MAPLETREE BRANCHES

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In this issue

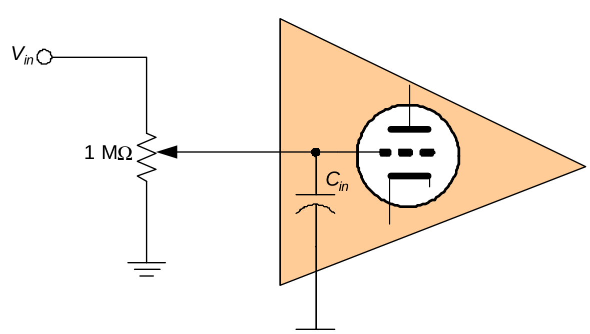
- Volume and balance controls
- More tube rolling with the *Ultra 4A*
- Inside the new *Stealth 60* power amplifier

Analog volume and balance controls: good, bad, and ugly

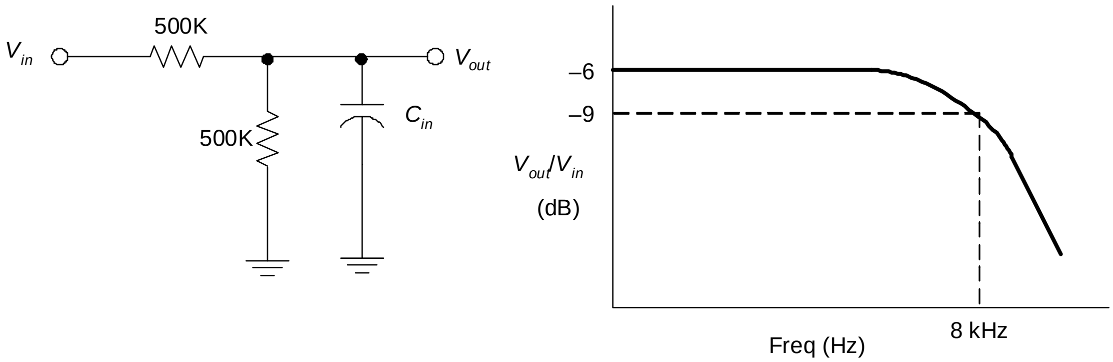
Even the most basic passive "preamplifiers" offer a means of controlling the signal level presented to the power amplifiers in an audio system. The classic preamps of 50 years ago, with their endless array of controls and switches, placed the volume control in the most prominent location, with the largest knob, because it was often the only control used for most listening sessions. The designers of the classic mono and stereo preamps and integrated amplifiers took the design of the volume control function seriously. If you look at the schematics of some of the old McIntosh and Marantz mono preamps, you will see that volume control units were often multi-section, with ganged controls placed at two or three locations along the amplification path. Many preamps today, after shedding all the peripheral equalization switches, tone controls, etc., take the simplest approach to level control: a two-section potentiometer (for stereo) located at the input to the first amplification stage. Is this the best way? Read on to learn a bit about the art and science of volume and balance control.

Tone controls?

First consider a 1 MΩ volume control placed at the input of the first stage of a preamp as shown. With a high mu triode such as a 12AX7, the stage can easily have a gain of 70 which creates a fairly large input capacitance of around 80 pF due to the Miller Effect (C_{in} ~ plate-grid capacitance x gain). If the volume control is set to



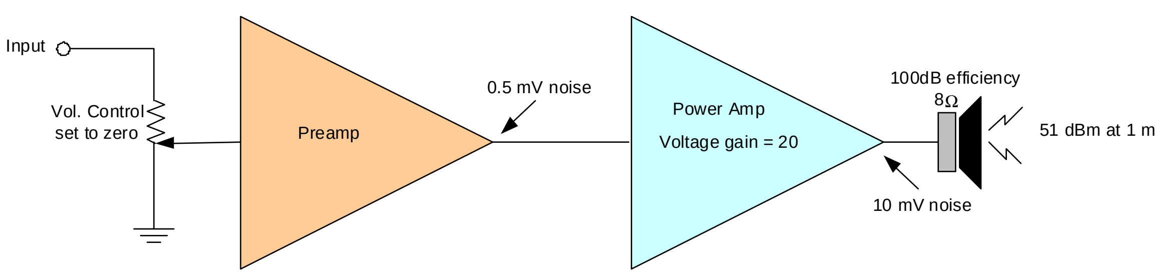
50% (attenuation of 6 dB), the equivalent circuit is shown in the next figure. The frequency response of this



