RIP YOUR VINYL TO BITS, WITH A USB PHONOSTAGE

So what do you do with that collection of LPs you have? Sure, they sound great and are fun to listen to, but let's face it, they're not exactly portable. Wouldn't it be great to digitize them and save to hard drive or burn a CD? This project solves that problem by providing a very high quality interface between turntable and computer. "The Ripper" is a high-end standalone analog phonostage, complete with power supply, but with a twist – the addition of a USB analog-to-digital converter.

Design

The circuit is built around the Texas Instruments PCM2906 USB audio interface chip (see Figure 1a). This remarkable piece of silicon does most of the hard work for us. It provides a standard USB 1.1 interface to the computer, and is recognized as a standard audio device by both Windows XP and Mac OS-X. Neither operating system requires special drivers; the chip is plug and play compatible. To simplify the overall design, this portion of the circuit is powered by the 5Vdc supplied across the USB bus. That keeps it separate from the low noise analog section and supplies.

The USB chip needs a few external components to operate, a 12MHz crystal and decoupling capacitors. Circuit board layout is critical requiring short, low inductance traces and both power and ground planes. All that high frequency digital noise must remain contained so it does not contaminate the analog signals, and the USB data lines must have a 93 ohm differential impedance.

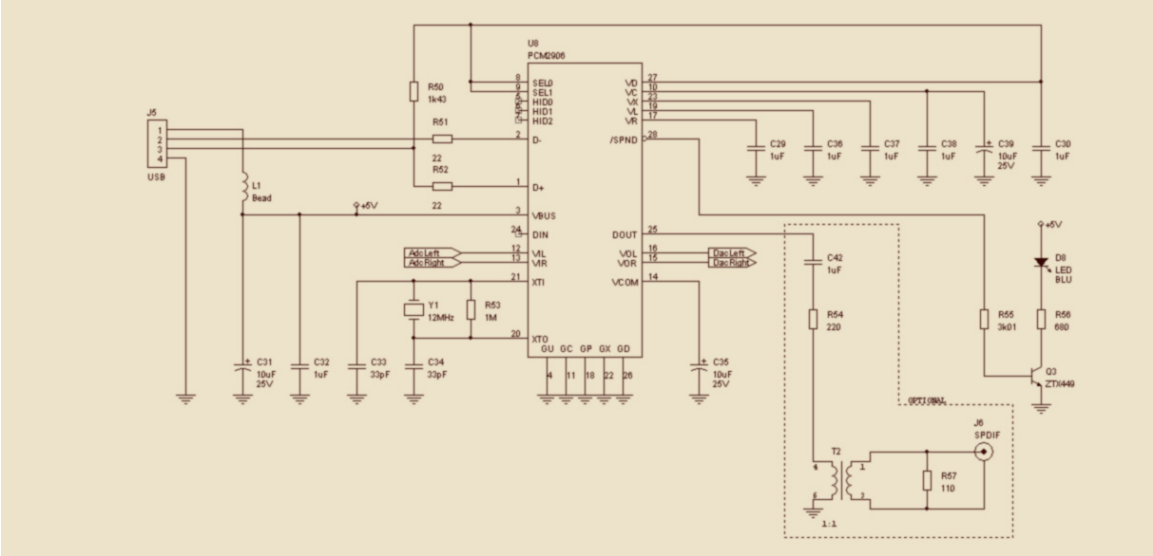

Figure 1a – USB Interface

The phono section (Figure 1b) is not your typical feedback type seen in most application notes. Instead, it is a high performance topology that implements the equalization passively in split sections. Gain is also spread out across three opamp stages, optimizing performance. Yes, this costs a bit extra and is more complicated, but the proven sonic benefits are worth it. The gain potentiometer acts like a volume control, which is used to set recording level. The buffered output is sent to the ADC input on the USB chip, a line-out buffer, and a headphone amplifier. Using headphones is a convenient way to monitor recordings.

The USB chip also contains a digital-to-analog converter for playback. This is fed to switch S1, which selects between the raw analog feed or the digital playback.

