DIY ECC802S (12AU7 / ECC82) Tube SRPP Preamp

Bruce Heran gofar99@Hotmail.com Share

ForeWatt: DIY ECC802S SRPP Tube Preamplifier

After designing and building a number of vacuum tube (valve) power amplifiers I decided to build a tube preamplifier. I did a lot of searching for the "right" design and really could not find one I liked. Not that there are no good ones out there, just none that inspired me. After the success with the various Odd Block amplifiers:

- OddBlocks: DIY KT88 / 6550 Tube Push-Pull Monoblock Amplifier Kit
- PoddWatt: DIY 5751 SRPP / EL84 (6BQ5) Push-Pull Tube Amp Project
- OddBlocks: DIY KT88 / 6550 Push-Pull Mono Block Tube Amp Project
- DIY OddWatt 6CA7 / EL34 / KT66 / KT77 Tube PP Stereo Amp Project
- DIY OddWatt ECC802S SRPP / EL84 Push-Pull Tube Amplifer Project

that used a SRPP (shunt-regulated PP) driver stage I started to do some research and modeling on a SRPP. The advantages of such a line stage are much the same as those when a SRPP is used as a driver. Good linearity, low distortion, low impedance output, good power supply noise rejection and modest gain. The research also indicated that the gain needed was usually between 3 and 10. This is a perfect application for a tube SRPP. There are many ways to determine what tubes to use in any given project and a line stage is certainly no exception. My method is to determine how much gain I need and then select a tube that has an amplification factor of about twice what I need. The gain in this case fit right in with one of my favorite tube types the ECC802S. The ECC802S is a variation of the 12AU7 / ECC82 family of vacuum tubes. Others may prefer different tubes but I have had good success with the ECC802S from JJ/Tesla. The actual design process for a SRPP stage is really best started with some type of modeling program. Otherwise you will probably have to make many test set ups to find good values for the components. If you don't have a distortion analyzer, good dual trace oscilloscope scope and low distortion signal generator, you will be in for a lot of trial and error (mostly error) to get something reasonable. I also considered using a Mu-follower stage. This is quite similar to a SRPP and often has some advantages (like lower output impedance). In the long run I was unable to come up with a Mu stage that I felt performed better than the SRPP.

Photograph 1: ForeWatt Type II Preamplifier with tubes inside the case

Warning: This project is based on the use of vacuum tubes and contains potentially dangerous voltages. If you are unfamiliar with the hazards or uncomfortable working with such voltages, please don't risk your health or possibly life building the preamp.

General Design Goals

For those of you who have looked at some of the other projects I have designed you are familiar that I insist that the end project have certain qualities. It must be quiet. I hate hum and noise. A signal to noise ratio of around 90 dB seems to suit me. More is better. The response must go from below 20 Hz to at least 20 kHz within 1 dB. Most of my projects are flat down to 10 Hz and go well past 20 kHz. I actually design in some high filter aspects so that the preamplifier will not pick up radio stations and other junk above audio frequencies. Distortion must be low. For a valve tube amp a maximum of 1% at full output is pretty good. For a preamp 0.1% or less is needed. A consequence of these limits, is that all components need to be of good quality and careful attention to the design and layout is required. Unfortunately, and particularly with valve power amplifiers these things raise the cost. I use whatever parts are best for the application and am not be concerned about cost or type. If a simple carbon resistor will do, then it gets used. If a 1% polyester capacitor is needed, it will be used. That is part of the reason for one very obvious departure in my projects from many tube designs. I use exclusively solid state rectifiers. True they are all fast recovery types, but still they are solid state devices. They do the job I require well. If you prefer tube rectification, fine, you will need to obtain a different power transformer and make some other circuit adjustments. If you go this route please let me know how it works out.

Photograph 2: ForeWatt Type I Preamplifier with tubes protruding from the case

Three Versions in One

As most of you have already noticed there are photos of two different preamplifier projects. One has the tubes protruding through the top top and the other preamp has them inside the enclosure. The preamp with the tubes located inside the chassis has identical active circuitry, but has wireless remote volume and input selection. Additionally it has a pass through mode for use as a passive preamp. The wireless portion is handled by modular units which could be used as a separate passive preamp. I have included details on building all three tube preamplifier possibilities. The wooden enclosure is available in limited quantities from an outside source.

