

SE5 Amplifier - Technical Description

A great sounding and unique looking 5 Watt single-ended valve stereo amplifier kitset, down to every last nut and bolt.

RedRoo uses only top-quality components from reputable mainstream suppliers.

Extra large output transformers are specially selected for their detail and extended bass reproduction, and there is no mains hum.



Contents

Why Valves?	2
Safety Precautions	3
Overview	4
Circuit Diagram	5,6
How it Works	7
Rolling Your Own	12
Specifications	14

Build details are shown in the Construction Manual supplied with the kitset.

Difficulty Level (1-5) 3.5

This work is licensed under the Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) Copyright licence. You are free to copy and communicate this work in its current form for all non-commercial purposes, as long as you attribute the work to the author and abide by these other licence terms: the work cannot be adapted or modified in any way; content should be attributed in the following way: Phil Wait - RedRoo Kits, 2022.

Copyright held by third parties is noted and remains with the original owner. Permission may be required to reuse that material. If you wish to copy, transmit or reproduce any of this content for commercial purposes you must first obtain written permission using the contact details at www.redrookits.com

Why Valves?

Despite the incredible technological development since the valve era, and the exceptional performance of modern solid-state devices, many musicians and audiophiles still prefer the sound of an old-fashioned clunky valve amplifier. How could valves possibly survive when they are clearly technically inferior? How could a state-of-the-art audio amplifier with impeccable specifications, vanishingly low distortion, and oodles more power, ever be considered inferior to something developed about a century ago?

Almost 40 years ago, (together with Ron Keeley, a noted Australian musician), I designed and described a 140 Watt DIY valve guitar amplifier in the Australian edition of Electronics Today International magazine (Eti) - a popular electronics magazine still published in some countries.

The words Ron and I penned on our Remington typewriters in 1980 are just as relevant today; “the valve vrs. transistor argument will probably never be settled conclusively. Despite all the obvious advantages of solid state musicians prefer valves because, they say, valve amps simply sound ‘better’, subjectively – like the preference some people have for an old Harley-Davidson or Triumph motor-bike, rather than a modern high-revving performance machine. On the other hand there are definite technical reasons why a valve amp will sound ‘different’.

It's All About The Sound

“The reason most often advanced is that valves produce predominantly second harmonic distortion, whereas transistor amp distortion is mainly third harmonic. While this is true, it is not the whole truth; the distinctive sound of valves is caused by the synergy of many factors, and the spectral balance of the distortion factors is just one of them. Other important factors are the shape of the distortion-power curve, the fact that valve amps are transformer coupled to the load (which affects the overall response of the amp), the higher output impedance of valve amps (resulting in reduced damping of the loudspeaker and a more ‘colourful’ sound), and the higher ‘dynamic output’ of valve amps (the ability to deliver relatively constant power output to a varying load; i.e. a speaker). If all these factors could be built into a transistor amp, then possibly it would sound, subjectively, like a valve amp. Many have tried to do this – most have failed”.

I do hope this little amplifier brings you lots of satisfaction, both in its construction and its use. I also really do appreciate feedback on any issues you may have and any suggestions about how we can improve this project. Send us an email at www.redrookits.com.au Have fun!

Phil Wait, RedRoo Kits, Sydney.



3-500Z transmitting valves undergoing stress testing. If you ever see anodes this colour there is something very wrong!

Photo: James Hawkins (Amateur Radio Callsign WA2WHV).

Safety Precautions - Read Me!

Valve amplifiers can be dangerous if they are physically damaged, misused, poorly located, or are being worked-on without taking appropriate safety precautions. Valve equipment contains hazardous voltages, (several hundred volts or more), and it can hold a high-voltage charge for a very long time even after the power is switched-off.

Valve circuitry can be very hazardous, even after the power is switched-off. Make sure the internal high voltage power supply is fully discharged before working on any part of the circuit.

- *Only work on valve circuitry if you are experienced in working with high voltages.*
- *Make sure somebody is with you, and have an emergency resuscitation chart on the wall of your work area.*
- *Switch off the equipment at the power point and remove the power-plug.*
- *Wait several minutes and then check the HV power supply with a DC voltmeter. Do not touch any part of the circuitry unless the DC voltmeter is reading less than 30V.*
- *Even if the voltmeter reading indicates that the power supply is safe, never trust the meter alone - always double-check. Use a thick insulated wire (bared at the ends), or a screwdriver with a plastic handle, to short out the power supply to the chassis-ground.*
- *If you need to take measurements or trace signals in valve circuitry while it is switched-on, always keep your free hand in your pocket. Never hold the chassis.*

Never work on hazardous voltage equipment if you are alone.

Valves run very hot and can cause a nasty burn. They can also ignite materials that come into contact with them such as a curtain flapping in the wind.

