GLASSWARE
AUDIO DESIGN

ACF

Aikido Cathode Follower

USER GUIDE

03/22/2010

☛ Warning! ☚

This PCB is for use with a high-voltage power supply; thus, a real shock hazard exists. Once the power supply is attached, be cautious at all times. In fact, always assume that capacitors will have retained their charge even after the power supply is disconnected or shut down. If you are not an experienced electrical practitioner, before applying the B-plus voltage have someone who is experienced review your work. There are too few tube-loving solder slingers left; we cannot afford to lose any more.

ACF PCB Overview

Thank you for your purchase of the Aikido ACF 9-pin stereo PCB. This FR-4 PCB is extra thick, 0.094 inches; thus, inserting and pulling tubes from their sockets won't bend or break this board; it double-sided, with plated-through 2oz copper traces on both sides; and the PCB is expensively and lovingly made in the USA. Each PCB holds two Aikido ACF unity-gain buffers; thus, one board is all that is needed for stereo unbalanced use or one board for one channel of balanced buffering. The boards are four inches by six inches, with five mounting holes, which also helps to prevent excessive PCB bending while inserting and pulling tubes from their sockets.

PCB Features

Redundant Solder Pads This board holds two sets of differently-spaced solder pads for each critical resistor, so that radial and axial resistors can easily be used (bulk-foil resistors and carbon-film resistors, for example). In addition, most capacitor locations find many redundant solder pads, so wildly differing-sized coupling capacitors can be placed neatly on the board, without excessively bending their leads.

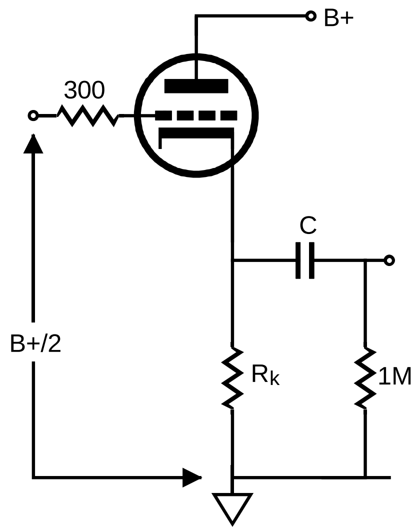
Multiple Heater Arrangements The ACF PCB allows either 6.3V or 12.6V heater power supplies to be used; and two 6V tubes, such as the 6Q8, 6CG7, 6DJ8, and 6H30 can be used with a 12V heater power supply.

No-Gain—No-Pain

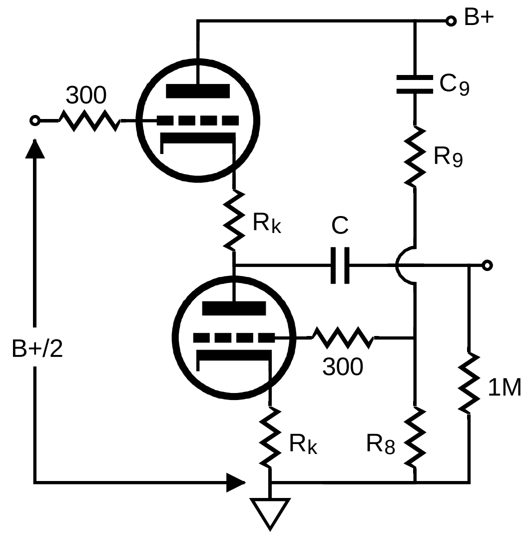
Tube-based buffer line stages that provide no voltage gain are, surprisingly enough, rare. As far as I know, no commercially-offered, unity-gain, tube-based line-stage buffer exists. This is an odd situation, as passive line-stages are popular, which proves that extra signal gain isn't always required. Additionally, the passive line-stage does not require plugging into the wall and it adds no extra active devices into signal path. The purest of the pure. Yet passive line stages often prove inadequate, incapable of driving high-capacitance cables or low-input impedances. Moreover, most active line-stage amplifiers can often impart the missing heft and solidity that is missing in many passive setups, even when the load is wimpy, but at the cost of greatly increased complexity and cost—with some added noise and distortion.

The Aikido cathode follower (ACF), in contrast, is a modest affair, consisting of one tube per channel (two triode per tube envelope) and a handful of capacitors and resistors. This unity-gain buffer, using a modified cathode follower, offers a high input impedance and a low output impedance and low distortion and great PSRR. In addition, the ACF does not invert the phase. The ACF use is not limited to line-stages, as the ACF can be used in creating an active crossover or even a headphone driver, if the headphone's impedance is high enough.

Introduction to the Aikido Cathode Follower



Cathode Follower



Aikido Cathode Follower

So what is required to make a good tube-based unity-gain buffer? For most tube fanciers, the immediate answer is to use a cathode follower. This solution makes a lot of sense, as the cathode follower offers a gain close to unity and both a low output impedance and distortion figure. A cathode follower, however, isn't the only circuit that will work as a buffer. For example, the plate-follower and White cathode follower also provide unity-gain, a low output impedance and distortion figure. The cathode follower, however is the most popular buffer, as it is the simplest. So simple in fact that a cathode follower can be made from just three resistors and one coupling capacitor as supporting parts. Several modifications to this simple circuit are possible. For example, the cathode resistor can be replaced by a choke, which will function as a constant-current source in AC terms. Another possibility is to replace the cathode resistor with a constant-current-source circuit. A discrete constant-current source can be made from triodes, pentodes, FETs, MOSFETs, transistors, or ICs. In fact, a fairly good constant-current source can be made from just one IXCY 10M45S current regulator and a resistor.

Unlike the grounded-cathode amplifier, whose PSRR improves by the replacement of the plate resistor with a constant-current source, the cathode follower's PSRR worsens with the replacement of its cathode resistor by a constant-current source. Why? In the grounded-cathode amplifier circuit, the constant-current source shields the plate from the noise source; but in the cathode follower circuit, the triode shields the constant-current source from the power-supply noise. With no external load impedance and a true constant-current source, the cathode follower's PSRR falls to 1/mu; thus the higher the mu, the smaller the percentage of power-supply noise making to the output.