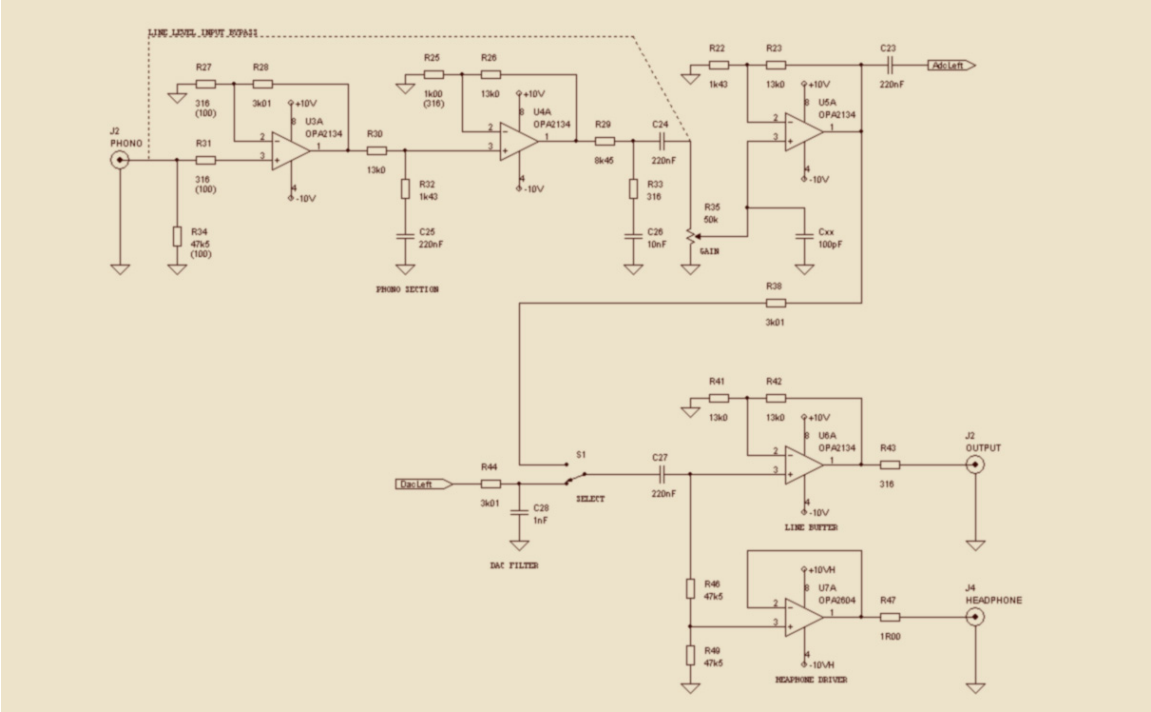

Figure 1b – Analog Section

The analog section is powered by regulated +/-10V supply rails (Figure 1c). The regulators are similar to the Sulzer/Jung designs, offering very low noise performance and a stable, low output impedance. This discrete design is far superior to the standard three terminal regulators typically employed. The primaries on the transformer can be strapped for either 115Vac or 230Vac operation by jumpers.

Instead of a normal fuse, solid-state resettable trip-resistors are used. These are PTC (positive temperature coefficient) types with a very non-linear characteristic. They remain at low impedance for normal operating currents, and then trip to a high impedance state during a fault. They also implement a low pass RC filter with C7, eliminating some high frequency noise from the ac line.