- *Position valve equipment carefully so it is away from combustible materials.*
- *Leave at least 200mm clearance on all sides and the top for adequate ventilation.*
- *Do not locate valve equipment near curtains or any flammable material.*
- *Never leave a valve amplifier switched on when unattended.*
- *Keep out of reach of children*

Never leave valve equipment unattended. Always switch it off after use.

Overview

This design is for a 5 Watt RMS single-ended (SE) class-A stereo amplifier for driving loudspeakers or low impedance headphones. It is aimed at DIYers who have some previous experience assembling electronics projects, and now want to try something a little different and more challenging. It's fun to build, a delight to use, and together with a good set of loud speakers it has sound which is unique and will rival amplifiers many times its cost.

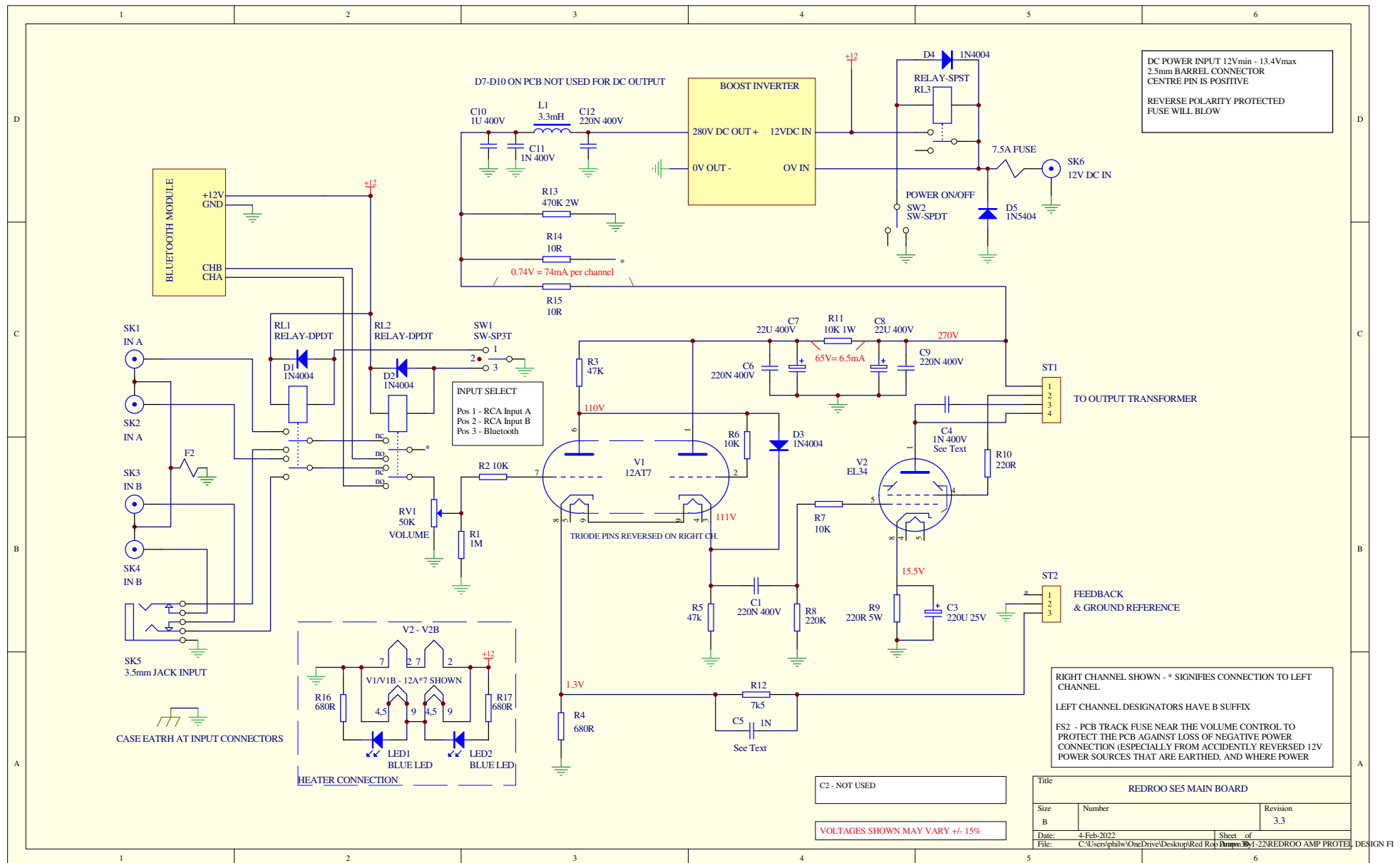
This information pack is at www.redrookits.com and is free to download for private non-commercial use. Redrookits sells a kitset, without the valves and the 12V power supply which are readily available direct from other suppliers. RedRoo kits also sell a high-quality PC board, boost-inverter power supply module, the output transformers, and chassis components for those who prefer to roll-their-own.

