

# Guerrilla Audio

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# The basics

Sometimes as radicals we need to play sounds, and there are times when the ability to rig up a speaker system is incredibly useful. Some setups are smaller than others, but all accomplish essentially the same purpose: make a lot of people hear you.

Generally, the components that go into a system are a set of speakers, enclosures, an amplifier, a power supply, and a source of audio.

## Speakers

Depending on your luck, speakers can often be dumpstered. Best places to look are stores that upgrade car audio equipment, as they'll throw out the original speakers when replacing a system. One can come across anything from

12" subwoofers to car sirens with ease.

Other speakers can sometimes be found in old electronics, or may already be on hand. Guitar speakers are great for our purposes as they're high efficiency. If one can gain access to PA horn speakers, they're also quite efficient. Car subwoofers tend to be the least efficient of speakers, but sometimes they're easy to come by. Car sirens are great for playing higher frequencies, although they require some disassembly to get rid of the siren circuit, leaving you with just a speaker.

## Enclosures

The majority of speakers need enclosures to sound decent and loud. The exceptions are horn loaded speakers like Pa horns, speakers that already come in enclosures, or have a sealed back.

Generally one can simply build a sealed box out of heavy cardboard or wood, and cut circular holes in it for the speakers. Medium density fiberboard (MDF) is used in building more professional speakers, and is likely to sound better, but most materials will still do well. If one wishes to get more volume and possibly some extra bass, one can add a hole and a pipe into the box, to function as a port tube. Do note that some materials (MDF in particular) are vulnerable to moisture and should be protected from rain.

## Amplifiers and Power Supplies

Amplifiers take several forms, each with their own power requirements, thus they must be discussed simultaneously. Generally, for a 12v power supply. one can use either a car battery, a smaller SLA battery, or a computer power supply when needing to drive a 12v device off of wall power. Wall power can be gotten from a car battery or similar source via a power inverter, although this step is generally best avoided.

To use a computer powersupply for these purposes, one needs to know that the 12v + is any yellow wire on it, and that the ground (- for our purposes) is any black line. Also, to turn it on, there is a green wire in the 20 or 24 pin cable that runs to the motherboard, it needs to be connected to a black ground wire.

Car amplifiers are wonderful devices, running portably off of 12v, some with thousands of watts of power rating. These can easily drive massive speaker setups, great for when you need a LOT of sound. Car radios are quite useful as well, due to the fact that they are compact, run off of 12v, and contain an audio source. Simply inserting a CD or tape with your audio will get the job done.

Home theater amps are generally meant to be stationary, quite heavy, and run off of wall power. But there are times when you need the power and sound quality, and portability isn't as much of a factor. Otherwise, they are not to useful to a radical. Having to carry a battery, a power inverter, and a amplifier which is bulky because it was meant to be stationary, well, it's not a fun task.

Guitar amps. suck. They run off wall power, have poor audio quality, and low power output. exactly things we don't need. yes, the do exist up to a couple hundred watts, but those are expensive as hell. As already mentioned though, the speakers are great, very high efficiency, because they need to run off of the crap output of these things.

If one is more skilled with electronics, they can build their own amplifier. Simply the ability to solder well is enough to make an alright sounding amp using a transformer, a \$2 IC, some capacitors, four diodes, and a headphone wire for input.

## Sample ideas

The combination of a car radio, car battery, and a couple of PA horn speakers can deliver a great amount of sound from a compact package. Not at all bassy, so it's no good for music, but for playing a message to a crowd of people, this is a great setup. And with the car radio, there is the added simplicity of simply recording the message to a cd.

A 14" MDF cube can be used to hold 4 12" woofers or subwoofers, and have a 3" hole cut in the top to function both as a port and to run the wires through. While it takes some effort and is important to assure that all of the speakers move in the same direction from the same signal, this setup will be heard far away, and produces very impressive bass for music. This is best driven with a 300+ watt car amplifier.

Some people have cut out holes in the bottoms of 55 gallon drums, and put 15" subwoofers in. The drum functions as a sort of enclosure, and also resonates to help with high frequency response. There are claims that at a couple hundred watts a pair of such speakers can be heard at 10 blocks away. 55 gallon drums are heavy though, so this isn't very portable. this is an example of where a high power home theater amp would work well. Although a car amplifier will do just as well.