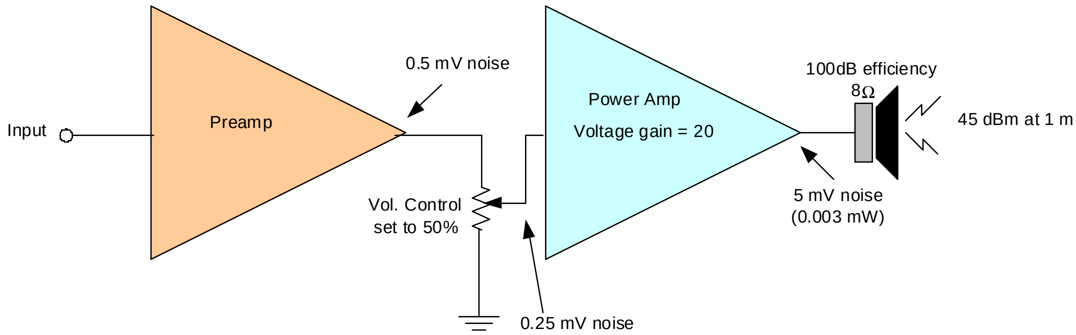
circuit has a bandwidth (3 dB frequency) of 8 kHz! So if you feel you are losing high frequencies as you turn down this volume control, you are right. At full volume, the bandwidth increases to 32 kHz which isn't a problem. What is the solution? Use a smaller value volume control, or an input stage with lower input capacitance. If a 100 kΩ control were used at the same 50% setting, the bandwidth would increase to 40 kHz! With a 250 kΩ control and a gain of 40, the bandwidth would be 28 kHz. Driven by a low impedance, such as the solid state output of a CD source, there is rarely a need for an input resistance of greater than 250 kΩ. The Mapletree *Octal 6B*/*Magic 5B* preamps have their 100 kΩ volume controls at the input to simplify topology switching (the control is common to all three circuits). In the *Ultra 4A*/*Line 2A* preamps, the volume control is after the line gain stage and before the output buffer stage where it yields both maximum noise attenuation and bandwidth.

Make some noise

Suppose the amplifier stage in the above example produces 0.5 mV of noise and hum at the output. This doesn't seem extraordinarily large for a tube preamp but remember that the gain of the power amp and the efficiency of the speakers will determine the actual noise power that is perceived by the ears. If your power amp has a gain of 26 dB (voltage gain of 20), and your speakers have an efficiency of 100 dB/W at 1 m, the noise power delivered to the speaker is 0.0125 mW and the acoustic noise power at 1 m will be 51 dBm [100 – 10log(1000/0.0125)]. The power will decrease as the square of the distance from the speakers but will most likely still be audible at your normal listening position. Remember, this noise is the same at any setting of the volume control.



Now, suppose we put the volume control after the gain stage (which still produces 0.5 mV of noise) and put a buffer (e.g. cathode follower) after the control. This decreases the capacitance seen by the volume control (a cathode follower has no Miller Effect) and gives a low output impedance for driving cable capacitance. It will add very little additional noise due to the low gain (less than unity) and large inherent negative feedback of this stage. Now, if you turn the volume control up full, you near the same noise level as with the first case. But as you turn the control down to normal listening levels, you attenuate the noise from the first stage. At 50% volume setting (not 12 0'clock which is usually much lower than 50% due to the log taper) you improve the signal to noise ratio by 6 dB, and the improvements only get better at lower listening levels where you really want to have no audible noise.



If you have two gain stages, you can see why putting ganged controls with attenuation after both stages, can achieve even better results.