Aikido Cathode Follower Here is a new circuit born from the rib of the two-stage Aikido amplifier topology. In other words, it is basically the last half of the Aikido amplifier, which uses a modified cathode follower circuit as the output stage. This modified cathode follower scrubs away the power-supply noise from its output and provides a complementarily non-linear load for the top triode's cathode. the Aikido circuit produces far less distortion than comparable circuits by using the triode's own nonlinearity against itself.

The triode is not as linear as a resistor so, ideally, it should not see a linear load, but a corresponding, complementary, balancing non-linear load. An analogy is found in someone needing eyeglasses; if the eyes were perfect, then perfectly flat (perfectly linear) lenses would be needed, whereas imperfect eyes need counterbalancing lenses (non-linear lenses) to see clearly. Now, loading a triode with the same triode—under the same cathode-to-plate voltage and idle current and with the same cathode resistor—works well to flatten the transfer curve out of that triode. Since the cathode follower already enjoys 100% degeneration at its cathode, the slight reduction in distortion by using the triode-based load is not as marked as in is in a grounded-cathode amplifier, but it is a worthwhile modification. I addition, the active load allows us to anticipate the power-supply noise that would normally appear at the output and counter the noise before it can appear.

Imagine that the output coupling capacitor is infinitely large in value and that the load impedance is zero ohms and that the input is grounded. No power-supply noise could make it to the follower's output. Now imagine no power-supply noise at the output, but with no coupling capacitor or external load, with only the bottom triode providing a current path into the top triode and the B+ connection. In both scenarios, only the top triode sees the power-supply noise at its plate. Thus, any signal (power-supply noise) on the top triode’s plate will impose a current conduction variation in the top triode equal to Vnoise / (rp + [mu +1]Rk). Since the both tubes are in series, the bottom triode must match this current variation to null the noise at the follower’s output. So, in the ideal setup, the top triode sees a fixed cathode and grid voltage, while its plate varies with the power-supply noise; and the bottom triode sees a fixed plate voltage, while its grid's voltage is varied to provoke a matching variation in current conduction.

A triode's a grid is—by definition—mu times more effective than the plate in controlling triode's current conduction; thus, the bottom triode’s grid must see the power supply noise dived by the mu of the triode used. For example, a 6GC7 (with a mu of 20) will need to see 1/20th of the power supply noise at its grid; a 12AX7 (with a mu of 100), 1/100th of the power supply noise at its grid. Therefore, the voltage divider resistors must conform to the following ratios:

R9/R8 = mu-1 and **R9 = R8(mu-1)** and **R8 = R9/(mu-1)**

For example, with a 12AU7 (with a mu of 17), R9 would equal 17 x R8; with a 12AX7 (with a mu of 100), R9 equals 99 x R8. The coupling capacitor feeds the two-resistor voltage divider needs to big enough in value to ensure enough low-frequency bandwidth to prevent excessive phase shifts at 50 or 60Hz. Thus,

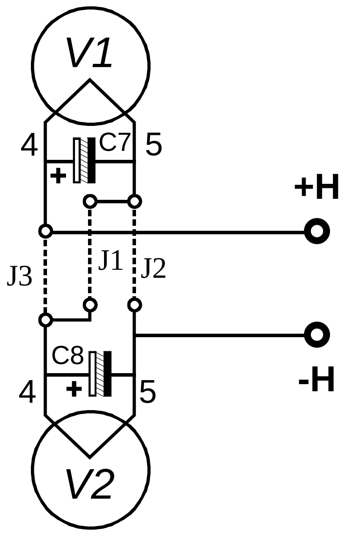
C6 = 318310/(R9 + R8)/F,

where F = frequency and the result is in µF; typical values fall between 0.047 to 1µF.

Conclusion Is the Aikido cathode follower worth the extra triode and the slightly higher output impedance? Yes, for several reasons. The first is simply that it offers an improved PSRR figure. Second, its distortion is slightly lower due to the extra signal degeneration at the output because of the top cathode resistor being in series with the output and because the bottom triode and its cathode resistor define a nicely complementary non-linearity to the top triode, balancing the curvatures into a straighter transfer function.

Heater Issues

The external heater power supply voltage can be either a 12V or a 6Vdc. Using a 12V heater power supply is more flexible, as both 12V and 6V tubes can be used, with the correct jumper settings. If an AC heater voltage is applied, be sure to remove capacitors, C7 & C8. Note: Perfectly good tubes with uncommon heater voltages, such as the 8CG7, can often be found at swap meets, eBay, and surplus stores for a few dollars each. Think outside 6.3V box.