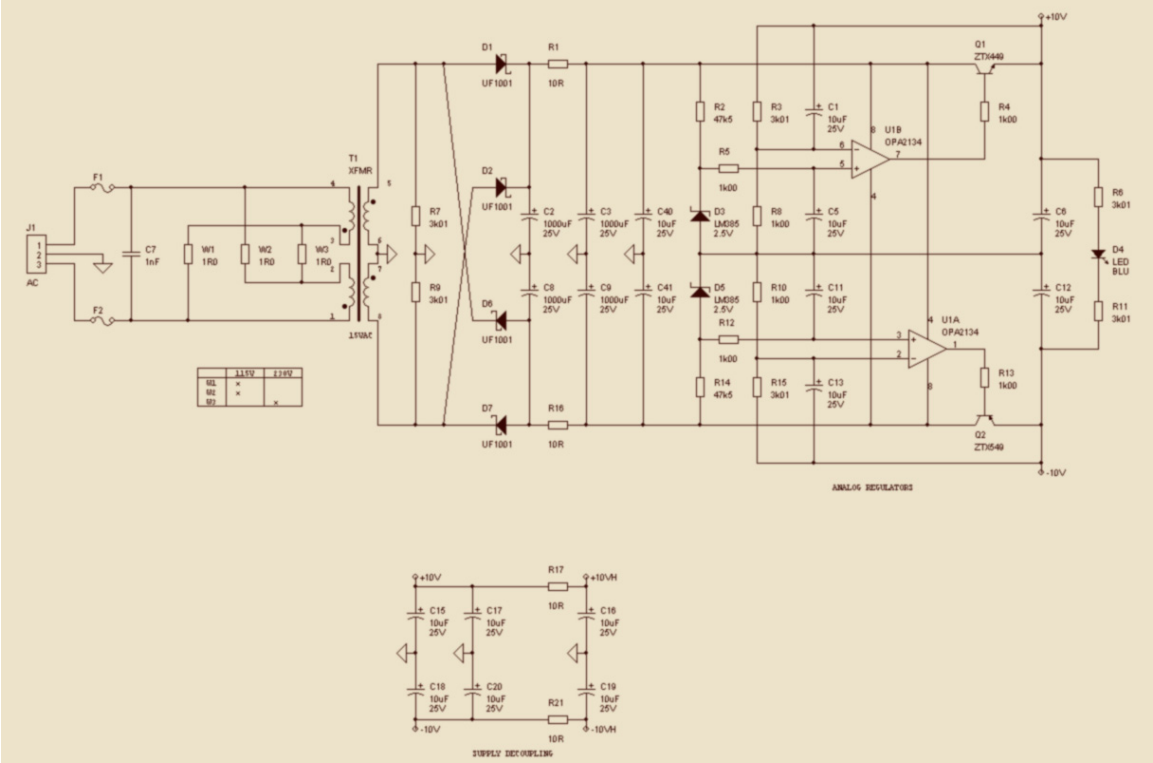

Figure 1c – Power Supply

SPECIFICATIONS

Gain	48dB
Input Impedance	47k ohms
Output Impedance	320 ohms
RIAA Flatness	+/-0.5dB
Bandwidth (-3dB)	16Hz, 32kHz
Distortion	0.05% @1kHz
SNR	72dBA ref 5mV
Computer I/O	USB 1.1
Data Rates	32k, 44.1k, 48k
Resolution	16 bits
Size	5” x 5” x 5”
Power	115/230Vac, 2W

Assembly

The circuit board is designed for easy assembly, requiring no wires whatsoever. This helps to eliminate errors. Also, when the circuit board is purchased from **www.hagtech.com** the surface mount components (USB chip and two capacitors) come pre-installed, leaving only standard thru-hole components.

Your first choice is to set the line voltage jumpers. These are just 1 ohm resistors soldered to the bottom side (under the power transformer). Then install all of the resistors, then opamp, then capacitors, etc. Start with the smaller components and work your way up in size. The heat sinks are not used for heat dissipation, but rather as electrical shielding between the power supply and phono circuits. Be sure to pay attention to polarity of electrolytic capacitors, diodes, and ICs.

