

Ten Strategies for Minimizing Turntable Hum

We start with a list of the top 10 strategies for minimizing turntable hum. We'll take a quick look at the physics of why hum often crops up in turntables. Then we'll explain the top 10 list so they make sense. Next, we'll go over the process described in point 10, the system build-up method. **Finally, if you have a PAT-4 Preamp, we'll go over my new favorite way to make a PAT-4 insanely quiet.**

1. Plug the amp, preamp, and turntable into the same outlet strip.
2. Use good, low ground resistance cables with double shields for phono inputs. (woven shield plus foil shield).
3. Make sure the ground connections (the crowns) of the RCA jacks fit snugly at both the preamp and phono ends.
4. Make sure that the ground connections are clean (no oxidation).
5. Use the shortest practical cable length to connect the phono to the preamp.
6. Make a clean, low resistance connection between the turntable ground and the preamp ground.
7. Keep the tonearm/cartridge away from large magnetic fields like those generated by large transformers.
8. Experiment with an additional green wire ground in strategic places.
9. Experiment with reversing two-wire plugs.
10. Build the system up one piece at a time, and do simple diagnostic tests to sort out the hardest problems.

Why Turntables Hum?

Turntable hum can be a problem because:

1. Ears are incredibly sensitive
2. Phono preamps have a lot of gain at 60-240 Hz
3. The electric and magnetic fields that cause hum are everywhere

Ears are incredibly sensitive

A really sensitive ear can hear air molecules bump together. Using a typical speaker that produces 87 dB SPL at 1 meter for a 1 Watt input, it takes just 2 pico-Watts to reach the threshold of hearing. That's 126 micro-volts into the speaker.

Phono preamps have a lot of gain at 60-240 Hz

Let's get a feel for the numbers. A typical phono cartridge generates 5 mV at 1 kHz for a modestly loud part on the record. We'll turn that 5 mV into 32 Watts, or 16 volts across an 8 Ohm speaker load. That requires a gain of $16/0.005=3200$. 32 Watts corresponds to 102 dB SPL at one meter assuming a speaker with 87 dB SPL sensitivity for 1 Watt at 1 meter ($87+10*\log(32/1)=102$). That's as loud as a Jack-hammer at 1 meter.

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The RIAA curve has, in round numbers, another 20 dB of gain at 60 Hz, so the gain around 60 Hz is about 32000. Let's say that the input-referred hum is only 1 micro-volt. That turns in 32 millivolts. That generates an SPL of 48 dB at 1 meter, equivalent to background noise in a city home. If you're an audiophile though, you keep your listening room quite quiet, and you'll put your ear next to the speaker to hear the hum! My experience shows that 10 mV of 60 Hz into a typical speaker is clearly audible with your ear near the speaker. 1 mV is almost inaudible at 60 Hz. We'll pick 3.2 millivolts, somewhere in the middle, as a practical limit. That says the hum seen on the input of the signal chain should be less than 0.1 microvolts to be totally blameless.

The electric and magnetic fields that cause hum are everywhere

The electric and magnetic fields that cause hum are an unavoidable side-effect of the process of distributing and using 60 Hz power. We can't get away from it, but we can minimize the noise it creates.

About the 10 Strategies

1. Plug the amp, preamp, and turntable into the same outlet strip

Voltage differences between system components get amplified. You can minimize undesirable voltage differences by plugging all the components into the same outlet strip. That assures that all of their power is in phase, and that minimizes the voltage differences that result between the components, minimizing hum. This is the single most effective thing you can do to assure low noise.

2. Use good, low ground resistance cables with double shields for phono inputs. (woven shield plus foil shield)

Even though we've done step one, there will still be currents induced onto the phono cable shield. Ohms law tells us that voltage equals current times resistance, so if we want to minimize the voltage, then we must minimize the resistance.

Double shields give us cables that block both hum and radio frequency interference.