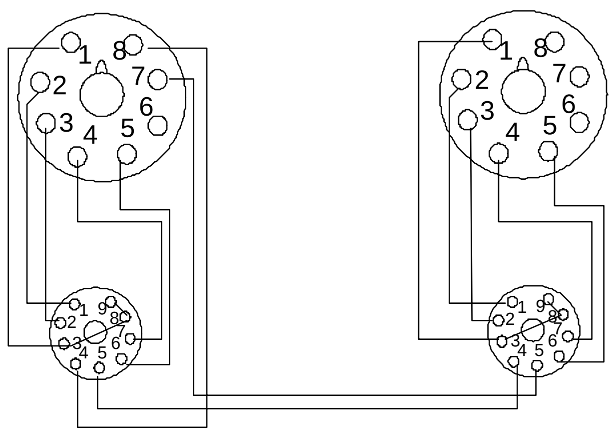
Balance controls—next issue

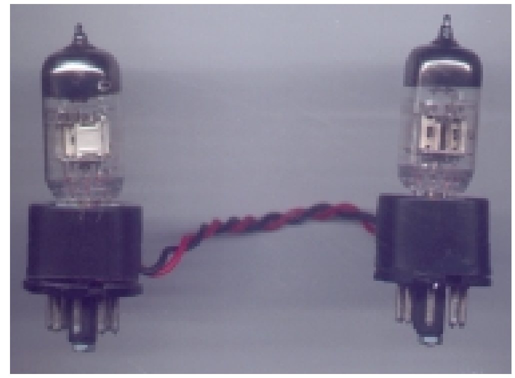
More tube rolling experiments with the *Ultra 4A*: detail, detail

Issue 1 of *Branches* reported on some tube rolling tests with the line stage portion of the Mapletree *Ultra 4A*. We looked at a variety of 12SN7GT and 6SN7GT types and presented the subjective results of an informal listening session. There is another target for experimentation, namely the 12SC7 phono stage. The 12SC7 is electrically identical to the 12SL7GT with a different pin-out, a metal shell connected to pin 1, and a common cathode connection between the two triodes. It was often used for cathode coupled phase inverter service where the common cathode connection was appropriate. It can also be used a mixer stage for line level inputs and was used for this purpose in some Fender guitar amps. GE also issued a phono preamp using the tube as an accessory to their variable reluctance phono cartridge in the 1950s. This was an open-chassis affair with built-in power supply and fixed equalization similar to the RIAA specification. It works well in the *Ultra 4A*, exhibiting excellent immunity to hum pickup, but in some samples, a tendency to microphonics. Those new to vacuum tube preamps may find the sonics seem to lack some of the detail and air of solid state phono preamps and, while this suits many listeners, some customers have yearned for a bit more excitement in the high frequency range. A Canadian customer, who is a dedicated sub substitution enthusiast, informed me of the results of experiments with the Russian 6H2P (6N2P) dual triode in place of the 12SC7 in his *Ultra 4A SE*. The 6N2P is essentially a 6AX7 with pin 9 connected to a shield between the two triodes. He made a pair of adaptors to accommodate the 9-pin miniature base of the 6N2P and the 6.3 V heater voltage, and reported a big jump in high frequency detail. I re-wired his *Ultra 4A* for permanent installation of the 6N2P and did some listening tests for myself. The difference was not subtle. However, as with many tube rolling experiments, there were some minuses too (to my ears). I felt the bass was a bit dispersed and weak sounding and some of the 3-D imaging that I had heard on some recordings was missing. Also, there was a tendency to pick up hum especially if you brought your hand hear the tubes. A metal shield may be a partial solution to this problem. With a high output magnetic cartridge, it is not a problem. Since then, I have made adaptors for several customers but have stayed with the 12SC7 for production units. While I don't plan on offering the 6N2P adaptors as a regular item, it is not difficult to make our own if you are inclined to DIY. Here is how.