One recent experiment involved using 14 volt laptop lithium-ion batteries (WARNING: these things WILL explode if charged improperly or if shorted) and the amplifier circuit taken out of a pair of computer speakers to drive a pair of coaxial sealed-back (they don't need an enclosure) car speakers. This whole assembly was designed to be compact enough to be mounted in a bike frame and to run off a cheapie mp3 player. Loud enough for enjoying music at a critical mass for example, although no good for serious public listening or PA.

# Advanced

## Effect of wire type and diameter

To begin, one should know that higher frequencies transmit only in the outer layer of a wire, so using braided wire is generally a good idea. Also, it's more flexible and thus durable than solid core wire. A smaller diameter wire will generally handle less current, although in the writer's experiences, some 20 gauge can handle the output from a 340 watt amplifier without any particular heating. If your system produces mostly high frequencies and the lower frequency sound is weak first check to be sure you are using an adequate diameter speaker wire, since bass requires more power to drive the cones it is the first range to be lost.

## Mobile PA vs. stationary event PA

The biggest difference here is in frequency response. a typical mobile PA system can get very loud, but it will sound "tinny", meaning it will lack lower frequencies. this is alright for transmitting voice at a demonstration, but no good for say music at a public event. A proper address system will have many woofers, and a full range of response, unfortunately speakers that produce bass are large, and hence unportable. The larger speakers can also get very expensive, hence the earlier recommendation of dumpster diving. It should also be mentioned here that many smaller speakers can be driven beyond their power ratings when high-pass filtered.

## Full-spectrum music system

Generally, a music system needs at least two channels of audio: the woofer and the tweeter. The woofer reproduces lower frequencies ( $< 3\text{kHz}$ ) and the tweeter plays those above it. Due to the mass of the speaker cone (large moving portion) of a woofer, it generally won't play high frequency sounds. A tweeter needs to be high passed to prevent it "bottoming out" (hitting the limits of it's movement). Better systems go on to separate the sound into 3-4 channels (subwoofer, woofer, midrange, tweeter, and sometimes supertweeter) each playing a respectively higher frequency. These systems will almost always use MDF speaker enclosures, so keep that in consideration when designing a box.

## Frequency Filters

As mentioned before, some speakers need to be high passed, and others will sound better and save energy when low passed. In building a quality system you may even need to bandpass midrange speakers. For the sake of simplicity we will discuss only first-order filters.

The high-pass, as it's name implies, passes only high frequencies. This is accomplished by means of placing a capacitor in series with the speaker. If one is experimenting, 10  $\mu\text{F}$  (microFarads) is a good

value to start, as it high passes an 8 ohm (most tweeters are either 4 or 8) speaker at about 2khz. If at your power level, there is no distortion caused by the speaker bottoming out, your high pass is high enough, if not, reduce the capacitance. Also, if the speaker is playing to quietly, you may need to increase the capacitance.

The low-pass filter is generally an inductor. For those who are unaware, an inductor is merely a coil of wire, sometimes with a metal core. Inductors can be as easy as insulated solid core wire wound on a pencil, adding a steel bolt allows it to be adjusted by sliding it into the coils, as does adjusting the number and spacing of the coils. It functions by resisting a change in current level, thus reducing the ability of high frequencies to play. These can also be selected by experimentation

The band pass filter is essentially a low pass filter in series with a high pass, with the low pass filter cutting off at a lower frequency than the high pass. This allows only a certain band of frequencies to be played.

## **Speaker placement**

PA speakers should be placed in high places so they can be heard further away. Places that echo will cause louder sound, but they also understandably distort the sound, use common sense with this.

Casual music speakers should be placed at ear level. if the speakers cannot entirely be fit at ear level, then having the higher frequency speakers at ear level is best. This is why tweeters are generally at the top of floor standing speaker towers. The purpose of this is to improve imaging (the effect that the sound is directional) and therefore this is most important with surround sound systems, and still significant with stereo (two speaker) systems. Don't bother if you have mono sound.

# Troubleshooting a sound system

## Why is there no sound playing?

Make sure everything is plugged in thoroughly. I've seen people fumbling around with their speakers wondering why the damn things won't work, only to find that they accidentally yanked the line-in cable.

## low input voltage?

Generally leads to low output voltage, and thus low output power. If you know that the amp can go louder, and just can't seem to get the volume out of it despite maxing out the volume settings, you might reasonably consider that this is the problem. If you're driving the sound system off of a media player, set the volume on it louder. If that doesn't work, or if you're using a microphone or similar low power input, consider getting a preamplifier (these can be rather pricey, so it is advisable to build one using an op-amp).