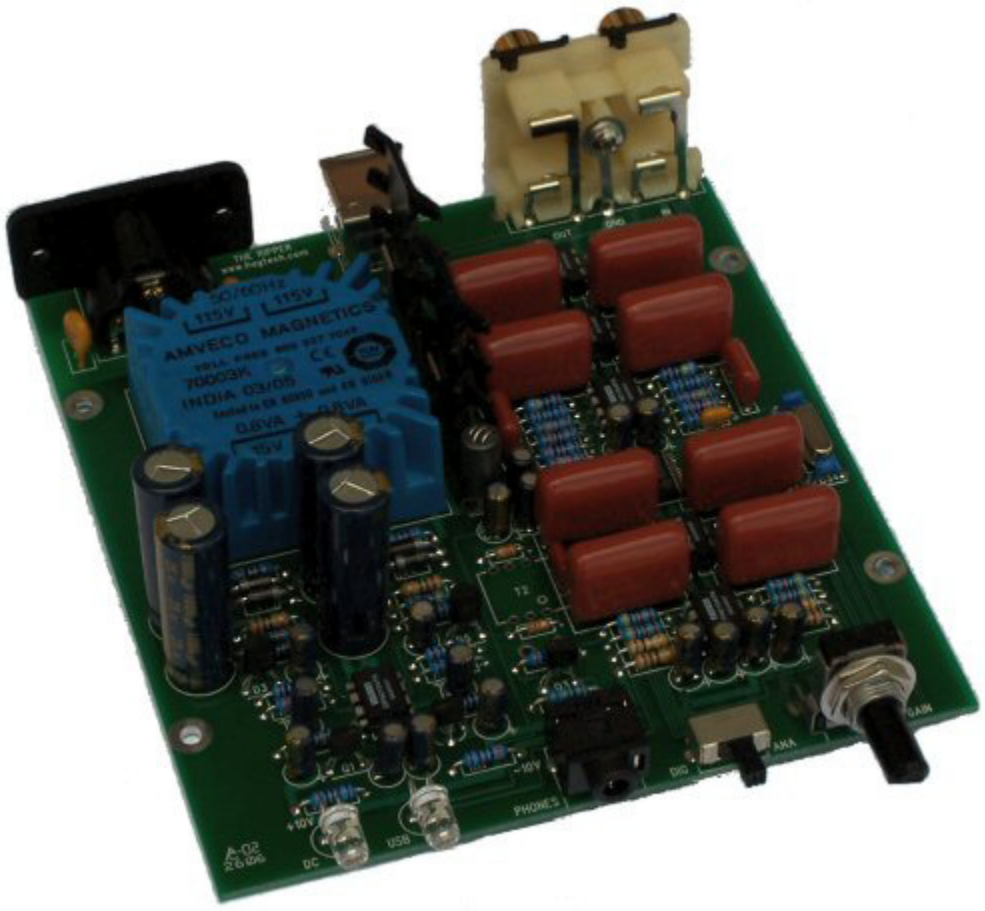

Figure 2 – Completed Circuit Board

The PCB comes with a pre-cut and silk-screened plastic box and associated hardware. They are designed to fit together like a glove, providing a professional appearance to the project. A couple of screws and nuts and you are done!

Figure 4a – "The Ripper" Front Panel

Figure 4b – "The Ripper" Rear Panel

RESOURCES

- PC board and pre-cut chassis are available from **www.hagtech.com**.
- Electronic components can be purchased from **www.digikey.com**.
- Audacity recording software is a free download from **http://audacity.sourceforge.net**.
- Data sheet for the USB chip can be downloaded from **www.ti.com**.

Testing

First, do a visual check to insure all components have been installed correctly and in the proper orientation. Then, wearing safety goggles, plug the machine in. There is no power switch (it only draws 2 watts) and the power LED should light up. Measure the +/-10V outputs from the regulators. If ok, then proceed.

Connect a turntable to the phono inputs, and the line outputs to your stereo system, or just plug in headphones. Set the monitor switch on the front panel to analog. You should now be able to play LPs as if this was a standalone phonostage.

Plug in a USB cable, the computer should recognize and enumerate the device. This will take a few seconds. You might have to set the audio output device to "USB Audio Codec" in the control panel dialog box. The USB LED on front panel should be lit and you should now be able to play music from your hard drive or CD ROM drive.

Recording

The last piece of the puzzle is to obtain recording software. There are many options, from GarageBand to Cakewalk. One popular choice is Audacity, a free download. It is very easy to use and works well.

In Audacity's preference dialog box, set both input and output devices as "USB Audio Codec". Also set the defaults to stereo, 44.1k, 16-bit. Now you are ready to go. Put on an LP and start playing it. Hit the "record" button in Audacity, and watch the input level meters. Adjust the gain control on the front of "The Ripper" to set the recording level as high as possible without clipping. Use the monitor switch on the front panel to select between analog or digital feeds. Hit "stop". Remove that track. Start the LP over and hit record again. You are now recording CD-quality sound! When done, you can save the track as either a WAV or MP3 file. From there you can convert it to many other formats (other programs), burn a CD, or download to your iPod.

