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Dear Aikido-Ardent Audiophile,

Thank you for your purchase of the TCJ Aikido 9-pin stereo PCB. This FR-4 PCB is extra thick, 0.094 inches (inserting and pulling tubes from their sockets won't bend or break this board), double-sided, with plated-through 2oz copper traces, and the boards are made in the USA. Each PCB holds two Aikido line-stage amplifiers; thus, one board is all that is needed for stereo unbalanced use or one board for one channel of balanced amplification. The boards are four inches by ten inches, with eight mounting holes, which help to prevent excessive PCB bending while inserting and pulling tubes from their sockets.

Warning!

The PCB is for use with a high-voltage power supply, so be cautious at all times once the power supply is attached, as a real shock hazard exists. 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, have someone who is review your work, before applying the B+ voltage. There are too few tube-loving solder slingers left; we cannot afford to lose any more.

Solder Pads

The board holds two sets of differently spaced solder pads for each resistor, so that radial and axial resistors can be easily used (bulk-foil resistors and carbon-film resistors, for example). In addition, each low-valued capacitor location finds many redundant solder pads, so wildly differing sized coupling capacitors can neatly be placed on the board, without excessively bending its lead. (Each tube's heater is shunted by its own 10-100µF 16V electrolytic capacitor; be sure to observe the correct polarity.)

Dual Coupling Capacitors

The boards hold two coupling capacitors, each finding its own 1M resistor to ground. Why? The idea here is that you can select (via a rotary switch) between C1 or C2 or both capacitors in parallel. Why again? One coupling capacitor can be Teflon and the other oil or polypropylene or wax or wet-slug tantalum…. As they used to sing in a candy bar commercial: "Sometimes you feel like a nut; sometimes you don't." Each type of capacitor has its virtues and failings. So use the one that best suits the music; for example, one type of coupling capacitors for old Frank Sinatra recordings and the other for Beethoven string quartets. Or the same flavor capacitor can fill both spots: one lower-valued capacitor would set a low-frequency cutoff of 80Hz for background or late night listening; the other higher-valued capacitor, 5Hz for full range listening. Or if you have found the perfect type of coupling capacitor, the two capacitors could be hardwired together on the PCB, one smaller one acting as a bypass capacitor for the lager coupling capacitor. On the other hand, each coupling capacitor can feed its own output, for example, one for low-frequency-limited satellites and one for subwoofers.

Heater Issues

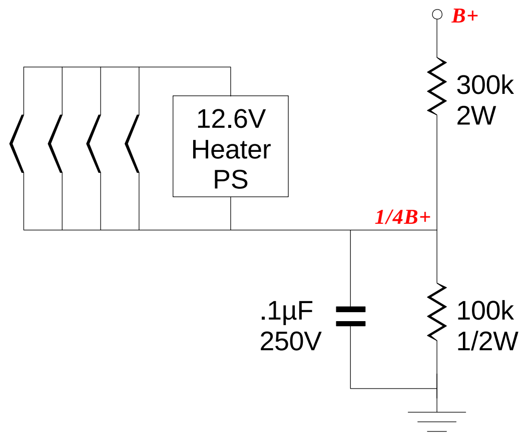
The board assumes that a DC 12V power supply will be used for the heaters, so that 6.3V heater tubes (like the 6FQ7 and 6DJ8) or 12.6V tubes (like the 12AU7 or 12AX7) can be used. Both types can be used exclusively, or simultaneously; for example 6GC7 for the input tube and a 12BH7 for the output tube. For example, if the input tube (V2 and V3) is a 12AX7 and the output tube is a 6H30 (V1 and V4), then use jumpers J1, J5 and J6.

Although designed for a 12V power supply, a 6V heater power supply can be used with the PCB, as long as all the tubes used have 6.3V heaters (or 5V or 8V or 18V power supply can be used, if all the tubes share the same 5V or 8V or 18V heater voltage). Just use jumpers J1 and J4 only. Note: Perfectly good tubes with uncommon heater voltages can often be found at swap meets, eBay, and surplus stores for a few dollars each. Think outside 6.3V box.

