The VSPS

Very Simple Phono Stage

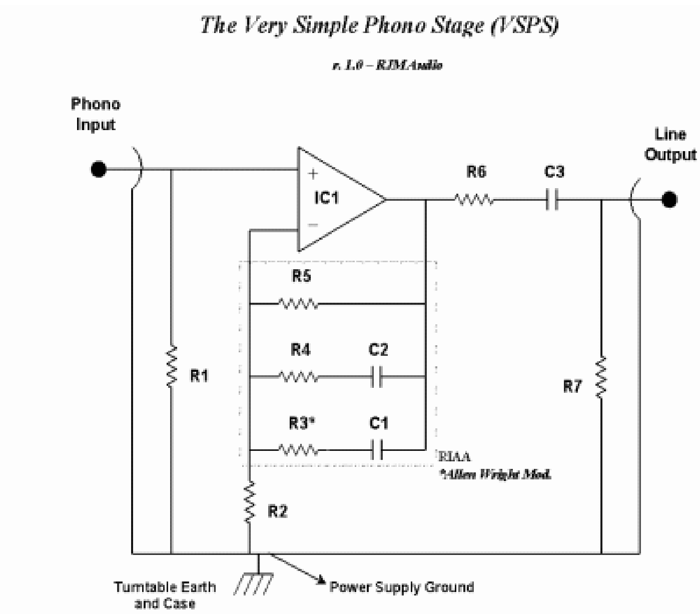
Presenting a simple, versatile phono stage using a bare minimum number of parts and the following features:

- 27 parts per stereo unit. Low parts count makes it cheap to build and easy to optimize.
- Wide choice of op amps. Just about any dual op amp can be used in this circuit.
- Accurate RIAA equalization obtained using common, standard value components. Uses Allen Wright's modified curve, with the additional zero at 3.2 µS.
- User variable gain. The circuit can be easily adapted to work with moving magnet and medium-to-high output moving coil cartriges.
- Low power consumption.
- Single stage, active equalization, non-inverting topology.

This circuit is appealing for beginners, of course, but the simplicity also offers more experienced builders the chance to evaluate and optimize each individual part. Taking my cue from 47 Labs I would also like to think there is an *inherent* benefit of a simple circuit, sonically, coming from the tighter layouts and better grounding arrangements - the direct result of having fewer parts to deal with.

The Amplifier Circuit

An op-amp is configured as a non-inverting gain stage. The RIAA equalization is done within the feedback loop. This is a classic circuit, but not seen too often in DIY since calculating the values of resistance and capacitance needed can be a pain. Modern software like MathCAD makes this task a breeze, however.

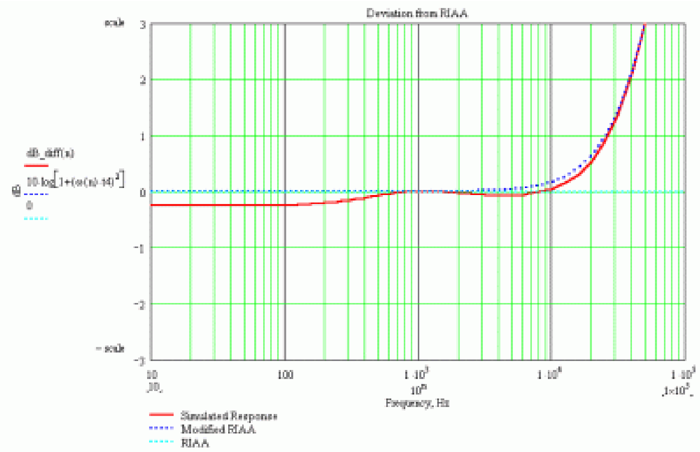


The circuit is so basic that each component can be discussed individually. I've split the design into low impedance (Lo-Z) and high impedance (Hi-Z) versions. The Lo-Z circuit is a low noise version optimized for Grado and other low inductance cartridges (<300 mH), the Hi-Z version is better suited for "traditional" MM cartridges with high inductance (>300 mH). The performance difference is small, both varients will work fine with any source.