3. Make sure the ground connections (the crowns) of the RCA jacks fit snugly at both the preamp and phono ends

4. Make sure that the ground connections are clean (no oxidation).

As in the previous step, freedom from noise means you need low resistance ground connections and wires between the cartridge and the preamp. The system is only as quiet as its noisiest element, so low resistance cables with high resistance contacts for the grounds owing to either a loose fit or connector oxidation will be noisy!

5. Use the shortest practical cable length to connect the phono to the preamp

Long cables have more opportunities to pick up noise. Therefore, you'll want to use the shortest cables that are practical for your setup.

6. Make a clean, low resistance connection between the turntable ground and the preamp ground

Most turntables come with a separate green ground wire that should be run to a ground screw on the preamp. Make sure that the connection is tight and clean so it will have low resistance.

7. Keep the tonearm/cartridge away from large magnetic fields like those generated by large transformers

Remember how much gain the system has at low frequencies? Recall also that the cartridge responds to small magnetic field changes generated by a moving stylus on the LP. External magnetic fields impinging on the cartridge from power equipment will generate hum. Sometimes the hum comes when the arm gets close to the turntable motor. Sometimes an adjacent component creates a magnetic field that creates hum. In such cases, your best defense against hum is to place distance between the source of the magnetic field (hum) and your phono cartridge.

8. Experiment with an additional green wire ground in strategic places.

An additional wire to a good ground can sometimes help the noise. Where to get a good ground? If the chassis of one component is grounded, then you might run a wire between that grounded chassis and the chassis of some component with a two-wire plug. This is a somewhat advanced skill, and if the idea makes you nervous at all, then don't do it.

9. Experiment with reversing two-wire plugs

Some components with two-wire plugs are polarized, with a wide blade and a narrow blade. You can't reverse them. However, a fair number of components have two-wire non-polarized plugs. This is especially true of vintage components. Reversing the way you plug a two-wire non-polarized plug into the power strip can significantly reduce system hum.

10. Build the system up one piece at a time, and do simple diagnostic tests to sort out the hardest problems

This is probably the best method to achieve a good result and find the source of funny problems. It's important enough that we'll devote the next section to the technique.

Build the system piece by piece for ultimate knowledge

Starting with nothing plugged in, have a power strip ready to receive all the power cords.

1. Connect the speakers to your power amp. Use an outlet on the power strip to connect power to the power amp. Check the hum and noise at the speakers with no inputs connected to the power amp. Is everything good? Then go on to step 2.
2. Connect power to your preamp using an empty socket on your power strip. Turn it on. Are the speakers still quiet? Then go to step 3.
3. Connect the preamp output to your power amp's input. Set the preamp for a high level input, like a CD player. All still quiet? Then go to step 4.
4. Set the preamp to the phono input, but make no other connections to the preamp. Set the volume control to a typical listening level. You may hear the sound of the rushing ocean and a little hum, but the rushing ocean sound should dominate. Listen to the noise from your normal listening position to judge if it's low enough. Remember that the record and turntable noise will mask some sins, but feel free to still be fussy at this point.
5. You might try reversing the preamp power plug to see which orientation minimizes noise.
6. For a more sensitive test, insert shorting plugs into the phono inputs (Turn the volume control down first. Make sure that your shorting plugs are short so they don't pick up hum. Shorting the phono input decreases the rushing ocean sound greatly, which unmasks any remaining hum. Return the volume to a normal setting, and listen to hum from your normal listening position. If there's too much hum here, then you may have an issue with your phono preamp. If it's a PAT-4, make sure you read that last section for an awesome, if awkward way to drop the hum a lot!
7. If tests 4 and 5 were quiet enough, set your turntable in place. Connect the RCA cords from the phono to the preamp (remember to turn your volume down first!). Make sure:
 - a. RCA cords fit snugly.
 - b. RCA jacks are clean.
8. Turn the volume up a little. It will probably hum too much! That's because you have yet to connect the green wire ground from the turntable to the preamp.
9. Turn the volume down, and run a secure connection from the turntable's green wire ground to the grounding screw on your preamp. Note that the turntable power is still not plugged in. Turn the volume up to a normal listening level. Is the hum/noise acceptable?
 - a. If it isn't – check for nearby hum sources, and turn them off or move them away.
 - b. Make sure you can tell the difference between acoustic buzz from big power transformers and electrical hum from the speakers. Fluorescent lights (and some TV's) typically have power transformers that buzz enough to mask hum from your system.
10. Turn the volume down, and plug the turntable power into the outlet strip. Turn the volume up to normal, and listen for the noise. If you can flip the turntable plug, experiment with which orientation minimizes the noise. Make sure to turn the volume down while applying or removing power. Doing so with the volume up often makes noises that sound like shotguns, and may startle you.