A 25V heater power supply can be used, if only 12.6V tubes are used. Just use the jumper settings that are listed on the PCB for 6V use. For example, if the input tube (V2 and V3) is a 12AX7 and the output tube is a 12AU7 (V1 and V4), then use jumpers J1 and J4.

An AC heater power supply (6V or 12V) can be used, if the heater shunting capacitors C7, C8, C9, C10 are left off the board, or are replaced by 0.01µF ceramic capacitors.

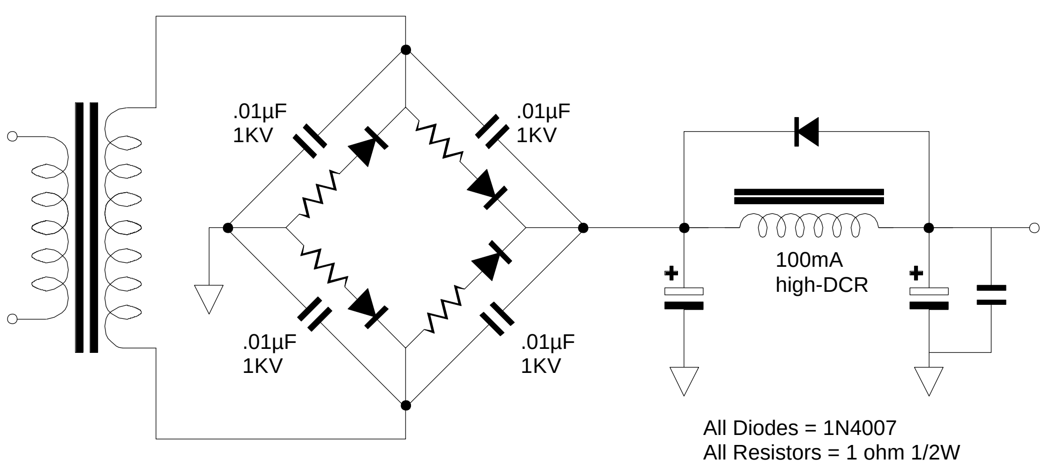
Since one triode stands atop another, the heater-to-cathode voltage experienced differs between triodes. The safest path is to reference the heater power supply to a voltage equal to one fourth the B+ voltage; for example, 75V, when using a 300V power supply. The ¼ B+ voltage ensures that both top and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



Alternatively, you might experiment with a floating heater power supply, by "grounding" the heater power supply via 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 cheap, it is often quite effective in reducing hum.

Power Supply

The power supply is external to the PCB and can be mounted in or outside the chassis that houses the Aikido PCB. The power supply voltage depends on the tubes used. For example, 6GM8s (ECC86) can be used with a low 30V power supply, while 6FQ7s work better with a 250-300V B+ voltage. The sky is not the limit here, as the heater-to-cathode voltage sets an upward limit of about 400V. The genius of the Aikido circuit is found in both its low distortion and great PSRR figure. Nonetheless, a good power supply helps. I recommend at least a solid, choke-filtered, tube or fast-diode rectified power supply be used. If you insist on going the cheap route, try the circuit below, as it yields a lot of performance for little money.



Jumper J7 connects the PCB's ground to the chassis through the top centermost mounting hole. If you wish to float the chassis or capacitor couple the chassis to ground, then either leave jumper J7 out or replace it with a small-valued capacitor (0.01 to 0.1µF).