Filament Jumper Wire Schedule

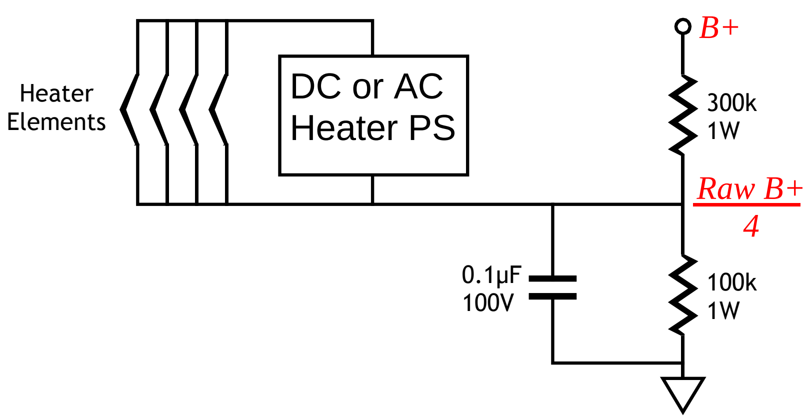
With a 12.6V PS

Both tubes are 6.3V:	J1 only
If both are 12.6V:	J2 & J3

With a 6.3V PS

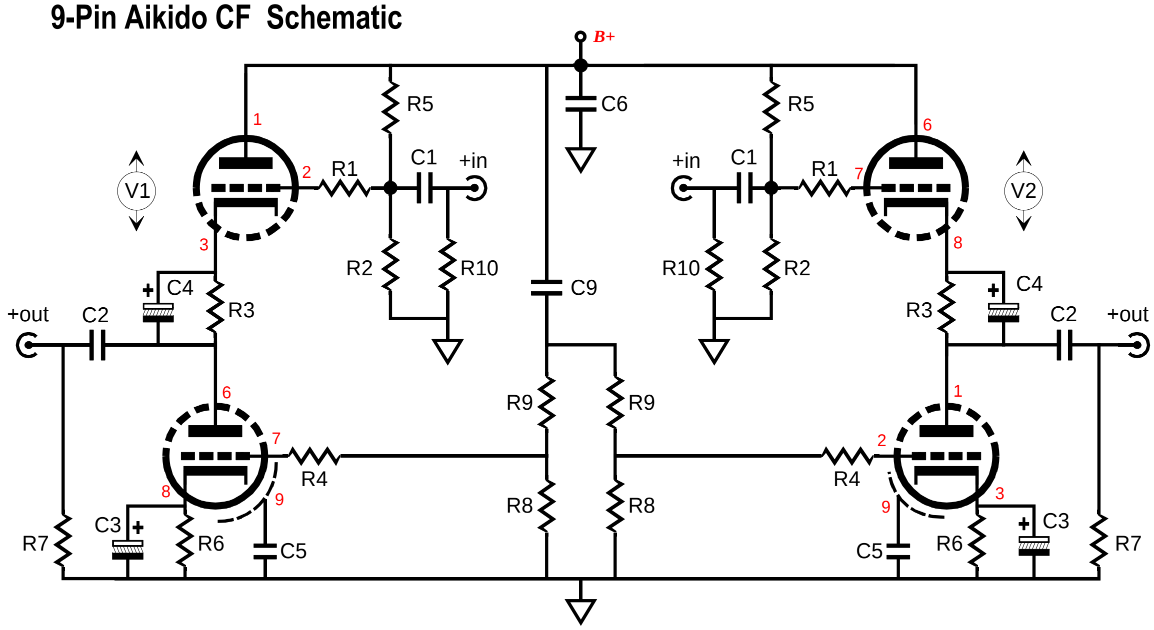
All tubes = 6.3V:	J2 & J3
If both are 12.6V:	Cannot be used with 6.3V PS

Since one triode stands atop another, the heater-to-cathode voltage experienced differs between triodes. The safest path is to reference the heater power supply to a voltage equal to one fourth the B+ voltage; for example, 75V, when using a 300V power supply. This ¼ B+ voltage ensures that both top and bottom triodes see the same magnitude of heater-to-cathode voltage. The easiest way to set this voltage relationship up is the following circuit external to the PCB:



Alternatively, you might experiment with floating the heater power supply, by "grounding" the heater power supply via only a 0.1µF film or ceramic capacitor. The capacitor will charge up through the leakage current between heater and cathodes. Not only is this method inexpensive, it is often quite effective in reducing hum with certain tubes.

9-Pin Aikido CF Schematic



Typical Part Values

() Parentheses denote recommended values

	6CG7	6DJ8	12AU7	6GM8 Low-Voltage Operation	6H30 High Current Operation
B+ Voltage =	240V	200V	250V	24V	120V
Heater Voltage =	6.3V @ 1.2A 12.6V @ 0.6A	6.3V @ 0.7A 12.6V @ 0.35A	12.6V @ 0.3mA	6.3V @ 0.7A 12.6 @ 0.35A	6.3 @1.65A 12.6V @ 0.825A
R1, 4 =	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*
R2, 5, 7, 10 =	1M	1M	1M	1M	1M
R3, 6 =	200 - 1k (470)*	100 - 1k (200)*	200 - 1k (340)*	300 - 680 (180)*	100 - 470 (150)*
R8 =	4.99k	3.48k	5.9k	7.68k	7.15k
R9 =	100k	100k	100k	100k	100k

*High-quality resistors essential in this position. All resistors 1/2W or higher

	6CG7	6DJ8	12AU7	6GM8	6H30
V1, V2 = (Subs)	6CG7, 6FQ7, 8CG8 12FQ7	6922, 7308, E88CC	6AU7, 5814, 5963, 6189, ECC82	ECC86, 6N27P	None

	6N1P	12BH7	12AT7	12AX7	5965
B+ Voltage =	240V	300V	200V	300V	240V
Heater Voltage =	6.3V @ 1.2A 12.6V @ 0.6A	12.6V @ 0.6A	12.6V @ 0.3mA	12.6 @ 0.3A	12.6 @ 0.225A
R1, 4 =	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*
R2, 5, 7, 10 =	1M	1M	1M	1M	1M
R3, 6 =	200 - 1k (300)*	100 - 1k (470)*	200 - 1k (340)*	300 - 680 (1.1k)*	100 - 470 (240)*
R8 =	2.87k	6.04k	1.69k	1k	2.15k
R9 =	100k	100k	100k	100k	100k

*High-quality resistors essential in this position. All resistors 1/2W or higher

	6N1P	12BH7	12AT7	12AX7	5965
V1, V2 = (Subs)	6BQ7, 6BS8, 6BZ7	12BH7A-EH	6201, CV4024, ECC81	12AX7A, 12AD7, 6681, 7025, 7729, B339, B759, CV492, CV4004, CV8156, CV8222, ECC83, ECC803, ECC803S, E2164	12AV7

C1 =	0.1 - 1µF* Film or PIO	Same	Same	Same	Same
C2 =	0.1 - 4µF* Film or PIO	"	"	"	"
C3 =	1µK/16V (optional)	"	"	"	"
C4[1] =	None	"	"	"	"
C5 =	0.01 - 0.1µF (optional)	"	"	"	"
C6 =	0.1 - 1µF* Film or PIO	"	"	"	"
C7, 8 =	47 - 470µF-6.3V - 16V	"	"	"	"
C9 =	0.1 - 1µF* Film or PIO	"	"	"	"