ECC802S (12AU7 / ECC82) SRPP Preamp Circuit Details

So let's get to the preamp project deatils. It has a reasonable input impedance of around 100 k-ohms and an output impedance of around 3 k-ohms. This is suitable for nearly all sources equipment and power amplifiers. Long cable runs and low impedance (input) power amps may require a series resistor of between 220 and 2700 ohms in the output of the preamp to maintain linear response. A pair of 2.2 k-ohm resistors are used in this instance. This allows for connection of both a set of main power amps and a set of subwoofer amps with reduced interaction between them. The voltage gain of this srpp preamplifier circuit can be either 7 times (17 dB) or 11 times (21 dB) - The choice is up to the builder. The only difference in the circuit is whether or not the cathode of the lower triode is bypassed (with a capacitor) or not. If you choose to bypass the cathode for higher gain, be sure to use a good quality capacitor. Elna Silmac, Black Gate or similar capacitors are fine in this role. As an aside, if you use the unbypassed version, you can to some extent tailor the top end response with a small bypass capacitor across the cathode resistor. I found that a 0.0047 uF capacitor gave a noticeable boost at 20 kHz. This could be used if you have some equipment that is connected with long cables to compensate for the losses in the cable. All resistors in the active part of the circuit are 1% Dale metal film although other brands and types should be fine. The volume control (potentiometer) is an Alps Blue in the Type I preamp. In the Type II with remote control a Alps Black motorized potentiometer is used.