Tube Selection

The Aikido amplifier defines a new topology without fixed part choices, not an old topology with specified part choices. In other words, an Aikido amplifier can be built in a nearly infinite number of ways. For example, a 12AX7 input tube will yield a gain close to 50 (mu/2), which would be suitable for a phono preamp or a SE amplifier's input stage; a 6FQ7 (6CG7) input tube will yield a gain near 10, which would be excellent for a line stage amplifier; the 6DJ8 or 6H30 in the output stage would deliver a low output impedance that could drive capacitance-laden cables or even high-impedance headphones. In other words, the list of possible tubes is a long one: 6AQ8, 6BC8, 6BK7, 6BQ7, 6BS7, 6DJ8, 6FQ7, 6GC7, 6H30, 6KN8, 6N1P, 12AT7, 12AU7, 12AV7, 12AX7, 12BH7, 12DJ8, 12FQ7, 5751, 5963, 5965, 6072, 6922, E188CC, ECC88... The only stipulations are that the two triodes within the envelope be similar and that the tube conforms to the 9A or 9AJ base pin-out. Sadly, the 12B4 and 5687 cannot be used with this PCB.

Internal Shields

If the triode's pin 9 attaches to an internal shield, as it does with the 6CG7 and 6DJ8, then capacitors, C3 and C4 can be replaced with a shorting wire, which will ground the shield. However, using the capacitors will also ground the shield (in AC terms) and allow using triodes whose pin 9 attaches to the center tap of its heater, such as the 12AU7.

Cathode Resistor Values

The cathode resistor sets the idle current for the triode: the larger the value of the resistor, the less current. In general, high-mu triodes require high-value cathode resistors (1-2K) and low-mu triodes require low-valued cathode resistors (100-1k). I recommend running the output tubes hotter than the input tubes. For example, 1k cathode resistors for the input tube (V2 and V3) and 300-ohm resistors for the output tubes (V1 and V4), when using 6FQ7s and 6CG7s throughout. Thus, the output tubes will age more quickly than the input tubes, so rotating output for input tubes can extend the useful life of the tubes.

Assembly

Before soldering, be sure to clean both sides the PCB with 99% isopropyl alcohol. All the parts sit on the side of the PCB with the white lettering. First solder the resistors in place, then the next tallest, and then the next tallest... If any of the parts have gold-plated leads, remove the gold flash before soldering the part, as only a few molecules of gold will poison a solder joint; use sandpaper or a solder pot. NASA forbids any gold-contaminated solder joints; you should as well. (Yes, there are many quality parts with gold-flashed leads, but the use of gold is a marketing device, not sound electrical engineering practice.) If you wish to have the tubes protrude from holes on the top of the chassis (and place the PCB within 1" of the panel), then all the other parts other than the sockets can be placed on the PCB's backside; it is a double-sided board after all (be sure to observe the electrolytic capacitors' polarity and hot glue heavy coupling capacitors to the PCB).