Component	Lo-Z	Hi-Z	Description

R1	47k		This resistor (and optional capacitor) should be set as directed by the cartridge manufacturer.
R2	220R	2.2k	This resistor sets the gain. It can be varied from 680R/6k8 (30dB) to 220R/2k2 (40 dB) to 68R/680R (50dB) and perhaps lower still.
R3	[1k-R2]	[10k-R2]	Allen Wright Mod., cuts treble attenuation above 50 kHz. 680R can be used when when R2 is 220R (40dB gain), as the value need only be approximate.
R4	**33k**	**330k**	RIAA. Match between channels.
R5	**220k**	**2.2M**	RIAA. Match between channels.
R6	47R		Isolates the op amp from the effects of output lead capacitance.
R7	33k		The value of this resistor isn't critical, it mainly serves to drain off charge from the output side of C3.
C1	**3.3n**	**330p**	RIAA. Match between channels.
C2	**10n**	**1.0n**	RIAA. Match between channels.
C3	4.7µ		Output coupling. Must be non-polar.
U1	NE5532	OPA2134	Any audio op-amp could be used with satisfactory results. The Lo-Z version is best matched to the NE5532 or similar op-amp with low voltage noise and good performance into low impedance loads. Use a FET input type like the OPA2134 for the Hi-Z version.

RIAA values shown in bold. With these exact numbers the response is accurate to 0.25 dB, so it might be worthwhile hand selecting parts that are within 1% of the list values. This is particularly true for the capacitors, which are normally available in 10% tolerances.



As seen in the graph, the Allen Wright modification boosts the treble by 0.5 dB at 20 kHz, a modest change by any measure. The VSPS follows this modified response.

Suggested Component Selection

Polypro film and foil for C1 and C2. For the Lo-Z version I used Vishay BC components KP 461 as these are available in 1% tolerances. Wima MKP, FKP etc. also ok. Black Gate non-polar electrolytic for C3. All resistors carbon film 1/4W 5%.

Use a socket for the IC and test various op amps to see which performs best. With an adapter board, available here the two surface mount AD825s can be made pin compatible with a standard DIP socket and dual op-amp pin connection.

Circuit Discussion

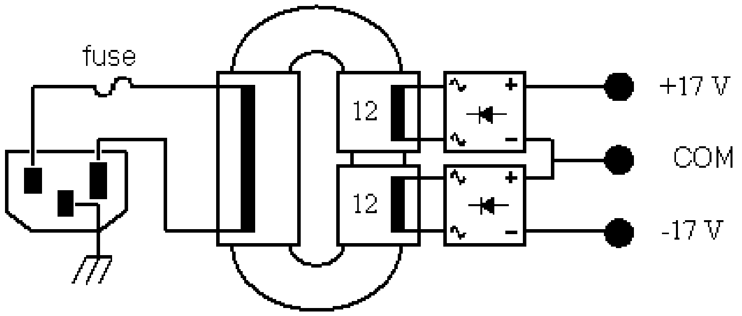
This circuit has two fundamental problems both of which are neatly circumvented by adopting the Allen Wright RIAA response curve.

The first issue is the limitation that the gain of a non-inverting amp cannot fall below unity. In principle the RIAA response calls for the high frequency attenuation to fall off at 6 dB per octave, so at some point the amp cannot provide sufficient attenuation to properly track the response. With the AW curve, however, this treble cut is deliberately defeated at 50 kHz so the treble gain remains above unity if the total mid-band gain is set greater than 30 dB. (It levels off at about +12 dB in the standard 40 dB configuration.)

The second disadvantage concerns the impedance of the active filter: without R3 the impedance of the feedback loop approaches zero at high frequencies. (The capacitor C1 essentially becomes a short circuit.) The op amp, under these conditions, drives R2 directly in parallel with the output load. The output signal will have high distortion if R2 is lower or close to the op amps optimum load resistance. This is avoided by adding resistance R3 in series with C1 to set up the fourth 3.18µs time constant. The high frequency impedance of the feedback loop is now R2+R3 = ~1k for the Lo-Z version, ~10k for the Hi-Z version.

Recommended Power Supply

The transformer is at least 35 VA and has two 12 V secondaries. One or two full-wave rectifiers, 200 V / 1 A or larger diodes or bridge diode units. Don't forget the fuse. Large toroidal or R-core transformers are recommended. Much of the quality of the sound depends on the power transformer, so don't skimp on this part just because the current demands are only a few milliamps. Dual mono is an option.

