

Car Stereo Replacement

02/13/20

1 Car Stereo Replacement

Replacing a car stereo. I could just go to ebay, and buy a used car stereo, but where's the fun in that? Let's DIY a car stereo from a PCB used as a frontplate, a connector for my vehicle, and an audio amplifier. I'll connect in signal from an audio player.



Figure 1: PCB rev 1

1.1 Items Included

I thought I would include the following:

- Arduino Nano
- Voltage and Gnd Breakout
- I2C Display
- Voltage Readout (of BAT)
- Current Readout (being drawn)
- Amplifier “Lvpin LP-838”

I also wanted to have the connectors that eurorack and synth designers use for mono audio cables, but the cables turned out too expensive. The current readout didn’t work initially, and I haven’t gotten to fixing it yet.

1.1.1 I2C OLED display

Just for fun, I bought an I2C oled display and am going to use it to display something.¹ Notes on this: Using the adafruit SSD1306 and GFX library (this procedure is well covered in other places), you can load an example sketch and get it running. First thing to change is to remove the Adafruit logo and replace it with my own. Let’s do that.

From <https://design.goeszen.com/convert-image-for-oled-display.html>

I’m on Linux here and found that the readily-available ImageMagick package will do the trick for you without any scripting. And runs on the CLI! Simple as that:

```
convert some_image.png some.image.mono
```

¹It’s an Arduino Uno, you can put almost anything on this.

That's efficient. But it didn't really work out. Too much work, I don't need it that bad. Have to convert it to something the c compiler can read. I instead, just deleted their logo. Good enough for now.

1.1.2 Internal AVR Temperature Sensor

I setup the code to read from the internal temp sensor on the duino. However there is also this:

<https://thecavepearlproject.org/2019/02/25/no-parts-temperature-measurement-with-arduino-pro-mini-to-0-005c-or-better/>

This would be something to do for more resolution. The built in sensor is not very good, so this above link would be great. Hack a day also covers it.

1.2 Wiring Pinout is wrong on Internet - Cable has labels

I looked at the picture I have detailing the pinout of my car connector (Delco Delphi radio wiring diagram.jpg in resources). It's close, but not 100% correct. I found that the cable itself has small text labels on each wire which explain which everything does. I didn't notice earlier, as I didn't look close enough (and no one mentioned this).

1.3 Arduino VReg Blowout

I had a knock off Arduino Nano, and the vreg blew out. I have some other vregs to replace it. I didn't have this problem with an Uno that I use as a ceiling dome light. Although that one is not left on as long, usually.

1.4 Amplifier

The amplifier I used is one of the cheapest available on ebay. I'm not proud. I'm poor. I had to take it apart, and reseal the amplifier ICs as the tab was not making contact with the chassis for one of them.

I also added thermal paste. This amp is underpowered for my car, and may need replacing. It gets a bit hot.²

Some other issues with this amplifier are that the output connectors can get pushed back, there is only one output connector option, and it must run on battery power, as a 12V 1A or 2A will not power it. Finally, there is a 6V DC bias on output. No output audio isolation, which means you get car noise.

1.5 AC Audio Coupling to Remove DC Noise from Auto

I had some fun with this one. Many videos on this in the video folder. I started with the speakers being directly fed by the amplifier. This worked, but there was some noise coming through. Cars are noisy, this is not surprising. I would've preferred the amplifier to isolate the outputs, but no luck... At this point, I considered two options to block DC and allow AC. 1) Use a transformer. 2) Use capacitors.³

1.5.1 Ground Isolator

I had been given a Ground isolator, which was two small transformers on a pcb intended to pass audio from a car powered signal source into the car speakers. I tried this isolator on the output of the speakers, and while it worked, the volume was lower, and it was impractical. I knew as soon as I heard the volume, that the issue was an impedance matching problem. The transformers were too small. They were intended for signal sources, not amplifier outputs. Onto option #2.

²This was later solved via using series low impedance caps on the output (coupling amp to speakers).

³A third option would've been to use a second set of batteries, but that would be laborious.

