20th January 2016, 08:49 PM #91

twest820
diyAudio Member
Join Date: Jun 2009

Another thing to check may be Simulate -> Control Panel -> Compression -> Enable 1st Order. .option plotwinsize=0 is supposed to turn it off but I find LTSpice overrides with the default settings on each new start; annoying and contributing roughly 0.3% THD.

I typically run with something like the below. Haven't put much effort into finding optimum settings but they may be of some help as a starting point. Curious if others have refinements; in particular, Tstep = 0 may be questionable. .param fin is the frequency of the input sine for THD measurement in Hz and out is whatever the name of the desired node voltage is.

```
.tran 0 {15/fin} {5/fin} {1/(16384*fin)}
.option numdgt=15 plotwinsize=0
.four {fin} V(out)
```

Quote

21st January 2016, 11:23 AM #92

SSassen
diyAudio Member

Join Date: Mar 2005
Location: Beta Zeticuly

I guess you learn something new every day? I've been well versed in the art of simulating with LTspice, however never figured the timestep option made such a big difference with Class-D, for linear amplifiers I've been using the 100ns option for years and it has always proved to work just fine and the simulations would accurately represent reality in the majority of cases.

In retrospect it makes sense, as the 'ideal power comparator' I used can indeed do ns switching. I've rerun the simulations with a 1ns timestep and things are now making a lot more sense. Thanks for the suggestions and feedback gents!

_____
Mediocre is not my middle name.

Quote

23rd January 2016, 03:49 AM #93

basreflex
diyAudio Member
Join Date: Oct 2007

re enable:
a solid state relay is a simple solution to softly switch the negative voltages.
CPC1008N - CLARE - MOSFET Relay, 100 V, 150 mA, 8 ohm, SPST-NO | Farnell element14
a bit more than a euro..

ps you even can create aliasing effects with the timestep set wrong

Quote

23rd January 2016, 03:51 PM #94

SSassen
diyAudio Member

Join Date: Mar 2005
Location: Beta Zeticuly

@basreflex,

Any reason why this wouldn't work?

Attached Thumbnails

_____
Mediocre is not my middle name.

Quote

23rd January 2016, 04:46 PM #95

basreflex
diyAudio Member
Join Date: Oct 2007

this schematic is fine. 10k/1k sets a max neg rail voltage of 50V.

Quote

23rd January 2016, 05:39 PM #96

nanonymous
diyAudio Member
Join Date: Mar 2012

Do D1, C3, D4, and C16 have the right polarity?

Quote

26th January 2016, 12:07 PM #97

SSassen
diyAudio Member

Join Date: Mar 2005
Location: Beta Zeticuly

I've been rather busy at work, but did manage to squeeze in some time to take a look at housekeeping and cleaning up the schematic. Attached are the revised amplifier and the housekeeping schematic.

For the housekeeping I had a few things I wanted to implement:

1) Delayed startup with AC detection
This has been implemented with a 4093 quad NAND gate powered off of the negative rail. The latter makes interfacing with the IRS2092 and the floating 12V supply a bit easier.

I've opted to have the +5V/-5V supply for the IRS2092 come up right after powerup, which is what the datasheet stipulates. The CSD pin and the 12V floating supply will come up after ~2 seconds. The amplifier will then be ready to play music after the cap on the CSD pin has reached upper treshold, typically ~0.1 seconds after.

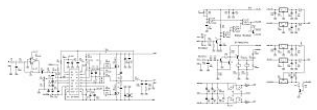
AC detection takes the two AC inputs from the transformer and makes sure that when the amplifier is switched off the CSD pin is pulled to -5V and the 12V floating supply is disabled. This should guarantee no squeeling or popping noises can be heard from the loudspeaker after the amplifier has been turned off.

2) DC Error
One of the things that kills a loudspeaker quickly is a large DC voltage across its input. I've implemented a DC error protection that will engage with DC voltages >6V by disconnecting the amplifier from its power rails and keeping it disconnected until power has been cycled. This way around any faults in the amplifier itself or the fuses failing to blow will not result in additional damage, unless the power supply itself is at fault of course.

I'm relying on the built in over current protection to detect any excess currents flowing due to a shortcircuit, or the amplifier being overdriven.

Anything I missed?

Attached Thumbnails



Mediocre is not my middle name.