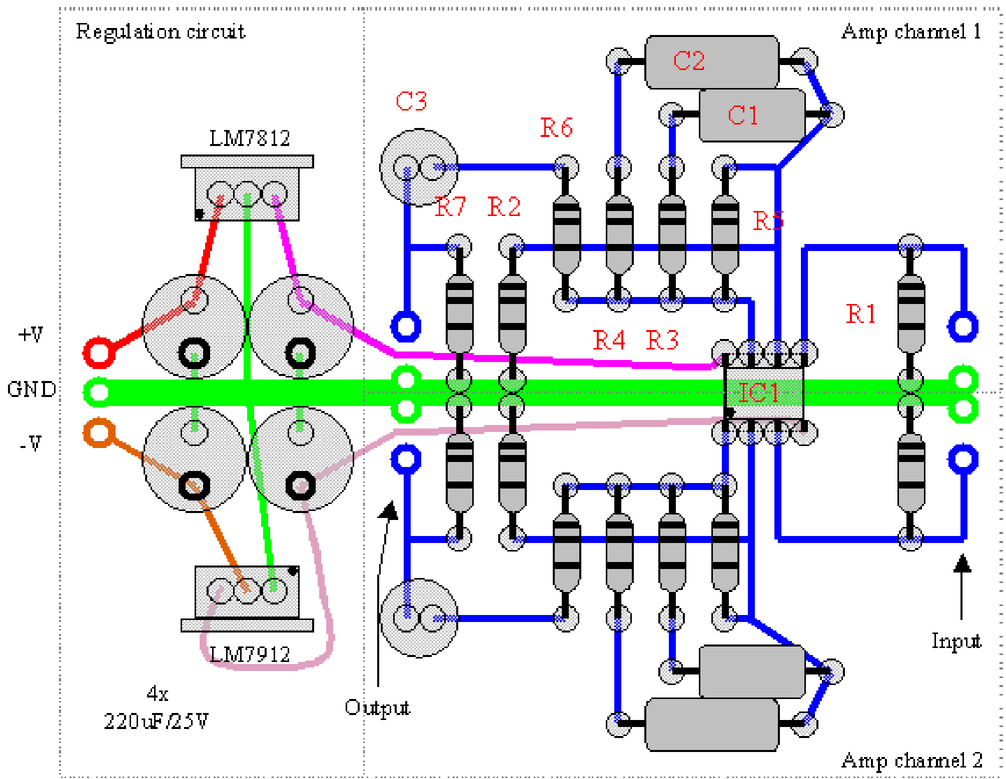


Next, placed as close to the amplifier as possible or integrated as part of the same board, is the voltage regulation circuit. In the simplest variation, the fixed voltage 3-pin regulators, e.g. LM7812 and LM7912, are used with electrolytic capacitors on the inputs and outputs. The input capacitor is around 330 µF to 480 µF, while the output capacitor should be a little smaller, 47 µF to 220 µF.

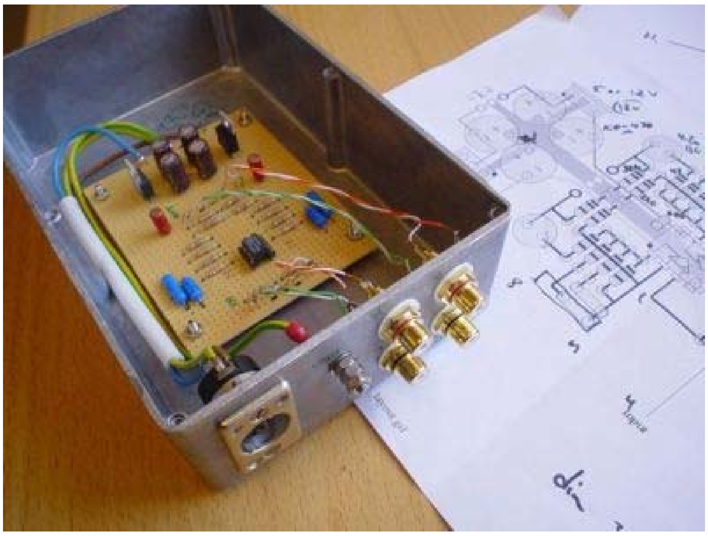
Adjustable regulators can be used instead for improved performance.

Layout

Layout shown for a dual op-amp. Since this is a "beginners" project I have drawn it with more detail than normal. All parts and distances are nearly to scale. The circuit can be mounted on a project board and point-to-point soldered using 24 gauge copper wire to connect the components.



In the photo, the board is mounted in a Hammond aluminum project box, with an external power supply connected via a 3-pin XLR jack.



A high-performance version would use single op-amps, with an individual regulation circuit for each one.

Notes

With the layout presented above there are some compromises, mostly to do with soundstage width and stereo imaging, which I suppose I deliberately took in the interest of keeping the complexity and costs down to a minimum. Moving to a dual-mono configuration, where each channel has its own individually regulated op-amp, brings the performance in this area to a much higher standard. A printed circuit board is available for this configuration.

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