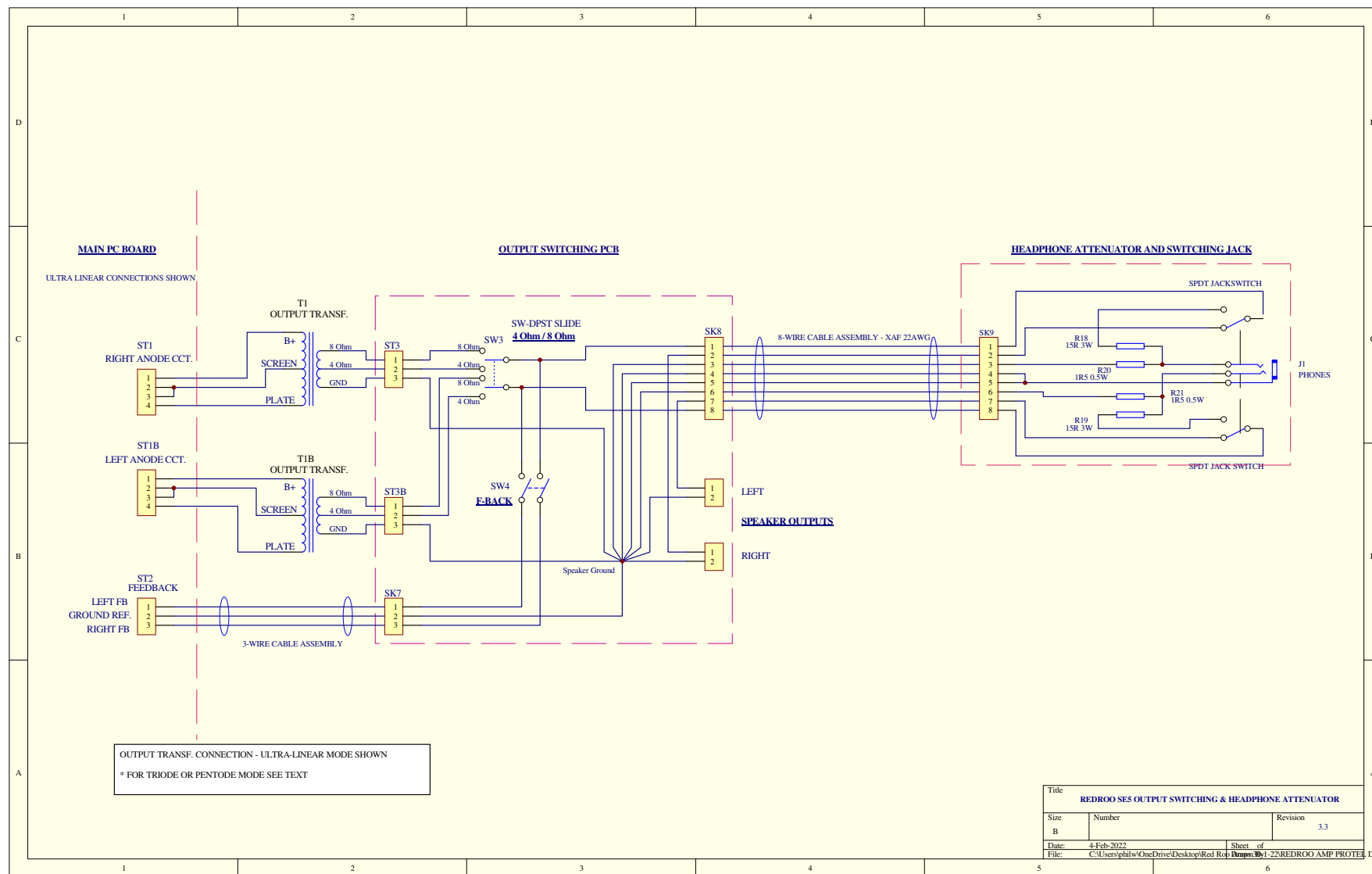
Valve technology is used exclusively in the audio signal path, with solid-state circuitry used where it makes good sense - in the high voltage power supply and the optional Bluetooth wireless input module. The circuit can be powered from any 12.0 - 13.2 Volt DC supply, however most constructors will probably use a commonly available 12Volt 10Amp in-line computer type power module. An internal voltage-boost inverter module converts the nominal 12.5V DC input to the high voltage (280V) required by the valves. Using a boost-inverter power supply has several advantages over traditional mains-transformer based power supplies, including: much smaller and lighter and less expensive than transformer based circuitry; no power supply induced mains hum in the speaker output; 12V DC is available for the valve heaters; and most importantly, no need for DIYers to work with mains-power wiring.

The signal inputs can be connected directly to the outputs of DVD/CD player; radio tuner; Computer sound card, RIAA preamplifier for playing vinyl records; or a Bluetooth input source for streaming from a smartphone or any other Bluetooth enabled device. With an external USB digital to analogue converter (such as the FX Audio DAC-X7 or Schiit Audio Modi 3 DAC) you can stream 24bit-192kHz music from a high quality streaming service, such as Tidal.