Quote

26th January 2016, 04:47 PM

#98

SSassen
diyAudio Member

Join Date: Mar 2005
Location: Beta Zeticuly

Alright, one of the tasks still left to do was to calculate the required resistor values for the over current protection. This is largely dependent on the MOSFETs used and the desired maximum current.

In my case I'll be using the IRFB4615 MOSFETs, which have a Rds(on) of 40mOhm and a maximum continuous current of 35A. For the sake of simplicity I'm going to go ahead and set the trip level to 35A.

Referring to the schematic in my previous post, R9 and R10 set the trip current for the low side over current protection (OCP). According to IRF's application note (AN-1138) these can be calculated given the following formula:

Vocset=Itrip*Rds(on)
Vocset=35*40mOhm
Vocset=1.4V

Vref=5.1V
R10=(Vocset/Vref)*10e3
R10=(1.4/5.1)*10e3
R10=2.7kOhm

R9+R10=10k (requirement)
R9=10-2.7
R9=7.3k

Closest E12 value is 6.8k, however that means that to meet the R10+R9=10k requirement, R10 will need to be 3.3k. That means Itrip will be different from calculated, so lets see by how much:

R10=3.3kOhm
3300=(Vocset/5.1)*10e3
0.33=Vocset/5.1
Vocset=1.683V

Itrip=Vocset/Rds(on)
Itrip=1.683/0.04
Itrip=42.1A

I guess with a Ipeak of 140A (pulsed drain current) on the IRFB4615, there's some margin (42A is 120% of 35A) so that's acceptable too.

High side current sensing is based on the measurement of Vds (Vdrain-source) across the high side MOSFET during high side turn on through pins CSH and Vs. An external reverse blocking diode, D2, is required to block high voltages from feeding into the CSH pin while the high side is off, hence the forward voltage (Vf) gets added to that voltage.

We'll set the high side over current trip point to the same value as we've set the low side over current trip point. To set the high side over current protection resistor values R11 and R12 need to be calculated given:

R11+R12=10k (requirement)
Vthoch=threshold voltage over current high side
Vthoch=1.2V
Vds=drain-source voltage at Itrip
Vf=forward voltage of D2

R12=10e3*(Vthoch/Vds+Vf)
Vds=Itrip*Rds(on)
Vds=42*0.04
Vds=1.68V (same as Vds on the low side!)
Vf=0.6V

R12=10e3*(1.2/1.68+0.6)
R12=10e3*0.526
R12=5.3kOhm

R11=10-5.3
R11=4.7kOhm

Picking E12 values, we'll select 5.6kOhm for R12 and 4.7kOhm for R11. This will set the Itrip for the high side to 38A, that's 90% of the low side overcurrent trip point, so I guess that's acceptable.

Mediocre is not my middle name.

Quote

26th January 2016, 06:16 PM

#99

SSassen
diyAudio Member

Join Date: Mar 2005
Location: Beta Zeticuly

The next item on the list is selecting the dead-time setting.

The IRS2092 comes with a range of preset dead-time settings, which can be selected using a combination of resistors, R13 and R14 in this case. The selection available is between 25 and 105ns. From looking at the various IRF reference designs, and some of the suggestions in the application notes, the DT2 option, 45ns, seems to be the most used setting, resulting in 8.2kOhm for R14 and 3.3kOhm for R13.

I'm going to assume that's safe to use, as any additional dead-time can be added by gate stopper resistors with the defacto diodes over them. Or, when needed, a different selection for R13/R14.

Thoughts?

Mediocre is not my middle name.

Last edited by SSassen; 26th January 2016 at 06:19 PM. Reason: Spelling and grammar.

Quote

28th January 2016, 08:55 AM

#100

Dimonis
diyAudio Member

Join Date: Mar 2011
Location: RF 33 Vladimir

Quote:

> Originally Posted by **SSassen**
> *the DT2 option, 45ns, seems to be the most used setting, resulting in 8.2kOhm for R14 and 3.3kOhm for R13.*

8.2k\3.3k results in DT3 option 75ns

Quote:

> Originally Posted by **SSassen**

as any additional dead-time can be added by gate stopper resistors with the defacto diodes over them.
Thoughts?

For your 5615\4615 mosfets , the best choice is DT3 75ns and 10Ohm in gates without any diodes.
Other combinations give a shoottthrough.

For the 4227 mosfets - DT4 105ns and 4.7Ohm in gates .
Made and tested in about 50pcs of 2092 based amps.

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