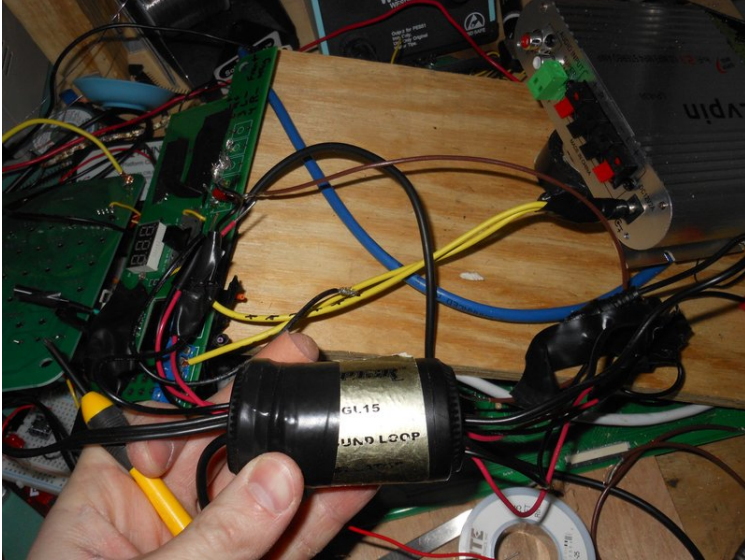


Figure 2: Ground Loop Isolator.

1.5.2 Capacitor Audio Coupling

My initial thoughts here were: “Let’s be careful and use non polarized caps”. I bought some 0.22uf and 0.022uf polyester film capacitors at Electronics Plus, the local radioshack replacement, and tried them. No sound. After adjusting the connectors on the amp (which were admittedly loose - it’s easy to push them back on the amplifier if you are not careful) I found that the capacitors didn’t work. One problem was evident in the oscpe. I only used one capacitor on the + output of the speaker amp, but the Amp biases the signal 6 volts. So I needed two. After that was resolved, the signal came through on the output of the capacitor, as viewed on the scope, however there was no sound output. I tried the safe way. It’s time to break some rules.

I grabbed some 1uf (electrolytic polarized) caps I had, and tried these. Again, no sound. Not giving up, I grabbed some 1000uf ’lytics, and tried once more. Now it worked.

1.5.3 Impedance / ESR of capacitors failing to pass enough power of signal

Capacitors are rated for impedance. Some data sheets also call this ESR, it appears after a quick look. It's either in there as impedance or ESR. It's not initially an issue if you are using the capacitor as a DC reservoir, but if you use it in an AC coupling situation then things get interesting. A high impedance, or ESR will block what a low one won't. In this example, it's as simple as the Amplifier either being able to power a speaker or not. Higher capacity caps will have lower impedance. See the picture. Other brands put impedance in a graph, or just call it impedance.

25	10000	109CK5025M	0.053	2800	18x40
35	33	336CKR035M	6.0238	110	5x11
35	47	476CK5035M	4.233	140	5x11
35	100	107CK5035M	1.989	235	6.3x11
35	220	227CK5035M	1.055	405	8x11.5
35	220	227CKR035M	0.904	450	10x12.5
35	330	337CK5035M	0.603	580	10x12.5

63	2200	228CK5063M	0.106	2300	18x35
63	8900	338CK5063MLC	0.0804	2500	18x40
100	1	105CK5100M	165.79	25	5x11
100	2.2	225CK5100M	75.357	40	5x11
100	3.3	335CK5100M	50.238	45	5x11
100	4.7	475CK5100M	28.219	55	5x11
100	10	106CK5100HEM	16.579	80	5x11



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CKR_CKS

+ 85°C, Standard, 2000 Hour

VVDC	Capacitance (µF)	IC PART NUMBER	Maximum ESR (Ω) 120 Hz, +20°C	Maximum RMS Ripple Current (mA) 120 Hz, +85°C	Dims Dxl (mm)
100	22	226CK5100M	7.536	135	6.3x11

VVDC	Capacitance (µF)	IC PART NUMBER	Maximum ESR (Ω) 120 Hz, +20°C	Maximum RMS Ripple Current (mA) 120 Hz, +85°C	Dims Dxl (mm)
350	47	476CK5350M	8.4657	390	16x25

Figure 3: Notice how impedance jumps very fast with a 1uf cap, compared to the higher values. Additionally, different brands will have different impedances for a similar value cap.