Minuture toggle switches on the front panel are used to switch the power on-off and to select between two sets of wired RCA inputs, or an optional Bluetooth wireless input. A 3.5mm input jack-socket is located on the rear panel - when a plug is inserted the second set of RCA inputs are automatically disconnected. All electronic components are mounted on an extra thick (2mm) high quality printed circuit board with extra with thick copper tracks, (2oz copper - twice as thick as usual). The heavy duty PC board provides high mechanical rigidity, durability, and improved heat transfer. All components have been carefully selected for superior performance, long-term stability, and ease of DIY construction. The attractive chassis is constructed from precision cut, bent, and powder coated steel, with detachable printed fiberglass front and rear panels. Chassis components are available from www.redrookits.com







Title		
REDROO SE5 OUTPUT SWITCHING & HEADPHONE ATTENUATOR		
Size	Number	Revision
B		3.3
Date:	4-Feb-2022	Sheet of
File:	C:\Users\philw\OneDrive\Desktop\Red Roo Amps\01-22\REDROO AMP PROTEC DESIGN F	

How it Works

Please refer to the circuit diagram. The amplifier is a three-stage, single-ended output (SE), stereo design, using thermionic valves (also known as tubes). The circuit uses a combination of classic valve and modern solid state technology. Valves are used exclusively in the audio path and solid state technology is used for the power supply module and an optional Bluetooth connectivity module. There are ample opportunities to experiment with this circuit using different valve and output transformer combinations.

Each channel uses a triode voltage amplifier followed by a cathode follower stage and a class-A power output stage. The first two stages form a constant current draw amplifier (CCDA) - a common-cathode voltage amplifier followed by a DC-coupled cathode-follower. The output stage can be configured as either an ultra-linear or triode power amplifier. It is also possible to configure it as a standard pentode/tetrode stage, though Ultra-Linear is recommended. Two slide switches on the rear panel select either a nominal 4 Ohm or 8 Ohm speaker impedance and switch in or out global negative feedback.

The output transformer is the most critical and expensive component in any valve amplifier, and a large variety were tested. The transformer supplied with the kit is epoxy potted into an attractive metal housing and provides excellent performance for its price. The cost of some output transformers can rival the cost of the entire amplifier, but their sonic improvement is marginal at best. Some audiophiles may wish to try alternative output transformers.

Input Switching: The input source is selected between two pairs of RCA sockets on the rear panel, or an optional Bluetooth wireless module. One set of RCA inputs is also connected to a 3.5mm stereo jack on the rear panel - if a 3.5mm jack plug is inserted, (say from a smart phone), its associated RCA input is automatically disconnected. Relay switching (RL1 & RL2) simplifies the input selection and allows an attractive miniature toggle-switch to be used on the front panel, rather than a large hand-wired rotary switch with a bundle of shielded cable terminations.

The Input Amplifier Stage: After input selection the signal passes through an audio-grade volume control (RV1) and is DC coupled to the grid of a 12AT7EH twin-triode (V1). The input is DC coupled to avoid using of a second coupling capacitor in the audio signal path, (coupling capacitors can add unwanted sonic characteristics). V1 is configured as a constant current draw amplifier (CCDA) consisting of two cascaded DC-coupled triodes. The first triode is configured as a common-cathode amplifier with an amplification factor (gain) of about 45, and the second triode is a cathode-follower providing no gain but a low output impedance to drive the grid of the power output stage.

The main benefits of the CCDA are low output impedance and a constant DC current drain from the power supply. When the input signal at the grid of the first triode goes positive and its conduction increases, its anode voltage will fall. As a result, the voltage on the grid of the DC coupled second triode will fall in line with the anode of the first triode, and its conduction will decrease, and its anode voltage will rise. If both triodes are set-up to have the same anode currents in the zero-signal state, they act as a see-saw; as the anode current through the first triode rises the anode current through the second triode falls. The total current supplied to both triode stages is therefore constant throughout an entire input signal cycle. Diode D3 prevents exceeding the maximum cathode to heater voltage on the second triode during the warm-up period after switch-on, when the valve is not fully conducting. The Electro-Harmonix 12AT7EH is specified due to its higher heater-cathode voltage breakdown rating.

The Power Amplifier Stage: The power amplifier (V2) is a single-ended (SE) class-A amplifier which can supply about 5 Watts RMS power @ 10% distortion into an 8 Ohm load, using a 12.5VDC power supply. Distortion falls off quickly as signal power is reduced. See the specifications pages at the rear of this Description.

