Budgie Overview

The diy*tube Budgie board is an easy to build, tube phono preamplifier for MM cartridges. Features include passive RIAA equalization with 6DJ8 tube types, 38dB gain at 1kHz, dual external power supplies, high performance constant current sources, small footprint and low build cost. The Budgie can also be built as a complementary or standalone 12B4 line stage.

Passive Equalization

The RIAA equalization used in the Budgie is the Lipshitz one-stage RIAA EQ. While his original AES article is not freely available online, KAB has a handy java calculator on their website (http://www.kabusa.com/riaa.htm) that calculates the needed values. In our case the output impedance of V1a, the grid resistor of V1b and the miller capacitance of V1b are key variables which are not part of the KAB calculator and must be accounted for. Morgan Jones goes into great detail in his "Valve Amplifiers" book explaining these additional influences on the RIAA EQ, and its latest edition is highly recommended.
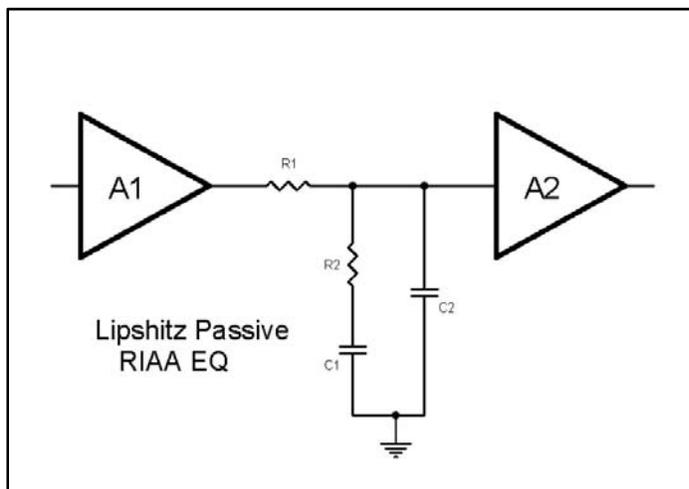

The relationship of the components in the Lipshitz one-stage EQ:

R1*C1 = 2187 us
R1*C2 = 750 us
R2*C1 = 318 us
C1/C2 = 2.916

Figure 1

While Jones suggests starting with a standard precision resistor value, I think starting with a capacitor value is best, as oddball capacitor values can make sourcing difficult. One percent resistors, on the other hand, are plentiful. We'll use the left channel of the Budgie (see Figure 2) to walk-through the filter design. Focusing on the **C1/C2** ratio, we can easily find our needed ratio with two paralleled 10nF caps, for a total of 20nF and a 6.8nF cap. The WIMA FKP series are film and foil capacitors that are readily available and intended for precision audio circuits. In the Budgie, **C2** is actually a combination of C7 and the Miller capacitance of V1b, which is around 60pF. So 20/6.86 is very close to our required ratio.
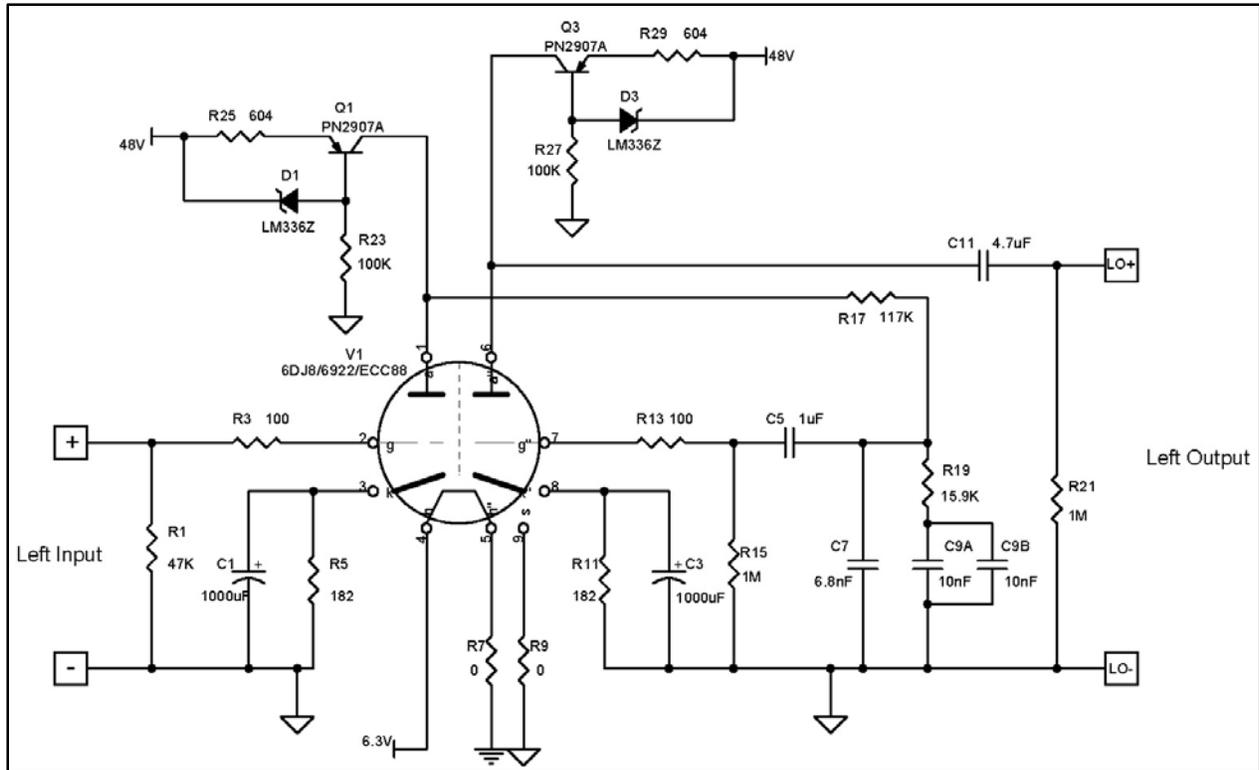
Figure 2