Let me know what you think

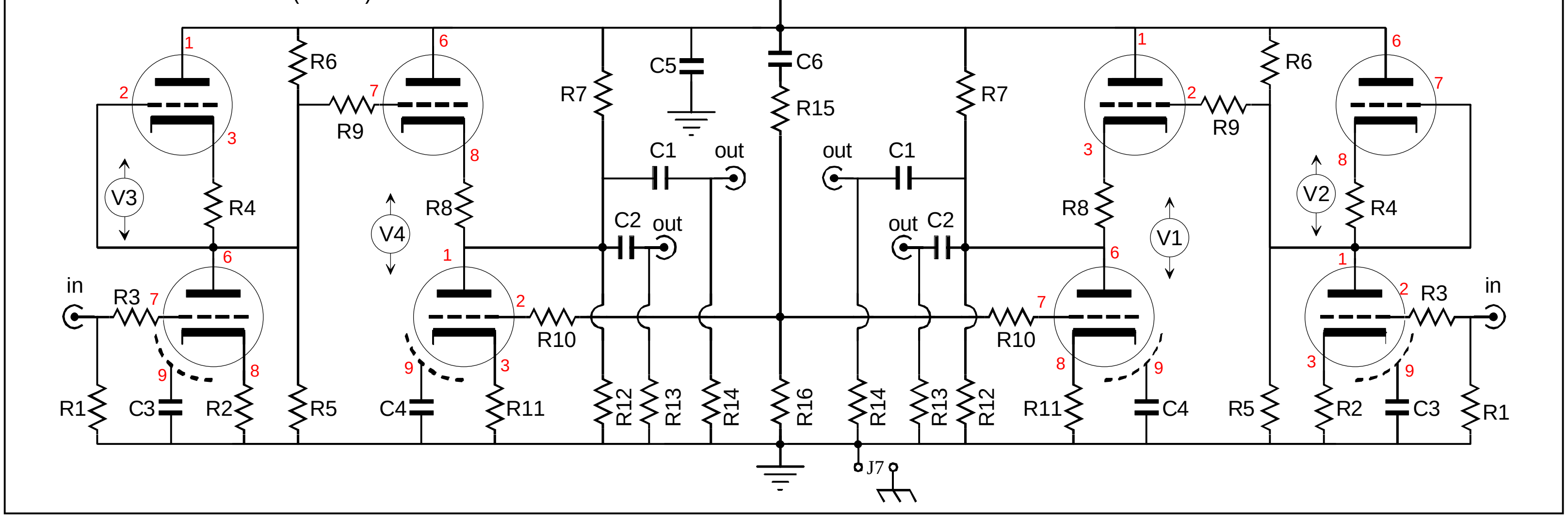
If you would like to see some new audio PCB or kit or recommend a change to an existing product or if you need help figuring out the heater jumper settings or cathode resistor values, drop me a line by e-mail to the address above (begin the subject line with either "Aikido" or "tube").

John Broskie

P.S.

Since the Aikido circuit came out in the *Tube CAD Journal*, people have been building it and marveling at its sound. A prediction: just as the 1980s were the cascode decade and the 1990s, the SRPP decade, this decade will be known as the Aikido decade. Spread the word.

9-Pin Aikido Schematic (Rev. A)



Part Values

R1, R5, R6, R7, R12, R13, R14 = 1M
R2, R4 = 200 - 2k (depends on tube)*
R3, R9, R10 = 100 - 470 ohm*
R8, R11 = 100 - 1k (depends on tube)*
R15 = R16 x (mu - 2) / (mu + 2)
R16 = 100K

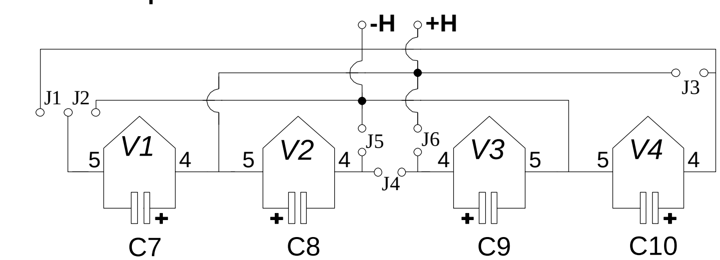
*High-quality resistors
All resistors 1/2W or higher

C1 = 0.1 - 4µF (voltage rating must exceed B+ voltage)
C2 = 0.1 - 4µF (voltage rating must exceed B+ voltage)
C3 = 0.1µF (optional)
C4 = 0.1µF (optional)
C5 = 1 - 10µF (voltage rating must exceed B+ voltage)
C6 = 0.1µF (voltage rating must exceed B+ voltage)
C7, C8, C9, C10 = 10-100µF Electrolytic (voltage rating must exceed heater PS voltage)

(outputs) V1, V4 = 6AQ8, 6BQ7, 6BS7, 6DJ8, 6CG7, 6GM8, 6H30, 6FQ7, 6N1P, 6N27P, 12AT7, 12AU7, 12BH7, 12DJ8, 12FQ7, 5963, 5965, E80CC, ECC81, ECC82, ECC83, ECC86, ECC88, ECC99

(inputs) V2, V3 = 6AQ8, 6BQ7, 6BS7, 6DJ8, 6CG7, 6GM8, 6FQ7, 6N1P, 6N27P, 12AT7, 12AV7, 12AU7, 12AX7, 12BZ7, 12DJ8, 12FQ7, 5751, 5963, 5695, 6072, E80CC, ECC81, ECC82, ECC83, ECC86, ECC88

Filament Jumper Wire Schedule



Assuming a 6.3V PS

Use J2, J3, J5, and J6 only.

