DIY HiFi Supply Active Bias Supply Module

Bias voltage:

A negative bias voltage is needed to prevent runaway current in a vacuum tube. The negative voltage can be applied to the cathode or to the grid.

1. Cathode bias: When applied to the cathode, it becomes self biasing, and the Anode voltage needs to be increased by the amount of voltage drop across the cathode resistor. So cathode bias circuits generally require a higher anode voltage to achieve the same power output.
2. Grid bias: when applied to the grid, a lower anode voltage can be used to achieve the same power. However Grid bias is not self adjusting and is referred to as "fixed bias". In the case of grid bias an adjustment pot or some other means of controlling the grid voltage is needed because if the negative voltage on the grid is lost there will be runaway current through the tube. In the case of push pull amplifiers, we want the same anode current flowing through each tube on the "push" and the "pull" sides of the output transformer. As tubes warm up and age they tend to conduct at a different rate. This causes the DC current to flow through the output transformer which in turn, produces a greater or lesser amount of saturation. Bass frequencies are the first to go. So while we may manually adjust the Anode current to be In perfect balance, a short time later there may be some imbalance and the amplifier is then not performing at its optimum level and sonics are degraded.

Active Bias Control

The ideal solution to fixed bias stability is to use an electronic circuit to actively sense current flow through the tube.

Benefits: tube life is extended, saturation of the output transformer is avoided, amplifier always operates optimally, better bass performance, more dynamics, danger of runaway tube current when amplifier is unattended is minimized. Also since most bias voltage supply filter networks tend to be very simple single diode or half wave, there is usually a great deal of ripple in the most sensitive signal path in the amplifier – the grid! And active bias system is also an opportunity to design a bias supply with extremely low levels of ripple. This imbues a sense of stillness and low-level detail not obtainable with standard bias voltage supplies.

Challenges: since the music signal its self effects a change in current through the tube, how can we devise a tube current sensor that responds only to changes in standing current but not respond to dynamic changes in current due to the musical signal on the grid? Also, since the circuit used to control the bias voltage will need to have some solid state devices, how can we make sure that we isolate the sound of solid state from our lovely tube's sound?

Through creative engineering and careful design this has been achieved with the DIYHFS Active Bias Supply (ABS module):

ABS Module Features

- Eliminates need for constant re-adjustment of Bias to compensate for mains variations and valve aging
- Regulation of cathode current of tubes from around 1mA to 250mA with10R cathode resistor current match between halves depends on cathode resistor tolerance ± 1% due to circuit (typical mismatch << 0.1mA). Perfect current balance produces better bass
- Current regulation is not influenced by music signal
- Current set by standard 1/4W leaded resistor (exchangeable)
- Current can be adjusted from 0mA to 90mA per tube if a 10K Pot is connected instead of the resistor
- reduces noise on bias supply by at least 40db (100 times) so even the most basic bias supplies sound good. Lower noise improves resolution and imaging
- Turn on Delay of 45 Seconds
- Slow ramp up of current over a further 45 Second
- Fault Indication via LED's (Red) on PCB; they can be re-mounted on the Amplifier chassis

- Fault Indication via TTL compatible open collector output (can be used for additional protection circuitry or for our upcoming electronic choke PSU PCB)
- multiple mounting holes for easy mounting
- Can be fitted to any existing fixed bias equipped Amplifier without changing the original circuit and with absolutely minimal modifications, except bias potentiometers (and possibly cathode resistor changes)
- Small size due to use of existing supplies already present in your amplifier
- No high voltage connections are required to be made

Electrical Parameters

- Maximum Tube current up to 250mA with 10R Cathode resistors
- Output voltage up to -150V (depending upon the original bias supply in the amplifier)
- Outputs can sink at least 2mA current or much more
- Requires a single, ground referenced 6.3V to 12.6V AC supply (ie power tube filament supply draws 60-100ma) for the actual module and the original negative bias supply of the Amplifier