In a Class-A amplifier, a constant current (called a bias current) continuously flows through the valve from cathode to anode, even when there is no signal. Class-A is a very inefficient type of amplifier, only achieving about 25 - 30% efficiency for a pentode or tetrode, and even less with a triode. The output valve dissipates all the constant unused electrical energy as heat in its anode, so for optimum valve service-life it's important not to exceed the manufacturers maximum anode power rating. Class-A is used almost exclusively in small valve amplifiers due to its simplicity and perceived superior sonic characteristics. The amount of bias-current flowing through a valve is inversely related the negative voltage on its grid with respect to its cathode, (called the negative grid-bias voltage). Electrons leaving the cathode are repelled by the negative charge on the grid, so as the negative grid voltage is increased fewer electrons successfully reach the anode. In short, the negative voltage on the grid controls the current flow through the valve from cathode to anode.

In this circuit, the grid-bias voltage on V2 is derived from the voltage developed across its cathode resistor R9. The constant bias current flowing through the valve (and through R9) develops a DC voltage across R9, with the cathode being positive with respect to DC ground. As the grid is tied to DC ground potential through R8 and R7, the grid is negatively-biased with respect to the positive cathode.

As a valve ages less electrons are emitted from the cathode and, without some sort of self-regulating bias arrangement, the bias voltage on the grid would need to be periodically adjusted to maintain the correct bias current through the valve. Cathode bias is a simple self-regulating (negative feedback) mechanism which strives to hold a constant DC bias current through the valve as the valve characteristics vary with usage and age. (If the current through the valve decreases the voltage developed across the cathode resistor R9 would also decrease, which in turn would reduce the the negative grid-bias voltage. The lower negative grid-bias voltage will then try to force the valve to conduct more. Naturally there is a limit, and eventually the valve's conduction would fall to a point where it can no longer be successfully regulated). Because the cathode resistor R9 is bypassed by a large value electrolytic capacitor (C3), which presents a near short circuit to audio frequency AC signals, there is no noticeable effect on the audio signal.

The output valve (V2) can be either be a pentode (like an EL34) or a beam-tetrode (like the 6V6, and KT77, or a 6BQ5 if a conversion socket is used). The maximum power output is mostly determined by the power supply voltage, the characteristics and limitations of the valve, and the design of the output transformer.

Power Amplifier Mode: The screen grid (G2) in the output valve accelerates the flow of electrons from cathode to anode, and how it's configured will slightly change the sound characteristics. Either ultra-linear, triode, or pentode modes can be selected by rearranging the screen grid connections on two 4-way screw terminals mounted on the PC board for terminating the output transformer primary windings. Each mode has it's advantages and disadvantages as shown below. The recommended mode for this amplifier is ultra-linear mode where the screen grid is taken to a tapping point on the output transformer. Audiophiles with efficient loudspeakers may prefer triode mode which is generally considered to be sonically superior (but only about half the power).

1. **Pentode mode** - where the screen grid is connected through a resistor to the amplifiers high voltage power supply. This mode gives the maximum amplification and maximum power output, but also the highest amount of distortion and the highest output impedance. The sound is rich in odd-order harmonics, and higher output impedance results in lower loudspeaker damping and more 'colouration' of the sound. For pentode mode strap the screen grid (G2) to B+ and remove the ULCAP links on the screw terminal blocks.
2. **Triode Mode** - where the screen grid is connected directly to the anode, so the output valve is configured as a triode. This is the mode favoured by audiophiles as it has predominantly even-order harmonic distortion, and a lower output impedance. Its disadvantage is lower gain (lower input sensitivity) and lower power output. Use this mode if you have a smallish room or spend most time listening through headphones.
3. **Ultra-Linear (UL) Mode** - where the screen grid is connected to a tap on the primary of the output transformer. This mode is really a blend of pentode and triode modes and is said to achieve the best characteristics of each. However, care must be taken to avoid oscillation, especially when the speaker is disconnected, so the ULCAP links are inserted on the screw terminal blocks.

The Output Transformer (OPT): The main task of an output transformer in a valve amplifier is to transform the high voltage/high impedance at the anodes of the output valves to a low voltage/low impedance AC voltage suitable for driving low-impedance loudspeakers. Importantly, it also provides voltage isolation for the loudspeakers which is important for safety. The OPT is the single most important contributor to the performance of a valve amplifier, and also the heaviest and most expensive component.

In a perfect lossless transformer, voltage and current are transformed up or down by exactly the turns ratio of the primary and secondary windings. However, as impedance is the product (multiplication) of an AC voltage and an AC current, impedance is transformed up or down by the square of the turns ratio. Impedances specified for an OPT are really only nominal impedances that match the square of the turns ratio - any two impedances (within practical limits) can be matched by the same transformer. When using the 8 Ohm speaker setting, the Red Roo OPT has a turns ratio of about 21, so an 8 Ohm loudspeaker connected to the secondary winding will reflect a 3500 Ohm primary impedance onto the anodes of the output valves. The same OPT could be used with an 8 Ohm loudspeaker connected to the 4 Ohm secondary and would reflect a 7000 Ohm primary impedance (for 6V6 or 6BQ5 output valves).