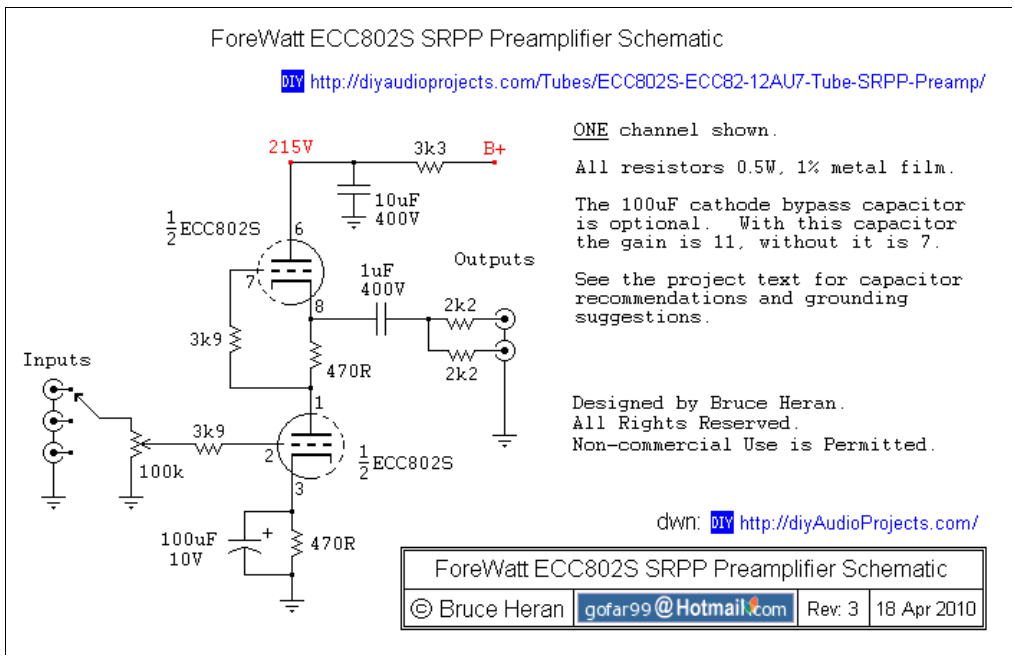


Figure 1: ForeWatt Type I - ECC802S / 12AU7 / ECC82 Tube Preamplifier Schematic

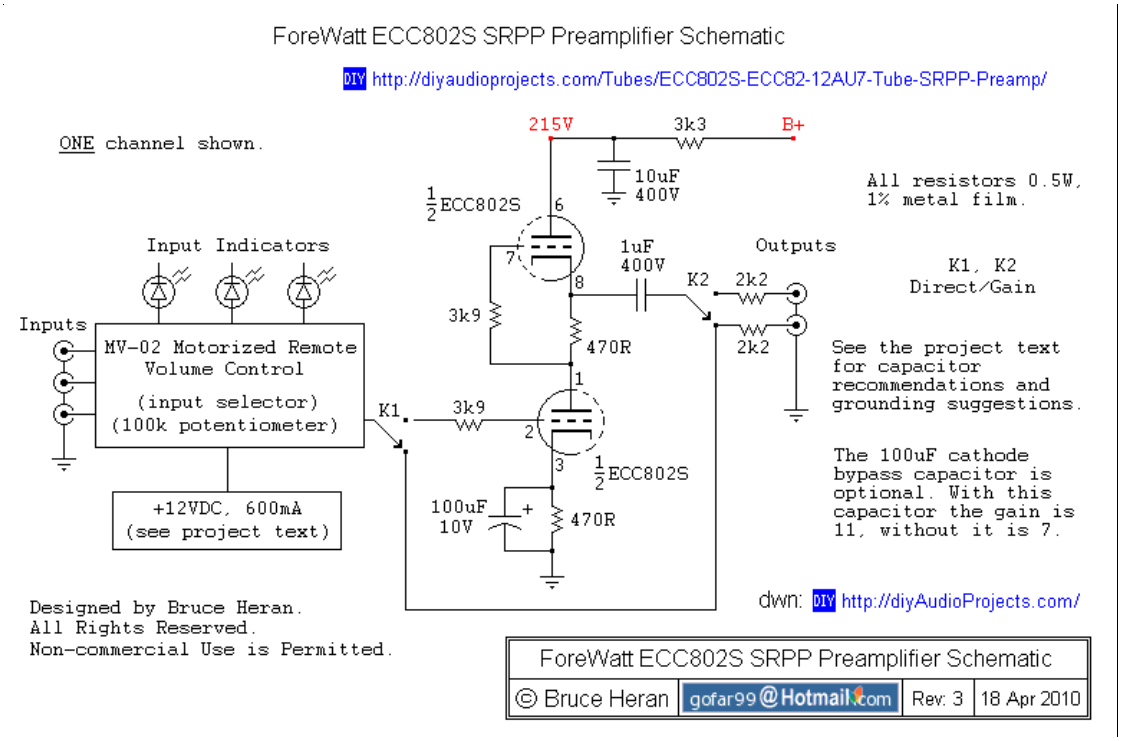


Figure 2: ForeWatt Type II - ECC802S / 12AU7 / ECC82 Tube Preamplifier Schematic (with Remote Control)