Assuming a 12.6V PS

Output Tubes V1 and V4:
If tubes are 6V, use J1 only.
If tubes are 12V, use J2 and J3 only.

Input Tubes V2 and V3:
If tubes are 6V, use J4 only.
If tubes are 12V, use J5 and J6 only.

Tube	mu	Rp Ohms	Rk Ohms	Ik (mA)	B+ Volts	R15 Ohms	R16 Ohms	Input Gain	Input Gain dBs	Output Gain	Output in dBs	Zo Ohms
6AQ8	57	9700	100	10.0	300	93220	100k	28.1	29.0	0.97	-0.24	248
6BK7	43	4600	200	10.0	300	91111	100k	21.2	26.5	0.97	-0.27	279
6BQ7	38.00	5900	191	10.0	300	90000	100k	18.7	25.5	0.96	-0.32	311
6BS8	36.00	5000	220	10.0	300	89474	100k	17.8	25.0	0.96	-0.33	321
6CG7	20.50	10200	583	3.0	150	82222	100k	10.0	20.0	0.93	-0.59	827
6CG7	21.10	8960	397	5.0	200	82684	100k	10.4	20.3	0.93	-0.59	657
6CG7	21.00	9250	626	5.0	250	82609	100k	10.3	20.2	0.94	-0.56	820
6CG7	20.80	9840	1000	4.5	300	82456	100k	10.1	20.1	0.94	-0.53	1063
6CG7	21.40	8370	470	7.3	300	82906	100k	10.5	20.4	0.94	-0.56	686
6CG7	21.90	7530	243	10.0	300	83264	100k	10.8	20.7	0.93	-0.60	489
6CG7	21.80	7680	352	10.0	350	83193	100k	10.7	20.6	0.94	-0.57	576
6DJ8	30.20	3670	182	5.0	100	87578	100k	15.0	23.5	0.96	-0.39	273
6DJ8	30.70	2870	124	10.0	150	87768	100k	15.2	23.7	0.96	-0.39	199
6DJ8	30.00	2960	205	10.0	200	87500	100k	14.9	23.4	0.96	-0.37	274
6DJ8	29.60	3060	291	10.0	250	87342	100k	14.6	23.3	0.96	-0.36	350
6DJ8	28.60	3980	673	5.0	250	86928	100k	14.0	22.9	0.96	-0.35	667
6DJ8	28.30	4080	845	5.0	300	86799	100k	13.8	22.8	0.96	-0.34	787
6DJ8	28.90	3400	481	8.0	300	87055	100k	14.2	23.0	0.96	-0.35	511
6FQ7	See **6CG7**											
6GM8	14.00	3400	187	2.0	24	75000	100k	7.0	16.8	0.90	-0.90	357
6H30	15.40	1140	69	20.0	100	77011	100k	7.7	17.7	0.91	-0.80	127
6H30	15.9	1040	74	30.0	150	76471	100k	7.9	18.0	0.92	-0.75	124
6H30	15.40	1310	221	20.0	200	90431	100k	7.7	17.7	0.92	-0.68	267
6H30	15.40	1380	294	20.0	250	89474	100k	7.7	17.7	0.93	-0.66	330
6H30	15.00	1670	530	15.0	300	89189	100k	7.4	17.4	0.93	-0.65	528
6N1P	39.8	12200	328	3.0	200	89189	100k	19.4	25.8	0.96	-0.32	539
6N1P	36.00	9480	221	5.0	250	75000	100k	17.7	25.0	0.96	-0.36	422
6N1P	35.00	956	642	5.0	300	89189	100k	17.1	24.7	0.97	-0.25	569
6N27P	14.00	3400	187	2.0	24	75000	100k	7.0	16.8	0.90	-0.90	357
9AQ8	See **6AQ8**											
12AT7	60.00	15000	270	3.7	200	93548	100k	29.1	29.3	0.98	-0.21	457
12AU7	17.00	9560	427	2.5	100	78947	100k	8.4	18.4	0.92	-0.75	757
12AU7	16.60	9570	741	3.0	150	78495	100k	8.1	18.2	0.92	-0.71	959
12AU7	16.70	9130	768	4.0	200	78610	100k	8.2	18.2	0.92	-0.69	959
12AU7	17.90	7440	336	8.0	250	79899	100k	8.8	18.9	0.92	-0.71	601
12AU7	18.10	7120	328	10.0	300	80100	100k	8.9	19.0	0.92	-0.70	581
12AV7	37.00	6100	120	9.0	200	89744	100k	18.3	25.3	0.96	-0.36	258