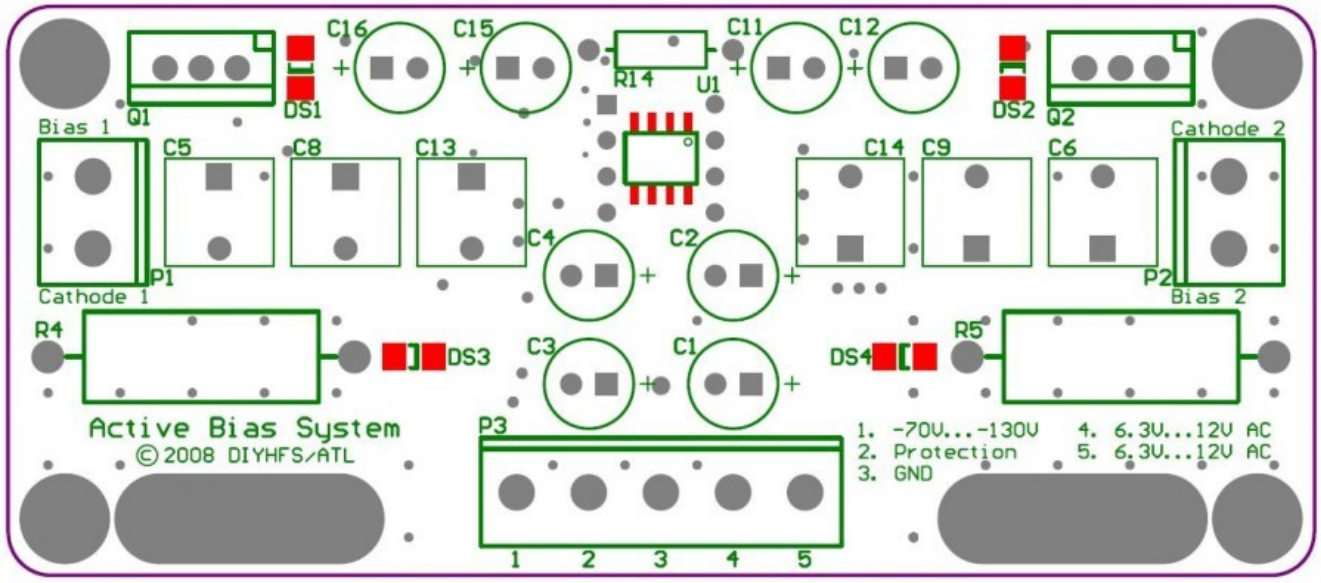
Mounting And Installation

- Designed for easy installation: one module can control two power tubes.

- The only connecting voltage is needed are the existing DC 70 -- 130 V bias voltage,a 6.3 -- 12V AC connection (taken from the filament supply of the power tube **{note: must not be a center tapped winding unless the winding is disconnected and if one side of AC winding is grounded then THAT side must connect to pin 4 of the ABS module}** current draw 60ma/100ma—6.3v/12.6v)), and then a single connection to the grid and cathode of each tube to be controlled.

- Designed to fit right into the current Ella chassis with no special mounting hardware or fixtures needed.

Circuit and wiring connections as follows:



Discussion:

Requirements:

To use the ABS Module, the amplifier must have the following:

1. At least one 6.3V….15V AC winding that has either one side grounded or is floating (not connected to ground at all – can be tested using a multimeter). If one side of the AC filament winding is grounded then **this grounded side must be connected to pin 4 of the ABS. Centertapped windings will not work unless the center tap is disconnected.**

2. A Bias supply voltage that is sufficient to bias any tube you may wish to use (eg. many EL34 Amplifiers have insufficient bias voltage under load to reliably bias all KT88 and 6550 Valves (you need at least 70V to reliably bias these with 430V HT).

3. A "current sampling resistor" in the cathode of each individually biased tube of 10 Ohm (or 1 Ohm in case of high current applications). If multiple tubes are paralleled one ABS PCB is needed per each pair of individually adjusted valves.

Example 1:

The ATM-3 Amp from Air Tight has six tubes per monoblock, all individually biased, so three ABS PCB's are needed per monoblock and each tube gets it's own 10R resistor. The each ABS PCB should handle one pair of Push-Pull Tubes (that is the "left & right" or "upper & lower" pair in the schematic). All ABS PCB's can share the same AC supply windings and bias voltage, as long as the same terminals are wired in parallel.

Example 2:

The Convergent Audio Technologies (CAT) Stereo Amplifier uses a complex bias system that combines all four paralleled KT88 in total. As a result despite having 16 Output Tubes only two ABS PCB's can/need to be used. Each "side" of the push-pull block runs at around 150mA (nominal) total bias, but has a common compound cathode resistor of 1 Ohm, with a further 1 Ohm cathode resistor common to both halves.

This means at nominal current each blocks common cathode will be at around 450mV. So on each ABS PCB the reference resistor R14 needs to be set to the value for 45mA with a 10 R "current sampling resistor", despite the complex cathode metering scheme.

In cases like the CAT Amplifier it is best to actually measure in place, with an optimally biased amplifier, the voltages that will be used to monitor the current in the tubes and to select the reference resistor R14 from the table (see below) based on reference voltage.

reference resistor R14/Voltage:

The ABS PCB contains a resistor intended for replacement by the customer to set the desired current through the valves. We fit as standard a "reference" Resistor (this is the small leaded resistor R14 in the front of the PCB as shown in above diagram) a 3k3 resistor.