An OPT needs to be designed and manufactured very carefully for both good low-frequency and high-frequency performance. Generally, the bigger the better - the larger the metal core volume, and the higher the primary inductance (more turns of wire), the better the low frequency performance. However, as size increases, high frequency performance usually suffers. Complex (and expensive) winding arrangements called sectioning are used to improve high-frequency performance, where the primary and secondary windings are split into sections and inter-leaved in order to minimise internal capacitance and magnetic 'flux-leakage', (called leakage-inductance). Output transformers range from a few tens of dollars, to many hundreds or even thousands of dollars for hand-wired examples. The OPT supplied from www.redrookits.com is large for the rated power output and is a good performer.

Negative Feedback: Feedback is where a sample of an output signal from a system is fed back to the input, in order to modify the total response of the system. Feedback occurs in areas such as electronics, engineering, economics and finance, climate, and our own biology - everywhere really. If the feedback signal is of the opposite polarity (out of phase to the input signal) it is called negative feedback, and it partially cancels-out the input signal. Errors in the output of a system (distortion) are reduced by negative feedback. Negative feedback is widely used in amplifiers to reduce distortion, and lower the output impedance to the loudspeaker (which increases the damping or suppression of loudspeaker resonance's). Negative feedback also reduces the overall amplification (gain) of the circuit.

If the output signal is fed-back in the same polarity as the input signal (in-phase with the input signal) it is called positive feedback and it will reinforce the input signal. If an amplifier has positive feedback the signal will quickly increase in amplitude to a point where the whole system will oscillate strongly at some Frequency - usually at some resonant frequency where amplification is highest. You can hear the effect of positive feedback when a microphone is placed too close to a loudspeaker.

Amplifiers with a large amount of negative feedback can have impressive specifications on paper, but the feedback could be masking some serious underlying design issues. A good amplifier should be designed for the best possible price/performance without any negative feedback, and then a modest amount of negative feedback applied to make it even better. Additionally, the entire system must be carefully designed ensure that the feedback doesn't swing from negative to positive at some frequency within the systems frequency/amplification range (called the gain-bandwidth). An amplifier may have a large phase-shift, or resonance, where the feedback swings positive at some frequency well outside the human hearing range and, although everything may appear normal to the ear, a powerful oscillation may be slowly frying the tweeter loudspeakers.

There is another important reason why a large amount of global negative feedback is not a good idea, especially when applied to valve amplifiers using output transformers - the slowest responding component in a valve amplifier is usually the output transformer and, as the output transformer is usually within the feedback loop, it mostly determines the speed (response time) of that feedback-loop. Imagine a circuit where there is 20dB of negative feedback, so the Feedback reduces the voltage amplification (gain) of the entire circuit by 10 times. During the delay period, before the feedback takes effect, the gain of the circuit would be 10 times higher, and the amplifier would be forced into overload and hard distortion (clipping) by a very modest input signal.

Music and human voice are rich in fast transients. So, if an amplifier has large amounts of negative feedback, common audio signals could drive it into hard distortion easily, before the global feedback has time to come into operation to reduce the gain. This can cause transient distortion in the loudspeaker output, and may be the reason why some amplifiers are said to sound harsh or fatiguing even though they have super-good specifications on paper.

Global feedback is where the feedback-loop is placed around the entire system, from the output right back to the input. This amplifier uses a small amount of global negative feedback that can be switched in or out using a slide switch on the rear panel. The amount of negative feedback is set by resistor R12 to be about 6dB in ultra-linear mode and about 4dB in triode-mode.

Amplifiers without global negative feedback still have feedback loops, but they are less obvious. Negative feedback also occurs in isolated loops around each stage, called 'nested' feedback loops. An un-bypassed (by a capacitor) cathode resistor is a common example of a 'nested' feedback loop. A Triode amplifier stage has an inherent 'nested' negative feedback loop within the operation of the valve itself (another reason why triodes are popular with audiophiles).

The Power Supply: Power supplies in valve amplifiers are large, heavy, and very expensive compared to modern solid-state amplifiers. Because mains power transformers operate at very low mains frequencies (50Hz or 60Hz) they have high inductance windings (lots of turns), and large heavy cores in order to avoid magnetic core saturation. Toroidal transformers (those with a closed-loop steel or ferromagnetic core in the shape of a doughnut) offer a significant improvement, but they are still comparatively large and are even more expensive.

The output of a full-wave rectifier is 100Hz or 120Hz pulsating DC. Turning this into smooth DC suitable for an audio amplifier requires a multi-stage low-pass filter consisting of large value filter capacitors, and often one or two large and expensive iron cored inductors (chokes). Additionally, the stray pulsating low frequency electromagnetic field emanating from such large transformers and chokes is often difficult to contain and can easily interfere with sensitive circuitry. The power supply in this valve amplifier is different and, along with the Bluetooth option, we believe a highly worthwhile concession to the 21st century. This amplifier requires 12V DC at approx. 5.5 Amps, and the 12V DC is up-converted to about 280V DC using a small and efficient voltage-boost inverter module.