You will need to locate a couple of dead or dying metal octal tubes with a full count of pins. The 12SC7 or 12SJ7 are both of this type and are not expensive even if you want to dismantle a good pair. First, use a small blade screwdriver to pry open the four tabs crimped to the base plate. Then, hold the base with a pair of wide-jaw pliers and rotate the tube body back and forth until it moves freely. Then you can either just twist it away from the base or pry it off with a small screwdriver inserted between the body and the base. Throw away the top of the tube and trim off any remaining wires sticking out of the pins.

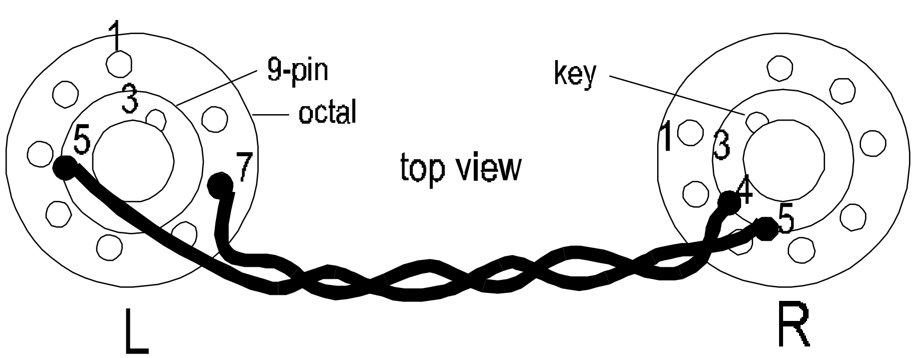
6N2P - 12SC7 Adaptor WIring

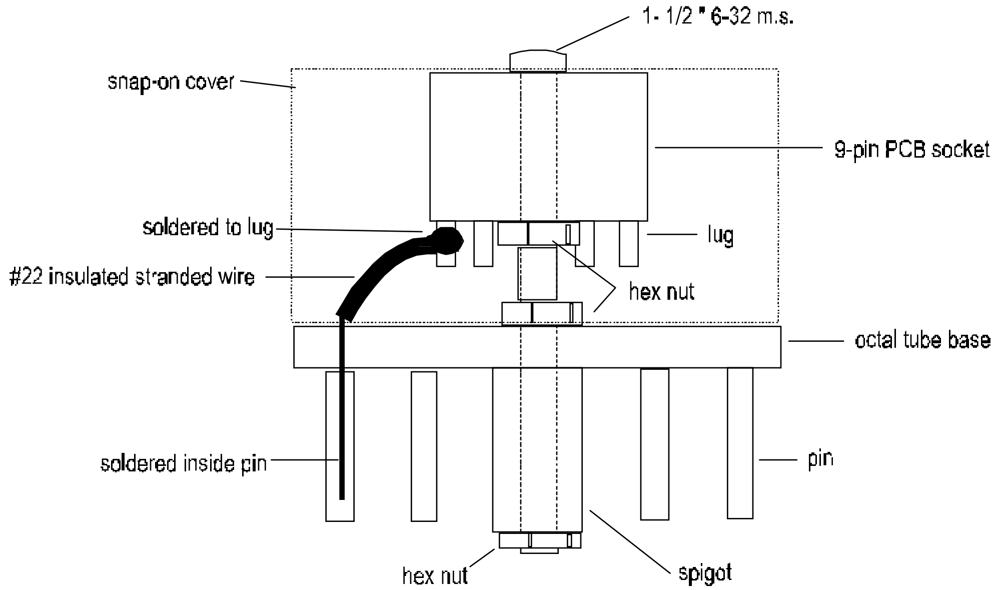




You can use any 9-pin socket but the best are the PCB type without any mounting ring. You can get these from he Parts Connexion (www.partsconnexion.com). You will need two 1½" 6-32 machine screws and 6 hex nuts. For each adaptor, feed the screw through the center hole in the 9-pin socket and secure with a hex nut. Carefully drill a 1/8" hole in the spigot of the octal tube base. Attach another hex nut to the screw attached to the 9-pin socket and adjust so you can just get a hex nut on the end of the screw when inserted through the base/spigot of the base. Align the 9-pin lug 3 with the octal tube base pin 1 and tighten the hex nut on the end of the spigot.