ECC802S (12AU7 / ECC82) Tube SRPP Preamp Build Details

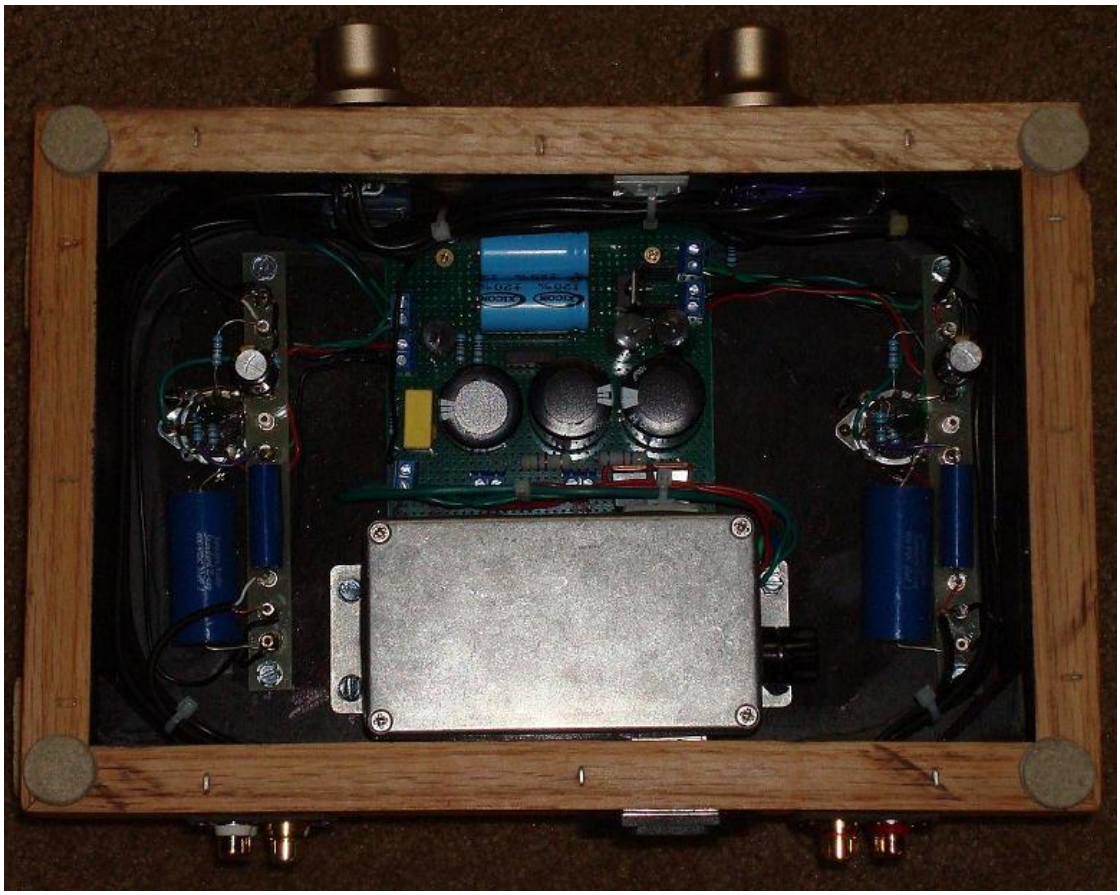
Pretty much everything in the preamp is standard tube amplifier construction. However, you do need to follow some standard tube layout and construction procedures. Keep the power and signal wires separated. If they need to cross, do so at right angles. The same is true for resistors and capacitors. Keep signal bearing components away from the power supply filter capacitors and especially transformers. I prefer to place power supply components in one section of a chassis and the signal portion in a separate area at least 2 inches away from the power supply parts. For more design and construction tips, see my Design and Construction of Vacuum Tube Amplifier tips and suggestions. Suggestions for a Tube Amplifier Wiring Color Code are also available.

The tube amplifier power transformer specified in the plans (Edcor XPWR083) is an inexpensive ($15 US, August 2010) PCB mounting type rated, 200 V at 40 mA and 8 V at 1.5 A. It is unshielded and if possible should be either enclosed in a metal enclosure (Photograph 3) or at least separated from the remainder of the circuitry with a shield. There is no reason other transformers can't be used; this one has the right ratings and and is inexpensive.

Photograph 3: ForeWatt Type II Preamplifier with remote control circuitry

The heater supply is regulated DC. The heaters must not be connected to the same ground as the signal, B+ or chassis. They need to float or tube failure may occur. The only connection of the heater circuit to the rest of the circuitry is a "bias" tap. This is developed from the main B+ supply and is about 1/3 the B+. No current flows through this connection (perhaps a tiny bit of leakage). It only establishes a reference for the heaters so that the difference between the heaters and any of the cathodes is less than 100 volts. One quirk of SRPP and other "totem pole" circuit configurations is that one of the cathodes is elevated quite a bit above ground. In a SRPP the cathode on the upper triode has a voltage potential of roughly 1/2 the applied B+. So with 215-225 V on the anode the cathode is over 100 V. During start up this value is actually 1/2 the full B+ (of about 275 V). This value exceeds the tube rating for heater to cathode voltage and will result in tube failure. Perhaps this will not occur immediately, but it will as the tube ages. I have had this happen. Not a good thing. It usually results a huge spike in the output that could be catastrophic further down the audio chain.