*Voltage rating must equal or exceed B+ voltage

1. A PCB mistake; capacitor C4 need never be used.

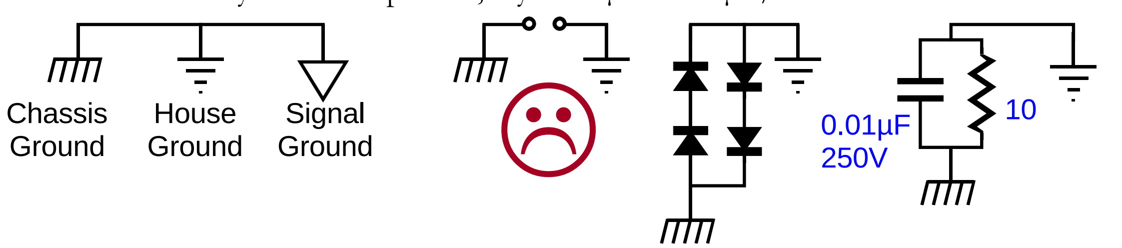
Grounding

The ACF PCB holds a star ground at its center. Ideally, this will be the only central ground in a line-stage buffer. A ground-loop is created when a device finds more than one connections to ground. Ground loops, unfortunately, are extremely easy to introduce. For example, if the input and output RCA jacks are grounded at the chassis, then the twisted pair of wires that connect the PCB to the jacks will each define a ground loop, as the chassis will attach to the PCB's central ground through at least four wires. The solution is either to isolate the jacks or use only a single hot wire from each jack to PCB (the wire can be shielded, as long as the shield only attaches at one end). Thus, the best plan is to plan. Before assembling the line-stage amplifier, stop and decide how the grounding is going to be laid out, then solder.

Three different schools of thought hold for grounding a piece of audio gear. The Old-School approach is to treat the chassis as the ground; period. Every ground connection is made at the closest screw and nut. This method is the easiest to follow and it produces the worst sonic results. Steel and aluminum are poor conductors.

The Spur-Star ground method uses several ground "stars," which then terminate in a single star ground point, often a screw on the chassis. This system can work beautifully, if carefully executed. Unfortunately, often too much is included in each spur connection. For example, all the input and output RCA jacks share ground connection to a long run of bare wire, which more closely resembles a snake than a spur ground. In other words, the spurs should not be defined just physical proximity, but signal transference. Great care must be exercised not to double ground any spur point. For example, the volume control potentiometer can create a ground loop problem, if both of its ground tabs are soldered together at the potentiometer and twisted pairs, of hot and cold wires, arrive at and leave the potentiometer, as the two cold wires attaching to the PCB will define a ground loop. The Absolute-Star grounding scheme uses a lot of wire and is the most time consuming to lay out, but it does yield the best sonic rewards. Here each input signal source and each output lead gets its own ground wire that attaches, ultimately, at one star ground point; each RCA jack is isolated from the chassis. The ACF PCB was designed to work with this approach, although it can be used with any approach.

House Ground The third prong on the wall outlet attaches to the house's ground at the service panel and usually the cold water pipe. The line-stage buffer can also attach to this ground connection, which is certainly the safest approach, as it provides a discharge path should the high voltage short to the chassis. Unfortunately, this setup often produces a hum problem. Some simply float the chassis (not safe!), others use several solid-state rectifiers in parallel to attach the chassis ground to the house ground (**NOT NEUTRAL**) via the third prong, and others still use a power 10-ohm resistor shunted by a small capacitor, say 0.001µF to 0.1µF/250V.



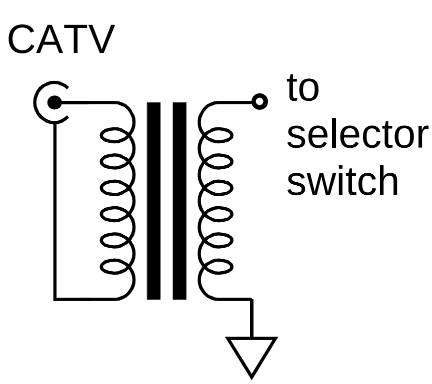
Never use a "cheater" plug to fix a hum problem; these plugs were design to promote safety, not to create a danger. Before trying any fix, make sure that all the wall sockets are wired correctly. For less than $10 you can buy an AC socket checker, which although not capable of revealing all miswires, can expose many wiring problems. A good second test procedure is to detach all the signal inputs and all the output connections from the line-stage buffer. Then measure the AC voltage between the line-stage amplifier's chassis and the house's ground. Then measure the chassis ground to the first signal source's ground on its output RCA jack (while the signal source is turned on). If it reads more than a few volts, try reversing the signal source's plug orientation as it plugs into the wall socket. Use which ever orientation that results in the lowest AC voltage reading. Then do the rest with the rest of the signal sources. The results can prove far more satisfying than what would be yielded by buying thousand-dollar cables.