Now, you can wire each pin of the octal base to the appropriate lug of the 9-pin socket according to the diagram below. For each pin connection to the base, first feed a ½" length of 1 mm solder down into each pin by hold the tip of your soldering iron against the pin until the solder melts. Use 22 gauge stranded wire for the connections, and strip about ½" of insulation from the end to be attached to a base pin and 1/8" from the other end, which will be soldered to a 9-pin lug. Pre-tin both ends and first feed the ½" end down into the pin by applying heat to the pin. The pin gets quite hot so give it a few seconds to cool before moving the wire (or touching the pin!). Ensure you have made a solid connection to the pin, then solder the other end of the wire to the appropriate lug on the 9-pin socket. The two wires running between the adaptors should be about 3½" long and twisted together. They should be oriented so they exit one base (left channel) around pin 6 and the other (right channel) around pin 3 as shown below.





The adaptors can be used as completed but it is easy to snap on the top of a plastic 35mm film can cut to the appropriate length and with a ¾" opening in the top to provide clearance for the tube socket. Once you have tested the adaptors, the cover can be glued to the base with a bit of epoxy or crazy glue. The Russian 6N2P tubes are not in current production but are commonly available on ebay as NOS from the 1980s and are very reasonably priced. If you like what you hear, you may wish to make a second set of adaptors with 9-pin sockets with metal shields. The tube base should be connected to lug 9 (ground).

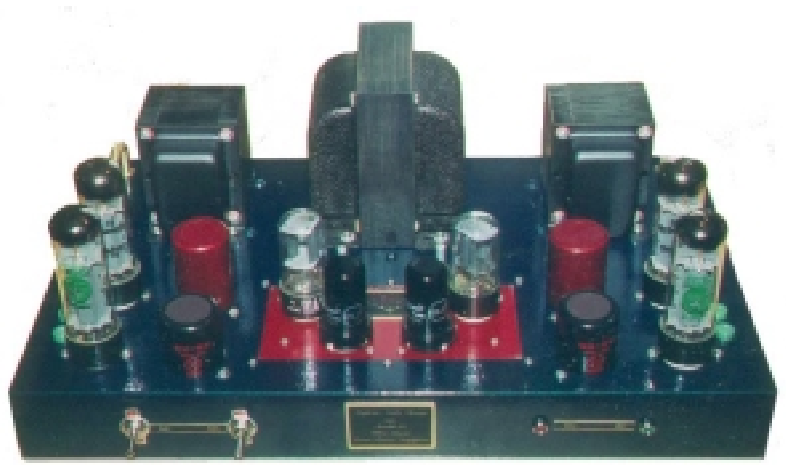
Introducing the new *Stealth 60* Stereo Power Amplifier

The EL34 pentode power tube was designed by Philips specifically to get the most power per dollar from a power amplifier. It was possible to get 40 W with conventional power supply and driver circuitry. It also made a single-chassis stereo power amplifier delivering 30-40 W/channel feasible. Two popular mass-marketed examples are the Dynaco *Stereo 70* and several Eico power amps, which were available as kits as well as assembled units. Monobloc power amplifiers used for stereo amplification offer some definite advantages in terms of size and weight, channel separation, and the capability to deliver full power in either or both channels under all input conditions. In terms of manufacturing cost, the need for separate power transformers, chokes, and chassis add considerably to the cost compared to a single chassis version. The Mapletree *Super Stealth* power amplifiers using 6V6s in push-pull ultra linear mode deliver a sweet 8 Watts but the combined price is over $1000 assembled. No one who has built the kits or assembled units has been disappointed with the results, but it seemed only fair to offer a higher power/price performance ratio with as few compromises as possible and where additional power is desirable. The result is the *Stealth 60*. While it is only available in assembled form at the present time, the price of $950 is a genuine bargain.