Use shielded wire from the inputs to the selector switch and to and from the volume control. As there in no provision for channel balance (IMHO no well designed system should need one) use either a quality variable resistor (I use Alps Blues) or a stepped volume control / attenuator.



Photograph 4: ForeWatt Type I Preamplifier - Interior View

One area that is always of concern is what to do with the metal chassis if you use one. Most inexperienced builders tie all the grounds to the metal chassis. This is nearly always going to result in ground loops. Depending on your electrical codes (which vary by country) you should connect the chassis (and actually any exposed metal parts like transformers) to the AC mains ground. In the US this is the third wire (supposed to be green). The signal and B+ grounds are connected to the chassis through a type X2 rated capacitor and a resistor in parallel with the capacitor. The capacitor is a special rated type designed just for this application (one brand is RIFA) and will range in value from about 0.1 to 0.33 uF. The resistor is typically a common carbon one of 100-150 ohms and rated at 1/2 Watt. A related mistake made by novice builders is to directly connect the input and output jacks to the chassis. The ground portions of the jacks should go to the "floating" signal ground in the circuit. Either of two types of ground system can be used for the signal and B+. I have used both "star" grounding and "buss" grounding in my projects. Either can work satisfactorily. In this project a modified star ground system is used. One star grounding point was used for each channel with a single connection to the B+ negative. For more information regarding grounding, see my article about grounding and shielding for your DIY audio projects.