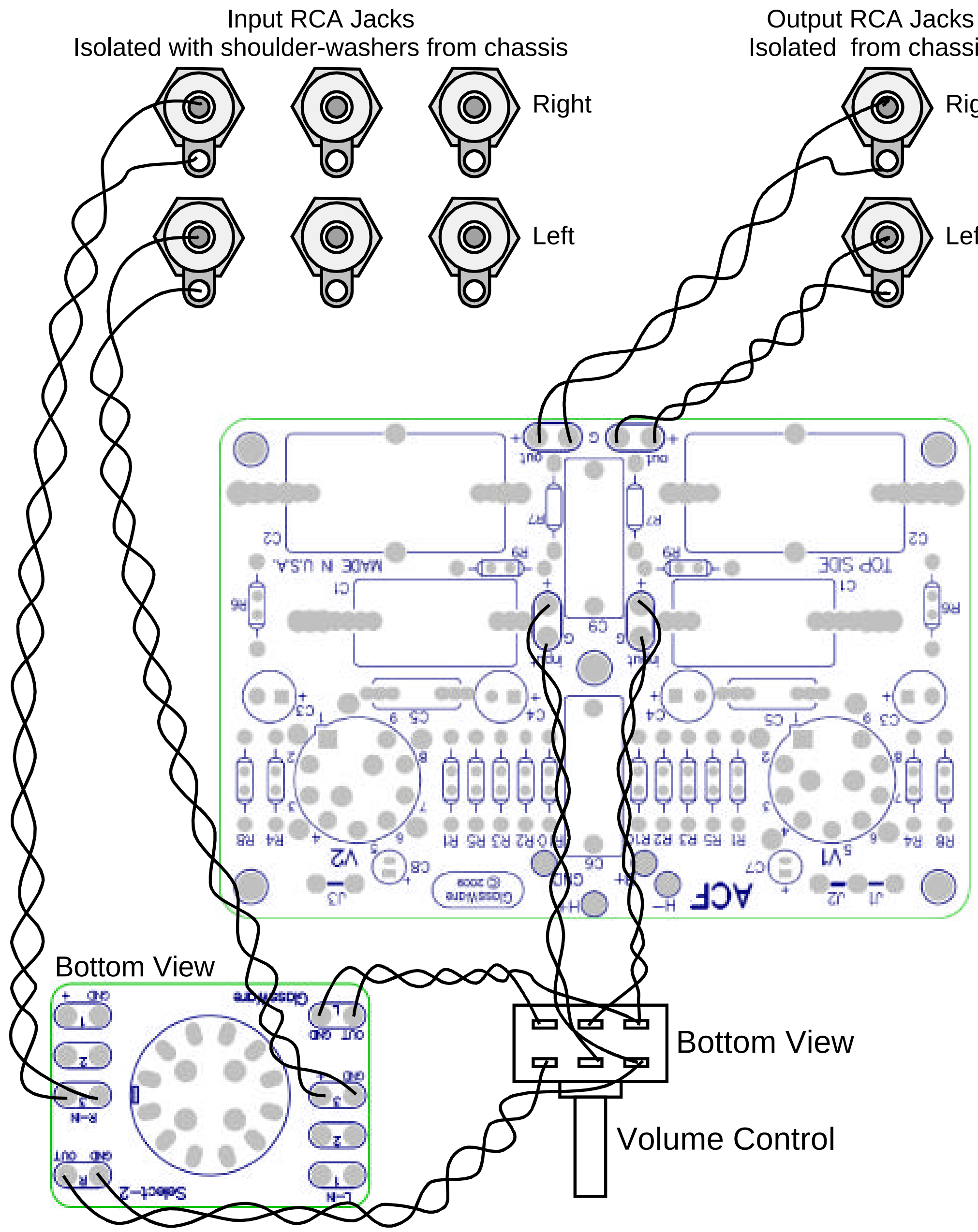
RFI Radio frequency interference can be a hassle to track down and eliminate. The air is filled with RFI from light dimmers, switching power supplies, cordless phone cradles, computers…First make sure that all contacts are clean. Second, make sure that the source of the problem actually resides in the line-stage amplifier. For example, if only one signal source suffers from RFI noise, make sure that it is normally RFI free. In other words, attach it to another line-stage amplifier and see if the RFI persists. If it does pass this test, then try soldering small capacitors, say 100pF, from this signal source's RCA jacks to the chassis, as close as possible to the jacks: if it fails, fix the source.

Ferrite beads can also help; try using beads on the hot lead as it leaves the input RCA jack and then again at the selector switch. Increasing the grid-stopper resistor's (R1) value, say to 1k or 10k, can also work wonders (use a carbon-composition or bulk-foil resistor or some other non-inductive resistor type).

Terminating Resistors Here's a cheap trick to try: at each input RCA jack, place a 100k to 1M resistor, bridging input hot and jack ground. Why? The resistor provides a path for the AC signal present at the jack, so given a choice between radiating into the chassis or going through the relatively low-impedance resistor, the AC signal chooses the latter path, reducing crosstalk.

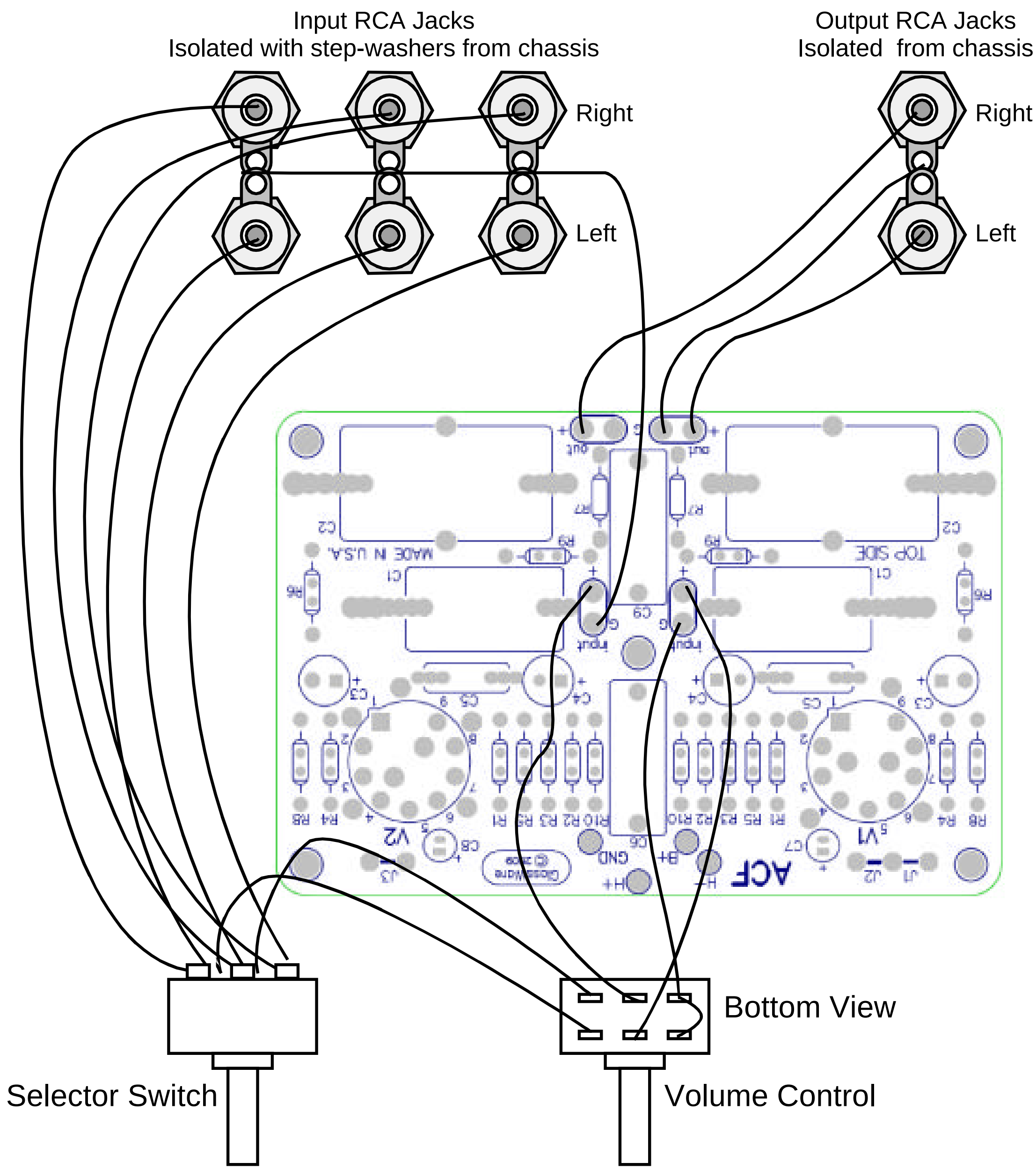
CATV Ground Attaching a line-stage amplifier to TV or VCR can cause huge hum problems, as the "ground" used by the connection TV cable connection my introduce hum. Isolation transformers work supremely well in this application. Be sure to use shoulder-washers to isolate the input RCA jacks from the chassis and the ACF ground. In fact, an isolation transformer can be used on all the input signals only (one transformer per channel is required, if it is located after, rather than before the selector switch.) Look on the Web for more complicated solutions to the CATV hum problem.