There are significant advantages to this approach:

1. The inverter converts 12V DC from a commonly available in-line or bench power supply to a high frequency AC waveform, which is then transformed up to the high voltage using a very small, lightweight, and inexpensive ferrite-cored transformer. (This is possible because of the high switching frequency, about 37kHz).
2. As the switching frequency is well above the human hearing range, there is no audible power supply noise (hum) in the loudspeakers.
3. The filter components following the rectifier in the inverter (L1, C10-C12) are small and inexpensive. (Again due to the high switching frequency).
4. The inverter is supplied as a pre-assembled module. The resulting amplifier is smaller and lighter. (The 150 Watt inverter used is loafing along).
5. And, possibly most important of all - there is no need to work on mains power wiring. The external 12V DC power supply is commonly available in most countries and, if purchased locally, should carry all the necessary regulatory approvals and the correct power plug for the country of purchase.

There are some excellent resources for those who wish to learn more about valve audio technology. For those starting out www.valvewizard.co.uk is excellent, or for those up for a challenge John Broskie's TubeCad Journal at www.tubecad.com is our favourite. Morgan Jones' Valve Amplifiers, Third Edition ISBN: 978-0-7506-5694-8 is required reading.

Rolling Your Own

Experimentation is in the DNA of an audiophile, and this amplifier provides opportunity to experiment in spades. However, the differences in sound are often subtle and almost always subjective, so you will need a very good set of loudspeakers, some high quality audio material, and loads of spare time. Here are some suggestions to try, listed roughly in order of effectiveness:

Feedback Selection

Switching ON or OFF the negative feedback using the slide-switch on the rear panel makes the greatest difference to the sound. Switching negative feedback ON decreases distortion, improves frequency response, and decreases the amplifiers output impedance for improved damping of resonance's in the loud-speaker. The sound produced will be technically superior and closer to the original recording.

Conversely, switching the negative feedback OFF will increase distortion and reduce damping of loudspeaker resonance's, and the on-paper specifications may look pretty ordinary. As we said previously, a valve amplifier could be thought of as a musical instrument itself, adding it's own unique characteristics, that many people find appealing.

The amount of negative feedback is determined by the mode of operation and (amongst other things) the values of the resistive divider formed by R4 and R12. Decreasing the value of R12 increases the amount of feedback and vice-versa. Increasing the amount of negative feedback will also reduce the input sensitivity.

Changing the Mode

The amplifier can operate in several different output-stage modes. Changing the mode will make a noticeable difference to the sound. Triode mode is the favourite of audiophiles and is very worthwhile trying, especially in a small room or with efficient loudspeakers. Triode mode will produce predominately second harmonic distortion, and also increase loudspeaker damping. Unfortunately, triode mode also reduces input sensitivity and will reduce the maximum power output. Triode and Pentode modes require wire links to be inserted between the output transformer terminals.

The Mode connections are shown in the Kit Construction Manual.

Changing the Output Transformers

Quality output transformers can cost many hundreds of dollars each - in fact, some output transformers can exceed the total cost of this kitset!

As part of our selection process we tested a wide range of transformers for performance, appearance and cost effectiveness and came to the conclusion that we should supply a custom transformer for this project to get the best performance and appearance possible for a reasonable price.

If you wish to use an alternative, any output transformer with a primary impedance of about 3500 Ohms and a power rating above about 6 Watts can be used, but the optimum values of capacitors C4/C4B and C5/C5B will need to be determined by frequency response and square-wave testing. Please ensure that any output transformer used has at least 1kV voltage isolation between its primary and secondary windings.

Changing Coupling Capacitors

Some people have their favourite type of coupling capacitor. The coupling capacitor (C1/C1B) is a high quality polypropylene capacitor, but other types can be substituted such as paper in oil, Teflon, copper foil, tin foil, aluminium foil, and others. Some of these capacitors are extremely expensive and their effects on the sound are subtle. The PC board has multiple holes for C1/C1B to allow for capacitors with different lead spacing.

Changing the Volume Potentiometer

The volume potentiometer has a logarithmic resistance taper, i.e. the resistance varies in a logarithmic function as the shaft is rotated. This type of taper broadly matches the logarithmic response of the human ear to sound level, but inevitably there are variations and inaccuracies in the taper, or variations between both sections of a dual potentiometer used in a stereo amplifier. Audio-rated potentiometers attempt to minimise these effects by tighter manufacturing tolerances. The PC board will accommodate either audio-rated Bournes PDB182 or ALPS type27 potentiometers, or the entire section of the PC board can be removed to allow other options.