1.5.4 Wikipedia on Impedance

In general, a capacitor is seen as a storage component for electric energy. But this is only one capacitor function. A capacitor can also act as an AC resistor. Especially aluminum electrolytic capacitors

are used in many applications as a decoupling capacitors to filter or bypass undesired biased AC frequencies to the ground or for capacitive coupling of audio AC signals. Then the dielectric is used only for blocking DC. For such applications the AC resistance, the impedance is as important as the capacitance value.

https://en.wikipedia.org/w/index.php\title=Aluminum_electrolytic_capacitor&oldid=940281525

Essentially, what I learned today.

1.6 DIY Amp

I was flipping through Practical Electronics for Inventors[1](page 959), when I came across an audio amplifier. He also gives one at the chapter on Semiconductors (pg. 467), although the former is more detailed. With a reasonably simple schematic available, and a high likelihood of it working, I say why not: let's build it up.

I've noticed that the "Lvpin LP-838" amplifier I'm using is under-powered for my two front speakers ⁴, so I will make two of the provided 16 watt amps.

1.6.1 LM383 is Obsolete

That explains why I haven't heard of it. The chip is obsolete. Some sell it on ebay for about \$5 each.

As a different route, could I use some other power amplifier op amp, with the same pinout? Hm... Aha, the LM1875 has the same pinout. Let's use that. ⁵

⁴Although it seems it would work for one channel, so two of them might be enough. It's rated for 20W, so that is about 15-20W per channel req'd. It works at 20W for both, just that it heats up too much. Multiple ebay sellers have it misquoted at 200W. Just an extra 0, no biggie. Based on all this, it appears each channel of my car speaker needs about 15 watts to be on the safe side. The example schematic is 16 watts. Two should suffice.

⁵How did I find this? I searched Digikey for the LM383 sold by rochester, noted it was in the category of Linear - Amplifiers - Audio, chose that, then searched for everything in the same package (TO220-5). Came right up. If this hadn't worked, I would've wanted to try other sites: Farnells, Mouser, etc...

Will it work with the same schematic? Questionable. May still need to buy a LM383, along with the LM1875, as backup. I might also try a generic power op amp.

Amplifiers are the expensive bom item here.

1.7 Noise remains with Speaker Isolation

I've isolated the speakers from DC with the caps, but noise remains. My next idea was a DC-DC isolated supply. But, I found two threads on eevblog forums[2], and they recommend a power line filter (they also mention the isolated supply). A filter with a coil and cap (2200uf even low enough) I can quickly build up.

I also want to fix up my portable CRO, I obtained the other day. That needs batteries.

One thing I noticed, is that the amplifier seems to no longer heat up, since the caps were added. Perhaps the DC bias was the cause. I need to confirm this.

I was able to pull an 16.5V transformer from industrial equipment, so let's try this filter:

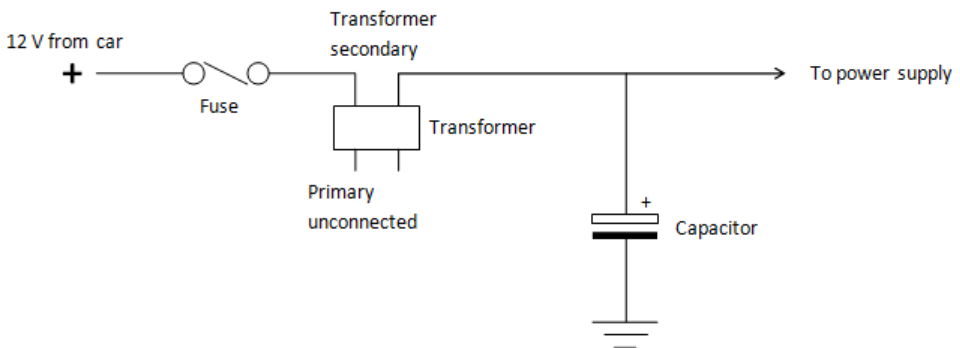


Figure 4: This picture was more difficult to download than it should've been. Spent 3 minutes on this. At least its not a discourse javascript pile of trash.

1.8 Low Pass Filter to remove Alternator Hum

I have built the Low Pass Filter consisting of a 120 to 16V AC transformer and a 2200uf Cap (LC filter). I tested it on my signal gen, and it works quite well. No AC ripple comes through. I tested it in the car, and success - there is no more alternator hum. However... There is still some noise on the speakers. It is not audible. I can't hear it, but I can feel my ears get sensitive after listening for a song or two. There must be something else getting through that is causing my ears to become sensitive. Either that, or I was not in the mood to listen to my stereo. See the picture of the filter below.