In this preferred physical setup, each input RCA jack gets its own pair of hot and ground wires; and the same holds true for the output RCA jacks. The six sets of twisted wire or coaxial cable travel from the input RCA jacks to a GlassWare Select-2 selector switch and then to the volume control and, finally, to the ACF PCB. All RCA jacks must be isolated from the chassis with non-conducting shoulder washers. Test each jack's ground tab for shorts to the chassis, before soldering the ground wires in place. In addition, make sure that only absolutely necessary ground wires that are soldered in place. (If the volume potentiometer presents only one ground tab, then tie both of the incoming ground wires from the selector switch to this connection and send one ground wire from the potentiometer to the PCB.)

Attach both the high voltage and heater power supplies wires to the bottom of the PCB and twist these wires into to a tight bundle that hugs the bottom of the chassis to their power supplies.



In this typical physical setup, the input RCA jacks have all their ground tabs soldered together to a common ground wire; and the same holds true for the output RCA jacks. These two ground wires then travel back to the ACF PCB; this arrangement will only work well, if the jacks are isolated from the chassis with non-conducting shoulder washers. Be sure to test each jack's ground tab first for shorts to the chassis, before soldering the ground wires in place. In addition, make sure that only absolutely necessary ground wires are soldered in place. Coaxial cable can be used for relaying the signals, but be sure to solder only one end of the shield to ground. The volume control (potentiometer) should attach to only one ground wire.

Attach both the high voltage and heater power supplies wires to the bottom of the PCB and twist these wires into to a tight bundle that hugs the bottom of the chassis to their power supplies.

Assembly & Testing

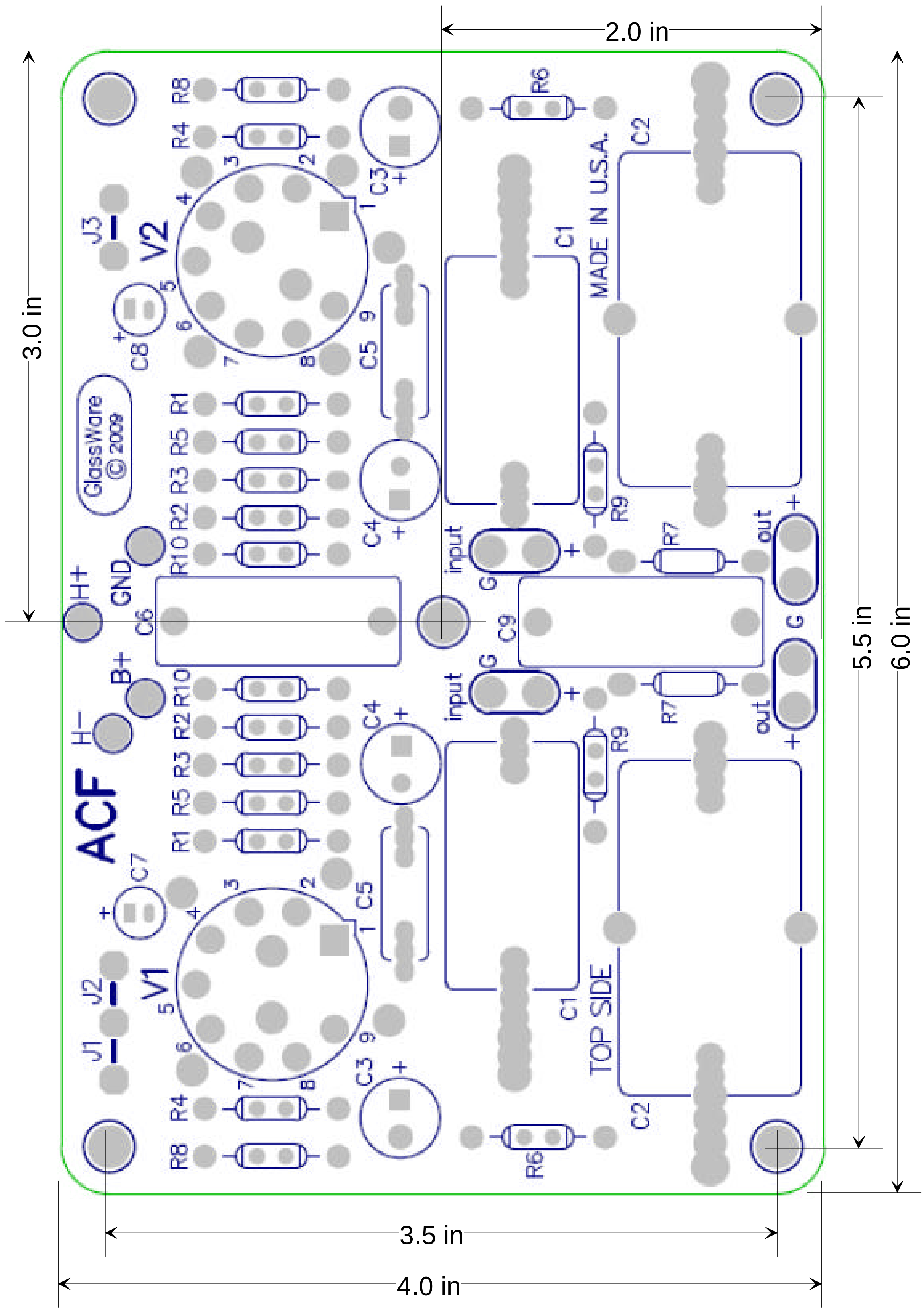
Assembly Cleanliness is essential. Before soldering, be sure to clean both sides the PCB with 90% to 99% isopropyl alcohol. Do not use dull-looking solder; solder should shine. If it doesn't, first clean away the outer oxidation with some steel wool or a copper scouring pad. If the resistor leads look in the least gray, clean away the oxidation with either steel wool or a wire sniper's sharp edges. Admittedly, with new resistors and a fresh PCB, such metal dulling is rare; but if the parts have sat in your closet for a year or two, then expect a good amount of oxidation to have developed.