So, how does it sound, and which connection mode is best? Audiophiles are a bit like economists – they never totally ever agree with each other. The problem is that the art of listening is *just so subjective*. Our favourite combination for this amp is with 12AT7's in the input stage and EL34's in the output (as specified), and our favourite connection mode is triode mode with no global feedback. Ultra-Linear certainly wins out if power and input sensitivity are important factors.

The sound is surprisingly 'forward' and 'open' and you can certainly hear that characteristic "valve sound", especially when the feedback is switched-off. On our reference VAF i-66 and Tanoy 800 monitor loudspeakers, and with master quality audio streamed down from Tidal, it all works just perfectly.

Specifications

All measurements taken in ultra-linear mode with Global Negative Feedback ON. V1: 12AT7 V2: EL34, with RedRoo Kit Output Transformer. Supply Voltage 12.5VDC. HP8903B Audio Analyser used for all frequency response, distortion and power measurements.

Power Output @ 10% Distortion: 5 Watts RMS per channel into 4 or 8 Ohms with EL34 output valves in Ultra-Linear mode. Both channels driven.

Circuit Configuration:

Input stage - Twin-triode CCDA configuration using 12AT7EH. Alternative tubes are all 12A*7 series with minor component changes.

PC Board links can convert heater connections for 6 volt heater valves such as 6DJ8/E88CC.

Output stage - Single-ended class-A with cathode bias. Uses EL34 in Ultra-Linear connection. Possible valves include: EL34/6CA7/6V6/KT77 and 6BQ5 with a conversion socket and minor component change. EL34 was found to give the highest output power at the HT voltage used.

DC heaters - Heaters connected in series to 12.5V DC input.

Mode selection - Ultra-Linear, Triode or Pentode by changing wiring configuration on screw terminals on PC board.

Feedback - Global negative feedback can be switched in or out using slide switch on rear panel. Ultra-linear mode: 6dB NFB. Triode mode: 4dB NFB.

Signal Inputs:

Three-position toggle switch selects between two sets of RCA wired inputs or optional Bluetooth wireless module. A 3.5mm jack socket on the rear panel automatically disconnects the second set of RCA connectors when jack plug is inserted.

Input sensitivity: Can be directly connected to any line-level audio source. Sensitivity depends on mode selection, input valves used, and negative feedback (GFB) ON/OFF selection. Ultra-linear mode with 12AT7EH and GFB ON – 700 mV RMS / GFB OFF – 350 mV RMS,

Outputs:

Speaker Outputs – Switch selectable 4 or 8-Ohm speaker outputs.

Screw terminals accept banana plugs with Industry standard 0.75 inch terminal separation.

Headphone Outputs - 6.35mm jack socket on front panel for low impedance headphones.

Inserting headphone jack disconnects speakers.

DC Input:

12.5 V @ 5.5 Amps (70 Watts). Input voltage range 12.0 -13.2 VDC. Polarity protected by reverse diode and a fuse. 2.1mm concentric dc plug - centre positive. Can be powered from any nominal 12 VDC power supply including commonly available 12 VDC 10 Amp SMPS desk-top power supply.

Max. Power Output vs supply voltage:

Ultra-linear mode with 6dB GFB.@ 10% Distorrtion

12.0V	4.5W
12.5V	5W
13.3V	5.6W
13.8V	6W (exceeds heater voltage ratings)

Total Harmonic Distortion vs Frequency @ 1Watt RMS:

Ultra-linear mode. 12.5V DC Input

Frequency	GFB ON	GFB OFF
100Hz	1.5%	3%
1kHz	1.3%	2.7%
10kHz	1.35%	3.1%

Intermodulation Distortion vs Power:

13kHz + 14kHz two-tone test - Ultra-linear mode with 6dB GFB ON.

Output Power (RMS)	IMD Distortion % (to nearest 0.5%)
0.1W	0.5
1W	1
4.5W	3.5

Frequency Response:

Ultra-linear mode with 6dB GFB.

Power	-1dB	-3dB
1 W RMS	10Hz – 16kHz	<10Hz – 33kHz

Ultra-linear mode with global **feedback OFF**

Power	-1dB	-3dB
1 W RMS	24Hz – 16kHz	12Hz – 26kHz

Hum and Noise:

Input terminated in 10K resistor, volume control at max.

<0.5mV RMS un-weighted. (85dB down compared to full power).

Channel Separation:

Better than 60dB – un-driven channel input terminated in 10K resistor.

Channel Balance:

Better than 0.5dB.

Damping Factor:

Ultra-linear mode with 6dB GFB – 3.3

Power Indication:

LEDs shine into in bases of both input valves when power is on. Blue LED's supplied.

Dimensions & Weight:

185mm wide, 215mm deep, 165mm high with EL34 output valves. Weight 4.5kg

For more detailed specifications, including spectrum and square wave analysis, and the performance using the Audiophile output transformer, please see www.redrookits.com