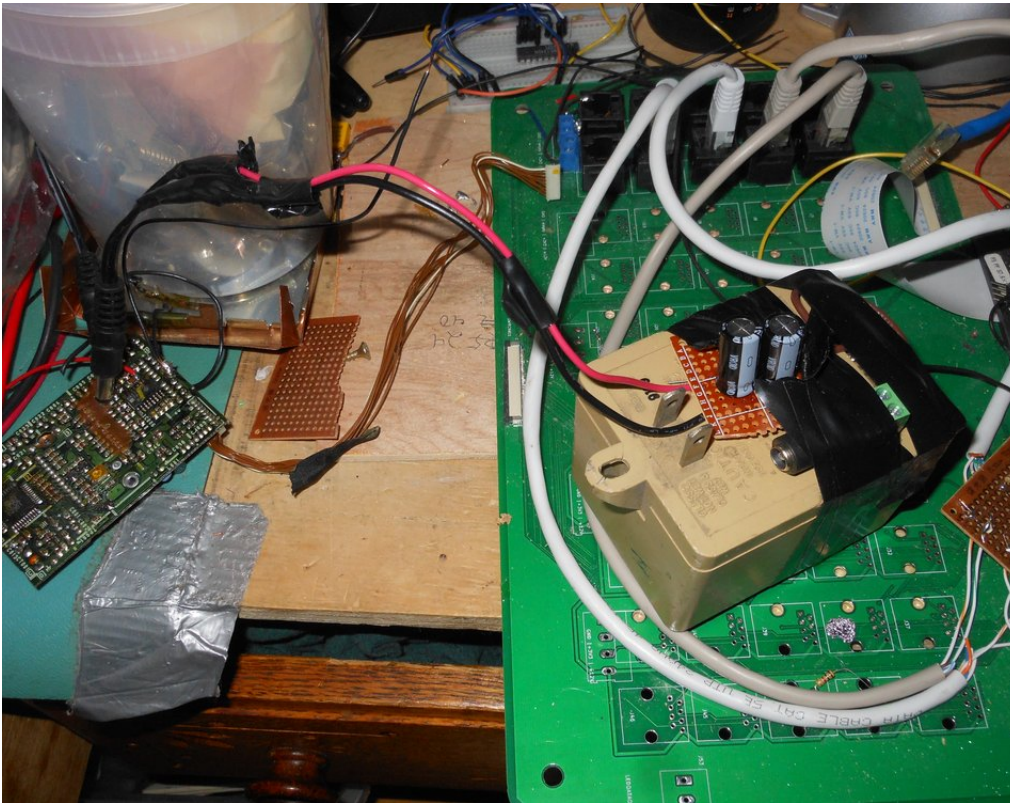


Figure 5: Fused supply from 12V car battery goes into the female barrel jack, into and out the secondary of the transformer leads. The primary is left floating. There is 2000uf 20% 25V electrolytics after the inductor. Eliminates all alternator hum. Remember that as men, we are in the business of making tools. I have made it a goal to create perf board prototypes, and usable electronic devices, such as this LC filter. This is modular (via barrel plugs) and sturdy enough that I can use it to filter any power supply.

1.9 The story so far

So far I have found the following:

- By using electrolytic caps in series to block DC Bias output on the amplifier audio, I reduced unnecessary power dissipation on the amp (doesn't heat up anymore)
- By putting an LC (AC) filter on the 12V input, I was able to block alternator noise.

I have yet to consider this project done. I suspect some noise still on the audio output. It must be coupled from the power supply.

1.10 References

References

- [1] Paul Scherz, and Simon Monk, *Practical Electronics for Inventors*, fourth edition - 2016, McGraw Hill.
- [2] Various, <https://www.eevblog.com/forum/projects/dreaded-alternator-whine-in-car-stereo/25/> Retrieved 2020-02-21. see also <https://www.eevblog.com/forum/beginners/car-engine-signal-interference-with-cell-phone/>
- [3] <https://partofthething.com/thoughts/building-a-low-pass-filter-to-remove-alternator-whine-in-my-car/>. Picture guide and showing basic build in project box. Eevblog users mention you

may be able to use the secondary of a transformer, to avoid building the coil.