First, solder the smallest components in place, and then solder the next larger, then the largest last. Be consistent in orienting the resistors; keep all the tolerance bands on the resistor's body at the right side as you face the resistor straight on. This will pay dividends later, if you need to locate a soldered a resistor in the wrong location. Because the board is double sided, with traces and pads on each side, it is easier to solder the resistors from their top side. It is often easier to solder one tube socket pin from the top first and then to solder the rest of the socket's pin from the bottom side of PCB. As the PCB is so overbuilt, it is extremely difficult to remove an incorrectly placed part. Be especially sure to confirm all the electrolytic capacitor and power supply connections are orientated correctly, as a reversed polarized capacitor can easily vent (or even explode) when presented with high-voltage. Confirm twice, solder once. By the way, the tube sockets must be soldered to the PCB's topside, but all the remaining parts can be soldered to the bottom side. Thus, the ACF PCB can be used with the tubes protruding from holes in the chassis top plate, with the all the other tall parts not interfering; be sure to use all five standoffs.

Testing Before testing, visually inspect the PCB for breaks in symmetry between left and right sides. Wear safety eye goggles, which is not as pantywaist a counsel as it sounds, as a venting electrolytic capacitor will spray hot caustic chemicals. Make a habit of using only one hand, with the other hand behind your back, while attaching probes or handling high-voltage gear, as a current flow across your chest can result in death. In addition, wear rubber-soled shoes and work in dry environment. Remember, safety first, second, and last.

1. Attach only the heater power supply, leaving the high-voltage leads unattached and electrical tape shrouded, with no tubes in their sockets.
2. Use a variac and slowly bring up the AC voltage feeding the power supply, while looking for smoke or part discoloration or bulging.
3. Measure the heater voltage pins 4 & 5 without and with the tube.
4. Next, power down the heater power supply and attach the high-voltage windings and insert the tubes in their sockets.
5. Attach the power supply to a variac and slowly bring up the AC voltage.
6. Measure the voltage across ground and B-plus pads in the top of the PCB; then measure the voltage across capacitors, C1 & C2. If the two channels differ by more than 10Vdc, try switching tubes from one channel to the other. If the imbalance does not follow the tubes, there is a problem, probably a misplaced part.

Only after you are sure that both heater and B-plus power supplies are working well, should you attach the Aikido cathode follower to a power amplifier.