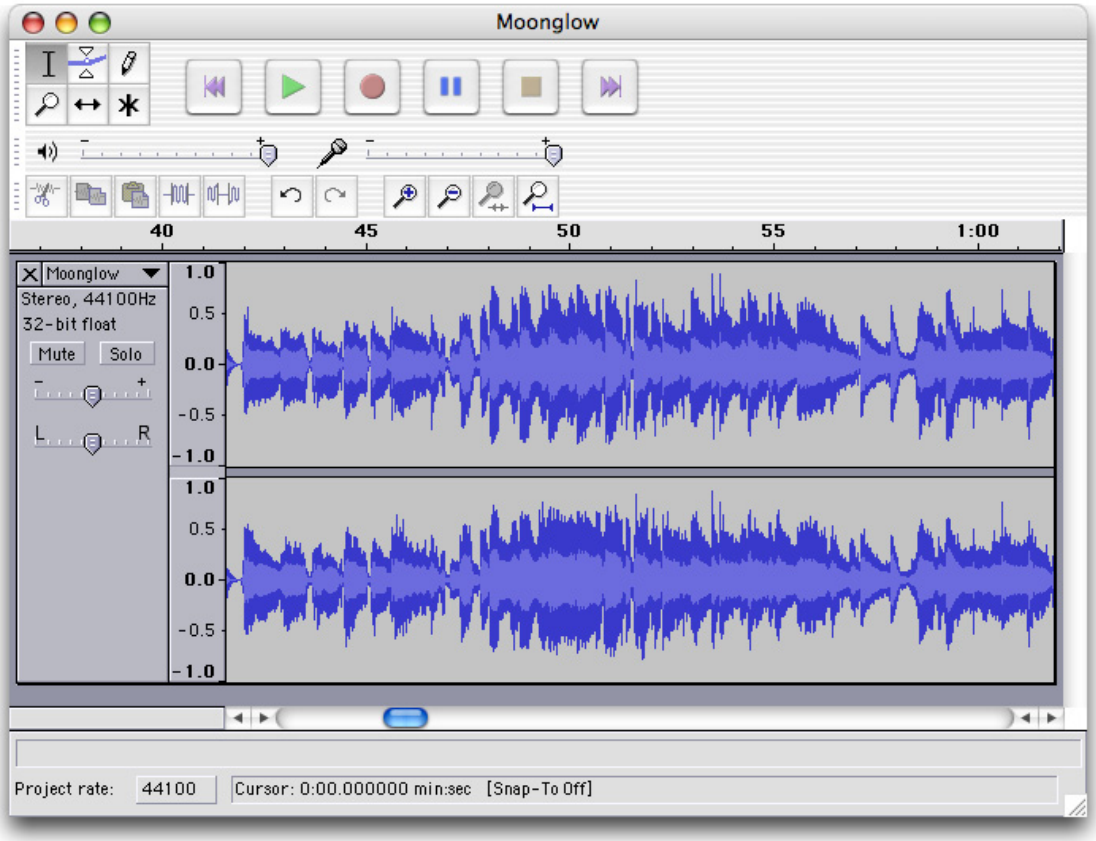

Figure 3 – Audacity Recording Software

PARTS LIST

ITEM	DESCRIPTION	PN	QTY
RESISTORS			
❑ W1, W2, R47x	1 1.4W	1.0QBK	5
❑ R1, R16, R17, R21	10 1/4W	10QBK	5
❑ R51, R52	22 1/8W	22EBK	5
❑ R31x, R27x, R33x, R43x	316 1/4W 1%	316XBK	10
❑ R56	680 1/4W	680QBK	5
❑ R5, R12, R8, R10, R4, R13, R25x	1.00k 1/4W 1%	1.00KXBK	10
❑ R32x, R22x, R50	1.43k 1/4W 1%	1.43KXBK	5
❑ R7, R9, R3, R15, R6, R11, R28x, R38x, R44x, R55	3.01k 1/4W 1%	3.01KXBK	15
❑ R29x	8.45k 1/4W 1%	8.45KXBK	5
❑ R30x, R26x, R23x, R41x, R42x	13.0k 1/4W 1%	13.0KXBK	10
❑ R2, R14, R34x, R46x, R49x	47.5k 1/4W 1%	47.5KXBK	10
❑ R53	1.0M 1/4W	1.0MQBK	5
❑ R35x	50k volume pot	P2U4503	1
CAPACITORS			
❑ C2, C3, C8, C9	1000uF 25V	P11223	4
❑ C40, C41, C1, C5, C11, C13, C6, C12, C15, C18, C17, C16, C19, C31, C39, C35	10uF 25V	P11212	17
❑ C32, C29, C36, C37, C38, C30, C42	1uF ceramic	P4968	7
❑ C25x, C24x, C23x, C27x	220nF film	P3224	8
❑ C26x	10nF film	P3103	2
❑ C28x	1nF film	P3102	2
❑ C7	1nF AC (250V)	P4490	1
❑ C33, C34	33pF ceramic	P4843	2
SILICON			
❑ D4, D8	LED blue	160-11610	2
❑ D1, D2, D6, D7	Diode	UF1001DICT	4
❑ Q1, Q3	NPN	ZTX449	2
❑ Q2	PNP	ZTX550	1
❑ D3, D5	LM385 reference	296-9563-5	2
❑ U1, U3, U4, U5, U6, U7	OPA2134 opamp	OPA2134PA	6
❑ U8	PCM2906	296-13479-5	1
OTHER			
❑ Y1	12MHz crystal	X1037	1

❑	L1	Ferrite bead	240-2492	1
❑	F1, F2	Fuse (resettable)	LVR005S	2
❑		Heat sink	HS224	2
❑		Knob	226-4092	1
❑	S1	Switch	EG1942	1
❑	J5	USB jack	609-1039	1
❑	J2	RCA dual	CP-1436	1
❑	J4	Headphone jack	CP-3554NG	1
❑	J1	AC input	Q310	1
❑	T1	Transformer	TE70003	1
❑		USB cable	AE9932	1
❑		Power cord	Q139	1
❑		Chassis	SRA31B	1