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11. With the cueing lever up, move the arm across the record to make sure that the noise doesn't change with arm position. If it does, you may have noise created by magnetic fields from the turntable motor.
12. At this point, you probably have a pretty quiet phono playback system. If it isn't quiet enough, you have good data on when and where it might be entering your system. Given a little time and thought, the cure will probably come to you.
13. Add other high level components one at a time, checking at each step along the way (connecting cables, adding power, flipping the plug if possible) to make sure that the phono hum remains low enough.

Making an insanely quiet PAT-4 Preamp

First, a story. Through the years, I've played in a number of community bands. One year, for a significant anniversary of the town of Westfield, NJ, Jerry Nowak was commissioned to write and rehearse a piece for the Westfield community band. Ever the optimist, he called for a lovely soft dynamic from the trumpet section at one point in the piece.

It only takes one trumpet playing loud to completely nullify the good and quiet sound from all the rest of the trumpet section. That's how it is with fighting hum...only the loudest source gets heard, and it can spoil the good work of all the others.

Shielded cable and the PAT4LP Upgrade

The stock PAT-4 uses twisted wire inside as a stand-in for shielded cable. You can replace that twisted wire with shielded cable, especially in the small signal sections and remove one entry point for hum.

The stock PAT-4 phono section has a pretty fair amount of "rushing ocean" noise. That's actually not such a bad thing, as it tends to mask the hum in a PAT-4 preamp. You can dramatically reduce the rushing ocean sound (by 4 to 8 dB) when you install the PAT4LP upgrade and the PAT4PWR upgrade. However, when the rushing ocean sound drops, the hum is a lot easier to hear. No good deed goes unpunished!

The Loud Trumpet

I spent quite a while diagnosing this. I used shorting plugs, a phono cartridge in a steel box, good cables, double shielded cables, bad cables, ground resistance experiments, an old turntable, a new turntable, my ears, and a spectrum analyzer. My conclusion was inescapable. The source of the noise is stray magnetic fields from the PAT-4 power transformer.

Thinking out of the box.

Mu metal shields helped a little, but not enough. The only thing that was going to make the PAT-4 audiophile quiet on the phono side was moving the transformer out of the box. So I did just that. I took a 5 foot length of 18 AWG shielded cable. It had a red wire, a black wire, a drain wire, and a foil shield. I disconnected power from the existing

transformer, and ran the AC input to the PAT4PWR board over shielded cable to a power transformer sitting outside of the box.

The difference was dramatic. The spectrum analyzer reported a spectacular drop in all power line harmonics with a shorted input. It reported a similar (though less spectacular) drop with a phono cartridge in a steel box, or in a turntable. This is the way to make a PAT-4 crazy quiet. Get the transformer out of the box.

If you do everything else right, this is the step that quiets the last loud trumpet in the section, and pretty well stops the hum. The hum at this point is way below record noise. You hear pre-groove echo, and a number of other things that might previously been masked. It is quiet!

Here are a few pictures of the experimental setup. You can make a rig to get similar results. The question is, should I design something nice to do this? If you'd be interested, please send me email (dan@akitika.com).

