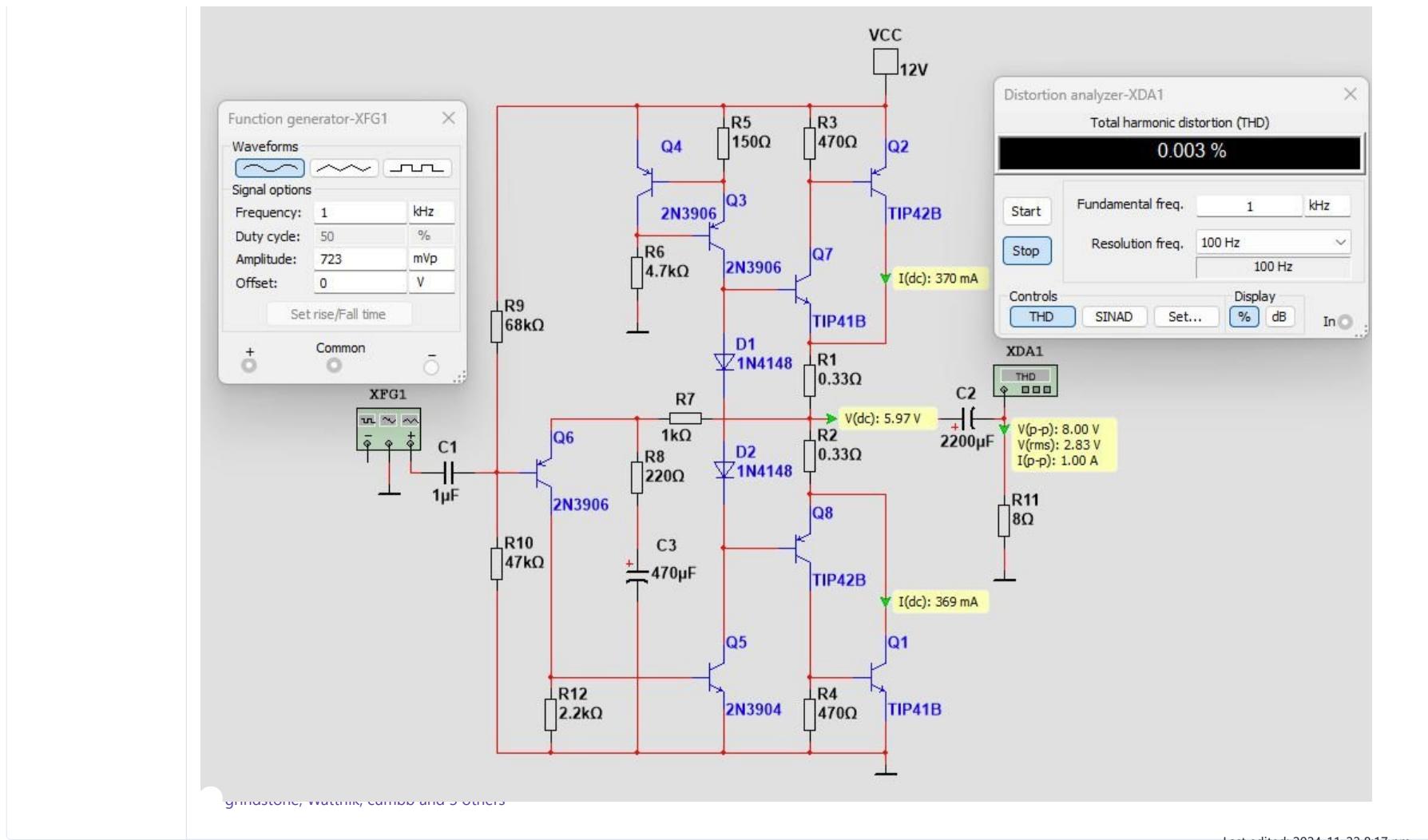
I have added one transistor at the input and made other changes.

With this the distortion is low.

See my image 😊

It works in Class A. That is possible at the low level and relative low current.

EDIT: There should be a capacitor 68pF at Q5.



Last edited: 2024-11-22 8:17 pm

J

jlinkels
Member
Joined 2019

2024-11-22 10:50 pm

#20

cumbb said:

Much later, when you know the sound of this amp very well, make a cut in the TO-220 as shown. And report;-)

@cumbb I think it is nicer if you limit your paraphilic audiophile nonsense to those threads were experienced technicians can assess the absurdity what you usually blabber. And not in threads were inexperienced beginners try to put their first steps in audio electronics.

Things like the case type of a transistor, the amount of solder on a joint or the directivity of copper only make a difference to your ears or imagination. Sometimes I think it is funny to read the fantasies you come up with. But please, post in the threads were you don't confuse people with less experience.

restorer-john, catd, Drone R2D2 and 17 others

1 2 3 ... 18

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