## line noise

This is most commonly either the amplifier mysteriously starting to play radio stations, or getting a "wall-power" 60hz buzz (this is low pitched). They're caused by induction in the lines going to your amplifier. The wall power buzz may be occurring because of a poorly plugged in cable, or a because you have run your input lines near a transformer or high power line. If correcting this does not help, or if you are hearing radio stations, it is advisable to replace the wire. If you are in a situation where you cannot replace the wire, you should try to somehow isolate it from outside electromagnetic waves, something as simple as wrapping the wire in aluminium foil, or even a fine metal mesh, can have a significant effect.

Please note that these effects are more pronounced with longer wires, so keeping your input lines to less than 3 metres (10 feet) in length. Coaxial cable helps reduce this effect, but still, keep the length of cable as short as possible. Also try to avoid having to spool up your wire.

## audio feedback

Audio feedback is most commonly high frequency. When a sound system screeches, that's audio feedback. Essentially, your microphone picks up the sound from the speakers and plays it again a little bit louder, this goes into a loop and gets quite loud. You can try reducing your microphone gain, or isolating it from the rest of the sound system somehow. Microphones should not be near any of the speakers!

You will also get a similar effect if you have too many wires coiled up, and the line out starts inducing current in the line in. Avoid coiling wires if possible, and if necessary keep the coils separated. Also note that coils will low pass your sound, which may not be a good thing!

## **Overloaded aka Bottomed-out Amplifiers**

If your gain is set too high, or if the amplifier's or power supply's current limits are exceeded (a speaker load with an impedance too low will cause this), you will get a very distinctive distortion, as your waves will essentially turn into square waves. Another symptom is heavily accented "s" and "f" sounds in speech (these are around 10khz, while most speech is in the 500-3000 hz range). The solution is quite reflective of the problem: get a more powerful amplifier or power supply. That or turn the gain down. If this occurs after wiring up some speakers in parrallel, consider rewiring them to series. this will reduce the power usage four times, and still give you the advantage of moving more air, making more sound.



# Concert Systems

Well, maybe you're intent on having a damn punk rock show, right? These systems tend to be expensive, so be warned.

## Power supply

When you pull this much power over a sustained period of time, car batteries won't cut it, they're only batteries after all. You need wall power. Unfortunately, most outlets are limited at 1800 watts (120v\*15A), sometimes you need to find outlets on different breakers and run them in parallel (the power rating adds). Outlets with one of the prongs being "T" shaped, are rated for 20 amperes rather than 15, meaning you can draw 2.4 kW (2400 Watts, but you should know metric conversion anyway). There are also some outlets that air conditioners and such run off of, they look distinctly different, and often have ridiculous power ratings. Unfortunately they require a special amp to plug into them, as they generally supply a different voltage (240). Thankfully, they exist with breakers set at up to 50 amperes, so if you are building a system geared towards them, you can draw 12kw, well beyond most sound requirements.

## Amplifiers

Use a DJ amplifier (they cost around \$60 for 1kw) or a high power car amplifier. There really is little else with enough power output for a large crowd. If you choose to go with a car amplifier, you need to supply it 12 volts, which as mentioned before can be accomplished with a computer power supply. Here it is advisable to wire the computer psu in parallel with a car battery, because the power supply is protected against too much current draw and generally shuts itself off.

## Speakers

Concert speakers are where it really gets expensive. 15" woofers in MDF enclosures. I don't see how you'd need any less than four such woofers for even a small public event. Note that large subwoofers allow you to band pass your woofers above about 100hz and push them to greater power ratings. For concert purposes, having your subwoofer play 40-100 hz is acceptable, whereas in a personal music system, its nice to have response down to about 20hz. You were warned that this is expensive: a good deal for some 15" poly cone woofers (poly cones are tougher than paper, and thus much more usable, and these are at the bottom of the price bracket anyway) is \$30 each. Thankfully, tweeters are much less expensive. A pair of horn loaded high power tweeters can be bought anywhere from \$5-20 and sound good enough for your purposes. You do want to use horn loaded tweeters however, as their efficiency is very good. Mid-range drivers have mid-range pricing. Of course, it's ideal to be able to just find/dumpster/liberate speakers for your purposes, but it's understood that this isn't always an option.

## Speaker placement

Put your speakers at appropriate angles to get stereo sound, but also remember that they will be better heard at a longer distance if they're placed higher up. They should at least be above human head level, as having the sound blocked by a crowd is no good.



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