Now we can determine the other values having decided on those capacitor values.

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2187us/20nF = R17 = 109.3K
750us/6.86nF = R17 = 109.3K
318us/20nF = R19 = 15.9K
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R19 needs no adjustment and 15.8K is a standard 1% resistor which will work well. But R17 is not a 109.3K resistor. R17 must be calculated in series with the output impedance of the first stage and in parallel with the impedance of the grid resistor R15. First we calculate the grid resistor's influence:

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(109.3K * 1000K) / (1000K – 109.3K) = 122.7K
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Then we subtract the first stage's output impedance, which is around 5.5K.

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122.7K – 5.5K = 117.2K
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We'll use a 118K resistor which is also a standard 1% resistor. Now we have our RIAA EQ filter values.

Support of that precision filter network is the goal of the rest of the Budgie circuit. We want hardly any degenerative feedback from the cathode biasing, so we need high capacitance to insure low impedance at lower frequencies. 1000uF will be a reactance of 8 ohms, and small compared to the 182 ohm resistor. It represents a sweet spot between diminishing returns with greater capacitance, and detracting from RIAA

accuracy in the bass region. The DC bias level itself – around 550mV - has been heavily tested for greatest linearity, so changing these values can hurt performance. One substitution I can recommend it replacing the resistor and capacitor with a single 1N4148, cathode to ground. It can be mounted in the resistor footprint. C5 and C11 are also chosen to remove interaction with our bass region. Due to their cost and size, I presume these are two of the worst offenders in inaccurate phono amplifiers. Even operating into an amplifier or preamplifier with 100K input impedance, significant 20Hz roll-off will occur with a 1uF capacitor and any effort towards building a "perfect" RIAA EQ will have been for naught. The grid resistor at R17 is chosen for highest gain, as well as least interaction with the filter. Grid stoppers at R3 and R13 are sized to squelch ultrasonic oscillations but not to interfere with the EQ.

Phono Gain

Budgie gain is approximately 38dB at 1kHz. That is about 80x gain, so a 5mV input will be a 0.4V output. This should be adequate gain for all high output moving magnet and moving iron cartridges.

Dual External Output Supplies

The Budgie uses two external, high efficiency AC/DC supplies. These will work world-wide. A 7.5V supply is for the control circuit and the heater supply. It uses around 100mA for the delay relay circuit and LEDs, and then 650mA for the heaters. Any substituted supply should be rated at 1A or more and have built-in short circuit protection. The supply is controlled with an ON/OFF switch and the red LED illuminates at turn on. A 48V supply is for the B+ for the 6DJ8s. Due to their high perveance and the lack of a large voltage drop through a plate resistor, they will work well at these lower voltages. The 48V supply is switched on 30 seconds after the 7.5V is switched on, providing a soft start for the 6DJ8 tubes. The red indicator LED will turn green once the relay engages.

High Performance Constant Current Sources (CCS)

In this low voltage design, a CCS is needed. Fortunately, a CCS can also represent very high performance and won't be a compromise. A traditional plate resistor would waste a large amount of voltage. For example, at 3mA with a 20K plate resistor, there would be a 60V drop – higher than our supply. Using a PNP small signal transistor, a precision voltage reference and a current set resistor, we can have an excellent current with PSRR of 130dB, equivalent to a plate resistor of around 3 megaohms. The Budgie

implementation is straight out of Walt Jung's April 2007 AudioXpress article "Sources 101: Audio Current Regulator Tests for High Performance" (http://waltjung.org/Late_Articles.html).

Size & Cost

No fancy boutique parts are needed for the Budgie. Total build cost can be under $200. It can easily use the recommended Pomona enclosure (6.2"x4.1"x2.7") for a small, smart footprint, or be mounted in one's own chassis. The dual silkscreened board permits populating the board for a suspended chassis build (as used in the Pomona) or as a "top pop" build on the socket side then mounted in any chassis with standoffs.