There is nothing new inside the *Stealth 60*. The driver circuitry is of the Mullard type with a 6SJ7 pentode voltage amplifier and a 6SL7GT cathode coupled phase splitter. The EL34s operate in class AB_1 push-pull ultra linear with fixed bias. The power output is conservatively rated at 30 W/channel. The power supply uses

Stealth 60 Prototype

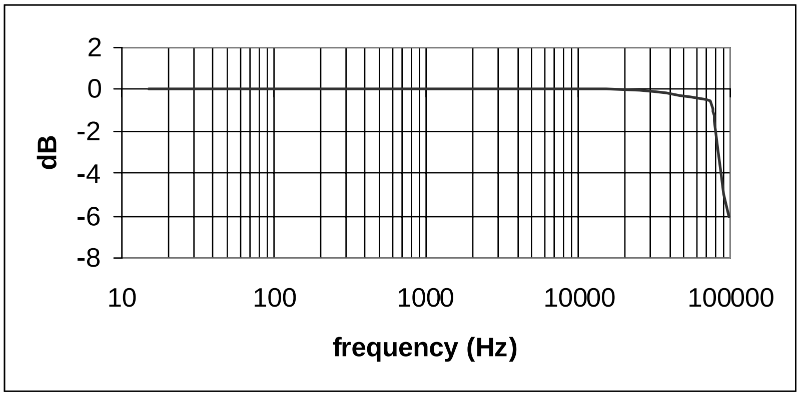
separate plate and filament transformers with solid-state (HEXFRED) rectification. The plate transformer is rated at 300 mA and provides excellent voltage regulation under the conditions imposed by the *Stealth 60* circuitry. From the main filter capacitor, the power supply feeds through two separate filter chokes and RC decoupling circuits. This is as close as you can get to having two separate power supplies and provides a high degree of channel independence. The driver/phase splitter circuits are constructed as a single point-to-point wired module (the Mapletree *Special Red* driver module, available separately for use with the Dynaco *Stereo 70* and similar amplifiers) which simplifies layout. The heaters of the driver tubes are supplied from a 12 VDC supply. A fixed bias supply feeds bias adjustment potentiometers for each channel. No provision is made for dc balance adjustment as it is assumed that most customers will use matched pairs of output tubes for replacement (Electro Harmonix EL34s are supplied). Bias is set by connecting a multimeter to two banana jacks for each channel. Until the end of January, a free digital multimeter will be supplied with each *Stealth 60*.



Stealth 60 Production Version (green chassis)

Performance

The open loop gain is 50 dB with a bandwidth of 7.9 kHz. 24 dB of negative feedback is applied, yielding an overall voltage gain of 26 dB or 20 V/V. This yields a sensitivity of 0.7 V for 30 W output. Maximally flat frequency response was chosen as the criterion for optimum transient response (as opposed to square wave measurement) and the compensating feedback capacitor was chosen accordingly. The 1 W power bandwidth is 83 kHz and the frequency response is 15–70 kHz –0.5 dB.



Specifications

Tube complement: 2 x 6SJ7, 2 x 6SL7GT, 4 x EL34 (matched pairs)
Rectifier: solid state with ultra high speed HEXFRED diodes
Output configuration: Class AB_1 ultra-linear push-pull with fixed bias (EL34 matched pairs recommended)
Phase inverter: cathode-coupled
Heater supply: dc heater voltage for driver tubes
Rated power output (8): 30 W/channel
Frequency response at 1 W output: 15 Hz–75 kHz –1 dB
Frequency response at 30 W output: 20 Hz–20 kHz –1 dB
Gain: 26 dB (20 V/V) or 0.7 V input for 30 W output
Input resistance: 430 kΩ
Noise: less than 1.5 mV (80 dB below rated output)
Dimensions: 17" W x 12" D x 8" H overall
Weight: 25 lb
Power consumption: 200 W, 115–125 VAC 60 Hz
Fuse: 4 A fast blow type rated at 250 V

The *Stealth 60* User's Manual can be downloaded from the Mapletree web site.