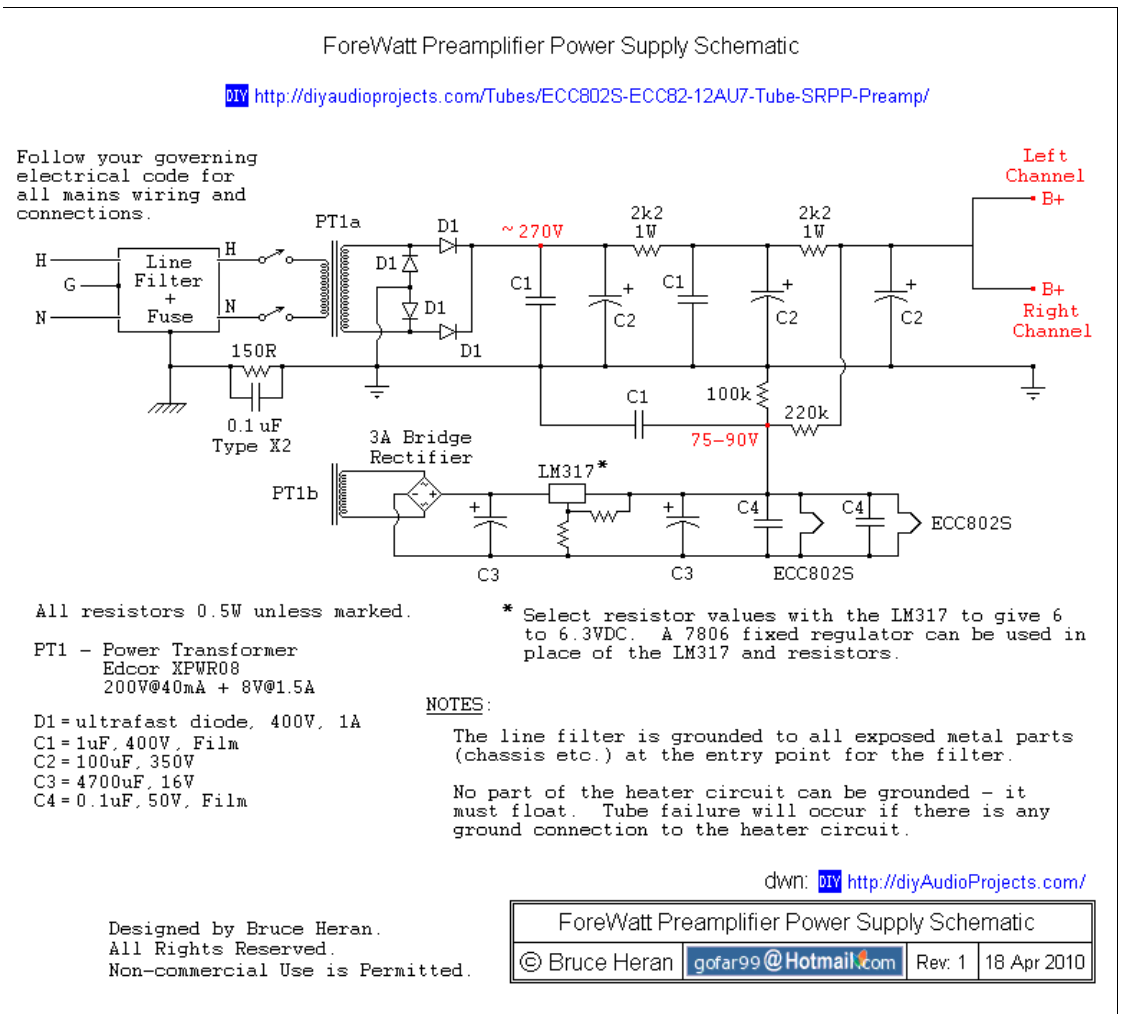


Figure 3: ForeWatt Preamplifier Power Supply Schematic

I used a type a LM317 variable voltage regulator in the heater supply as I am familiar with their operation (and have lots of them), but a fixed voltage regulator like a 7806 can be used as well.

The B+ is filtered through a total of 4 stages. Another thing I don't do is use chokes. I have nothing against them; I just don't need them to get the performance I require. The final filter stage to each tube is isolated from the alternate channel and each uses a polyester capacitor. I have found that using poly (polyester or polypropylene) caps in the final stage seems to improve the overall quality of sound. It is possible that an electrolytic with a suitably sized bypass cap would work well also.

The one component (other than the vacuum tube) that has the most effect on the sonic signature of the preamplifier is the output capacitor. The choice of brand, size and type are significant in this component. I recommend no less than 0.47 uF if you are feeding a high impedance load (50 k-ohms or more and short cables). Values as high as 10 uF are suitable for lower impedance (5 k) loads. I tried several types and sizes and finally settled with a 1 uF Russian K40Y9 paper-in-oil (PIO) capacitor in one version and a 1 uF Jantzen Standard Z capacitor in the other preamp. I suggest you use whatever brand and type you like as it will color the sound a bit. Some types I tried were Auricaps (nice clean sound with a little less bottom end), Jantzen (good overall performance, but not as detailed as the K40Y9), WIMA MKS (OK but not as nice sounding as the K40Y9), a cheap unnamed one (to protect the innocent) - it was horrible, bass OK, everything else edgy and not really listenable). So pick something you like.

The remote control portion of the second type of preamp is powered separately by a small 12 volt SMPS. Any kind of 12V power source will work fine provided it can deliver over 600 mA. It must be a type that is isolated from the AC line as the inputs and control circuitry are attached to the negative side of the 12 volts. It cannot use the same power source as the tube heaters as they have a positive bias on them to protect the heaters and cathodes from failure as noted earlier. See the schematics for the components I used. The instructions provided with the remote control module are a bit unclear so be sure to watch the interconnections. I misconnected them several times apparently without damage. Another thing that was confusing was that the module automatically selected input 2 on start up. This is not really a problem; just connect the component you use most to that input.