Top Side ACF PCB Mechanical Layout

Tube	Unbypassed R3 and R6; R9 = 100k										With R3=0, C3=1kµF		
	mu	rp	R3 & R6	Ik(mA)	B+	R8	Wp	Gain	Gain dB	Zo	Gain	Gain dB	Zo
6AQ8	57	9700	100	10.0	300	1.79k	1.49	0.97	-0.30dB	263	0.96	-0.38dB	164
6BK7	43	4600	200	10.0	300	2.38k	1.48	0.96	-0.40dB	298	0.95	-0.43dB	102
6BQ7	38	5900	191	10.0	300	2.70k	1.48	0.95	-0.45dB	334	0.94	-0.50dB	147
6BS8	36	5000	220	10.0	300	2.86k	1.48	0.95	-0.47dB	346	0.94	-0.51dB	132
6CG7	20.5	10200	583	3.0	150	5.13k	0.22	0.91	-0.81dB	1009	0.90	-0.90dB	453
6CG7	21.1	8960	397	5.0	200	4.98k	0.49	0.91	-0.79dB	767	0.91	-0.86dB	388
6CG7	21	9250	626	5.0	250	5.00k	0.61	0.91	-0.79dB	1000	0.90	-0.87dB	402
6CG7	20.8	9840	1000	4.5	300	5.05k	0.65	0.91	-0.80dB	1386	0.90	-0.88dB	431
6CG7	21.4	8370	470	7.3	300	4.90k	1.07	0.91	-0.78dB	807	0.91	-0.85dB	358
6CG7	21.9	7530	243	10.0	300	4.78k	1.48	0.92	-0.76dB	548	0.91	-0.82dB	315
6CG7	21.8	7680	352	10.0	350	4.81k	1.71	0.92	-0.77dB	659	0.91	-0.83dB	323
6DJ8	30.2	3670	182	5.0	100	3.42k	0.25	0.94	-0.56dB	290	0.93	-0.59dB	114
6DJ8	30.7	2870	124	10.0	150	3.37k	0.74	0.94	-0.55dB	208	0.94	-0.57dB	88
6DJ8	30	2960	205	10.0	200	3.45k	0.98	0.94	-0.56dB	291	0.93	-0.59dB	92
6DJ8	29.6	3060	291	10.0	250	3.50k	1.22	0.94	-0.57dB	378	0.93	-0.59dB	97
6DJ8	28.6	3980	673	5.0	250	3.62k	0.61	0.93	-0.59dB	780	0.93	-0.62dB	130
6DJ8	28.3	4080	845	5.0	300	3.66k	0.73	0.93	-0.59dB	951	0.93	-0.63dB	135
6DJ8	28.9	3400	481	8.0	300	3.58k	1.17	0.94	-0.58dB	575	0.93	-0.61dB	110
6FQ7	See 6CG7												
6GM8	14	3400	187	2.0	24	7.69k	0.02	0.87	-1.16dB	388	0.87	-1.19dB	212
6H30	15.4	1140	69	20.0	100	6.94k	0.97	0.89	-1.06dB	131	0.88	-1.07dB	66
6H30	15.9	1040	74	30.0	150	6.71k	2.18	0.89	-1.03dB	128	0.89	-1.04dB	58
6H30	15.4	1310	221	20.0	200	6.94k	1.91	0.88	-1.06dB	284	0.88	-1.07dB	75
6H30	15.4	1380	294	20.0	250	6.94k	2.38	0.88	-1.06dB	356	0.88	-1.07dB	79
6H30	15	1670	530	15.0	300	7.14k	2.13	0.88	-1.09dB	597	0.88	-1.10dB	98
6N1P	39.8	12200	328	3.0	200	2.58k	0.30	0.95	-0.43dB	612	0.94	-0.53dB	292
6N1P	36	9480	221	5.0	250	2.86k	0.62	0.95	-0.47dB	464	0.94	-0.55dB	249
6N1P	35	956	642	5.0	300	2.94k	0.73	0.95	-0.48dB	650	0.95	-0.49dB	26
6N27P	See 6GM8												
9AQ8	See 6AQ8												
12AT7	60	15000	270	3.7	200	1.69k	0.37	0.97	-0.29dB	507	0.95	-0.41dB	242
12AU7	17	9560	427	2.5	100	6.25k	0.12	0.89	-0.97dB	907	0.89	-1.05dB	503
12AU7	16.6	9570	741	3.0	150	6.41k	0.22	0.89	-0.99dB	1214	0.88	-1.07dB	514
12AU7	16.7	9130	768	4.0	200	6.37k	0.39	0.89	-0.99dB	1214	0.88	-1.06dB	488
12AU7	17.9	7440	336	8.0	250	5.92k	0.98	0.90	-0.92dB	693	0.89	-0.98dB	374
12AU7	18.1	7120	328	10.0	300	5.85k	1.47	0.90	-0.91dB	665	0.89	-0.97dB	354
12AV7	37	6100	120	9.0	200	2.78k	0.89	0.95	-0.46dB	273	0.94	-0.51dB	156
12AV7	41	4800	56	18.0	300	2.50k	2.68	0.95	-0.41dB	166	0.95	-0.46dB	112
12AZ7	See 12AT7												
12AX7	100	80000	2000	0.5	200	1.01k	0.05	0.98	-0.18dB	2757	0.91	-0.84dB	784
12AX7	100	62500	1100	1.0	300	1.01k	0.15	0.98	-0.18dB	1699	0.92	-0.70dB	612
12BH7	16.1	5480	340	4.0	100	6.62k	0.19	0.89	-1.02dB	624	0.88	-1.06dB	303
12BH7	15.7	6090	706	4.0	150	6.80k	0.29	0.89	-1.04dB	1009	0.88	-1.09dB	344
12BH7	15.9	6140	787	5.0	200	6.71k	0.48	0.89	-1.03dB	1085	0.88	-1.08dB	343
12BH7	17.4	4870	383	10.0	250	6.10k	1.21	0.90	-0.95dB	614	0.89	-0.99dB	251
12BH7	18.4	4300	267	15.0	300	5.75k	2.19	0.90	-0.90dB	464	0.90	-0.93dB	211
12BZ7	100.0	31800	560	2.0	300	1.01k	0.30	0.98	-0.17dB	866	0.95	-0.44dB	312
12DJ8	See 6DJ8												
12FQ7	See 6CG7												
5751	70	58000	1250	0.8	200	1.45k	0.08	0.97	-0.25dB	2034	0.92	-0.73dB	805
5963	21	6600	200	10.0	250	5.00k	1.23	0.91	-0.79dB	478	0.91	-0.85dB	287
5965	47	7250	220	8.2	300	2.17k	1.22	0.96	-0.36dB	363	0.95	-0.42dB	148
6072	44	25000	1250	2.0	300	2.33k	0.30	0.96	-0.39dB	1763	0.93	-0.60dB	543
7119	21.7	2390	324	15.0	300	4.83k	2.18	0.92	-0.77dB	411	0.91	-0.79dB	101
ECC81	See 12AT7												
ECC82	See 12AU7												
ECC83	See 12AX7												
ECC85	See 6AQ8												
ECC86	See 6GM8												
ECC88	See 6DJ8												

The above table lists many of triodes suitable for the 9-pin-based Aikido-Cathode-Follower PCB. This table lists the same tube under several different B+ voltages and with different cathode resistor values. Resistor R9 = 100k in the above calculations of R9's value. Two gains are listed: the first is the gain the tube realizes with unbypassed cathode resistors; the second is the gain of the same tube, but with resistor R3 replaced with a jumper and resistor R6 bypassed with 100-1kµF capacitor, which will result in the lowest output impedance, but at the expense of increased distortion.