Tube	mu	Rp Ohms	Rk Ohms	Ik (mA)	B+ Volts	R15 Ohms	R16 Ohms	Input Gain	Input Gain dBs	Output Gain	Output in dBs	Zo Ohms
12AV7	41.00	4800	56	18.0	300	90698		20.4	26.2	0.96	-0.35	160
12AZ7	See **12AT7**											
12AX7	100.00	80000	2000	0.5	200	96078	100k	39.0	31.8	0.99	-0.11	1719
12AX7	100.00	62500	1100	1.0	300	96078	100k	42.6	32.6	0.99	-0.12	1238
12BH7	16.10	5480	340	4.0	100	77901	100k	8.0	18.0	0.92	-0.76	549
12BH7	15.70	6090	706	4.0	150	77401	100k	7.7	17.7	0.92	-0.71	826
12BH7	15.90	6140	787	5.0	200	77654	100k	7.8	17.8	0.92	-0.68	877
12BH7	17.40	4870	383	10.0	250	79381	100k	8.6	18.7	0.93	-0.67	541
12BH7	18.40	4300	267	15.0	300	80392	100k	9.1	19.2	0.93	-0.65	422
12BZ7	100.00	31800	2200	2	300	96078	100k	48.5	33.7	0.98	-0.17	292
12DJ8	See **6DJ8**											
12FQ7	See **6CG7**											
5751	70.00	58000	1250	0.8	200	94444	100k	30.5	29.7	0.98	-0.17	1407
5963	21.00	6600	200	10.0	250	82609	100k	10.4	20.3	0.93	-0.63	433
5965	47.00	7250	220	8.2	300	91837	100k	23.1	27.3	0.97	-0.26	337
6072	44.00	25000	1250	2.0	300	91304	100k	20.3	26.2	0.97	-0.25	1272
ECC81	See **12AT7**											
ECC82	See **12AU7**											
ECC83	See **12AX7**											
ECC85	See **6AQ8**											
ECC86	See **6GM8**											
ECC88	See **6DJ8**											

The table above lists many triodes suitable for the 9-pin-based Aikido amplifier PCB. The table lists the same tube under different B+ voltages and with different cathode resistor values.

Two gains are listed: the first is the gain the tube realizes in the input position in the Aikido; the second is the gain of the same tube in the output stage.

To calculate the final gain multiply the two voltage gains together (or add the gain in dBs together). For example, given an Aikido line amplifier with a B+ voltage of 300V, and a 6CG7 input tube with cathode resistors of 1k, and a 6DJ8 output tube with cathode resistors of 481 ohms, the final voltage gain equals 10.1 from the 6CG7 against the 0.96 gain of the 6DJ8, with a product of 9.7. or, working with dB instead, 20.1dB plus -.35dB, for a total of 19.75dB. (Aren't decibels great?)

If you have additional data, send it in and I'll add to the list.