I used relays and a switch to activate the bypass function. The relays can operate off the same power supply as the remote control module. Just be sure there is sufficient current available. I used an underpowered one at first and had the relays chatter when the motorized volume control was operating. Very bad for the speakers. The MV-02 motorized remote volume control module is approximately $35US (August 2010). Remember that there can be significant shipping costs on items from Hong Kong so check first. It comes complete with the hand held remote control. It is a collection of assemblies that interconnect with ribbon cables. The instructions are a bit vague so read them carefully. Out of a total of five MV-02 motorized remote volume control that were ordered, one failed to operate properly. Despite the one DOA module, they are still a great buy. It the MV-02 comes with an Alps Black 100k stereo motor volume control. This potentiometer alone is worth the price. You can design a "passive" preamplifier around the module itself. Essentially, the bypass mode in the Type II schematic is just that. The indicator LEDs are not included, so you will need to provide your own. A series resistor of about 2 k is required for use with them. Since the module uses a common signal and power ground it could not be powered from the existing preamp power supply. I used a Mean Well PM-05-12 SMPS module to power it. This SMPS takes 100-240

VAC and converts it to 12 VDC. Importantly, it has 1000 volts of isolation of the inputs to the outputs. I attached it to the main power supply just after the power switch.

Measured Performance - ECC802S Tube SRPP Preamplifier

Frequency response of the SRPP Preamplifier circuit with JJ ECC802S tubes was from 10 Hz to 50 kHz within 0.1 dB. The high end was down 0.8 dB at 100 kHz. Distortion at 1 volt output was at the limits of my test gear (under 0.1%) at any frequency. Maximum output was over 15 volts (into a 50 k-ohm and 100 pF load) at the same distortion and response levels. Signal to noise was at the limits of my ability to measure at approximately -90 dB (ref. 1 volt). Gain was 7 (about 17 dBV). I did not use the capacitor to bypass the cathodes as I did not need the additional gain. Square wave response was excellent. This is one of a few similar pieces of tube equipment that can deliver clean 10 volt square waves at 40 kHz. With the 100 uF capacitor in place the gain rises to 11 (about 21 dBV). Sonically, I could not tell the difference between the two gain settings, but since I believe the fewer parts the better and I did not need the gain I left it out.

The performance testing equipment setup consisted of:

- HP 331A Distortion Analyzer
- Tenma 25MHz Dual Channel Digital Storage Oscilloscope
- Velleman Dual Channel USB PC Oscilloscope
- Tenma Low Distortion Signal Generator (0.05% residual THD)
- APC H10 Power Conditioner (120VAC output)
- Several digital volt meters

Listening Notes - ECC802S Tube SRPP Preamplifier

What does it sound like? IMHO really great. I used the following equipment to do the listening tests: Sources were a modified Marantz 5001 CD player, Dual 701 direct drive turntable with Grado Silver Prestige cartridge, power amplifiers were a pair of Odd Blocks (the original prototypes) with Blue Glass JJ KT88 tubes, for main speakers Martin Logan Vistas accompanied with dual 15 inch subwoofers fed by a Marchand 24 dB / octave electronic crossover set at 50 Hz and a 50 watt per channel LM3875 chip amp (with flat response to DC!). With the ForeWatt there is lots of detail, a wide soundstage and response from below audible frequencies to above them. Very clean sound and that typical warm lush tube sound. Using just the passive section of the one preamp the sound was as you would expect, very clean and detailed. Switching back and forth between the active and passive modes reveals that the preamp sounds much the same in either mode. The biggest difference is of course the gain as an active preamp. I use short, balanced, shielded interconnects from the preamp to the amps. I suspect that using high capacitance or long ones would affect the signal balance, particularly at high frequencies in the passive mode as the control is 100k.

Additional Information

Another DIYer replaced much of the power supply with a high voltage SS regulator and small poly caps. He indicated that it added "speed" to the preamp. I have yet to try that modification, but it certainly could work. My reference system is on the fast side and additional speed is not something that I desire. If someone else tries this I would like to hear the results. For those of you who do not want to source the parts for this project, like most of my other projects kits will be available from OddWatt Audio. I am happy to support either DIY or kit builds. The wood cases were courtesy of another diyer (thanks Jeff) and if you sweet talk him (and pay him as well) he might be convinced to make some for you. For the latest information about this project, see the ForeWatt Tube SRPP Preamplifier Support / Update Thread.