This resistor produces a settled current of 38mA with a 10 ohm resistor between cathode and ground ("current sampling resistor").

Below is a table listing the resistor R14 values for a given current and reference voltage value using the nearest E48 and E24 series resistor.

Instead of the resistor R14 a suitable value potentiometer can also be wired in, if the value is too high a suitable resistor may be wired in parallel to limit the amount of current adjustable.

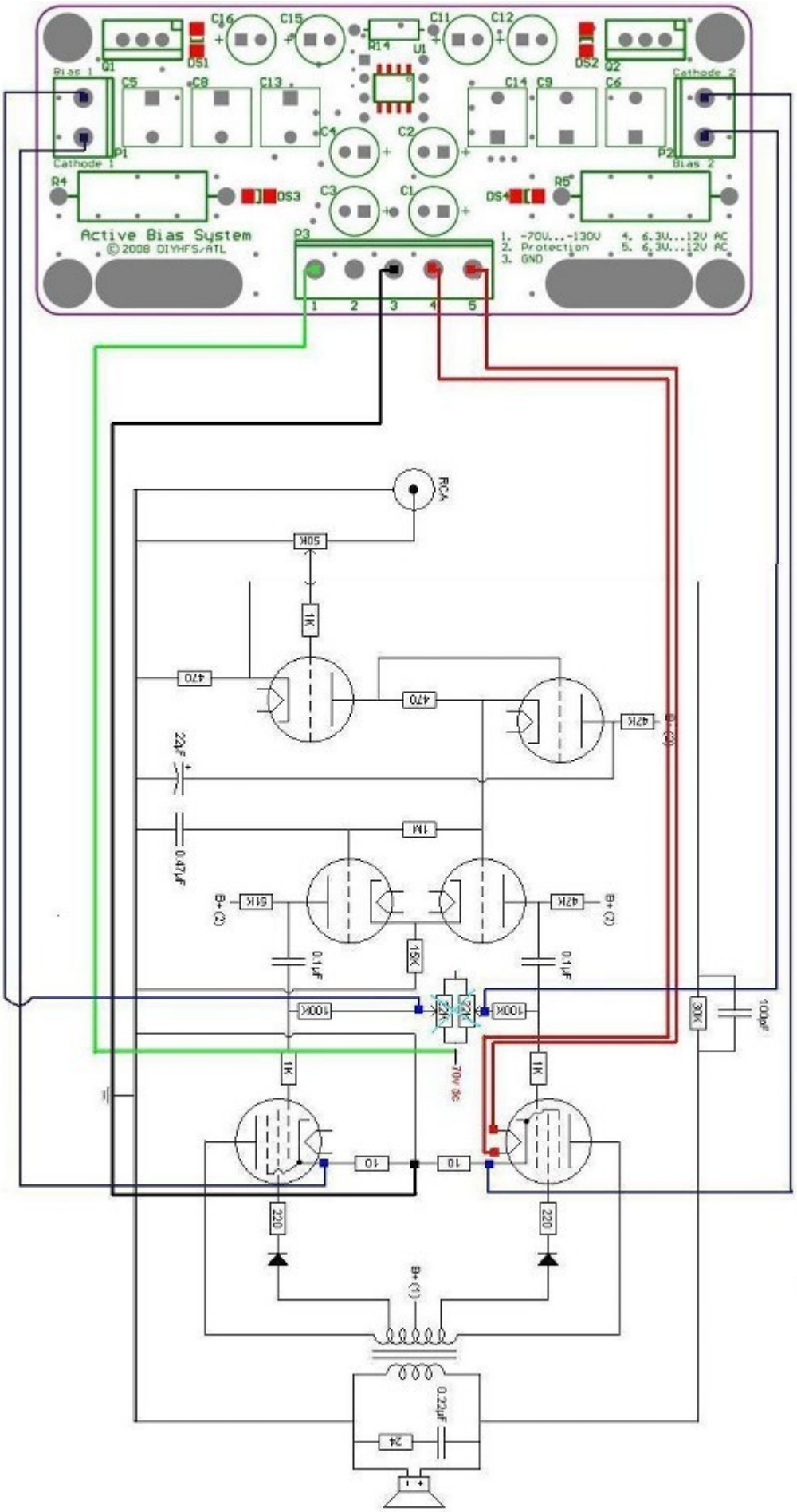
Example:

Maximum desired current: 60mA

Theoretical reference resistor R14: 5K62

Potentiometer: 10K

Place a 13K resistor in parallel with the Potentiometer, giving a maximum combined resistance of 5K65 so at maximum turned up current only 60mA will be allowed.


Active Bias System
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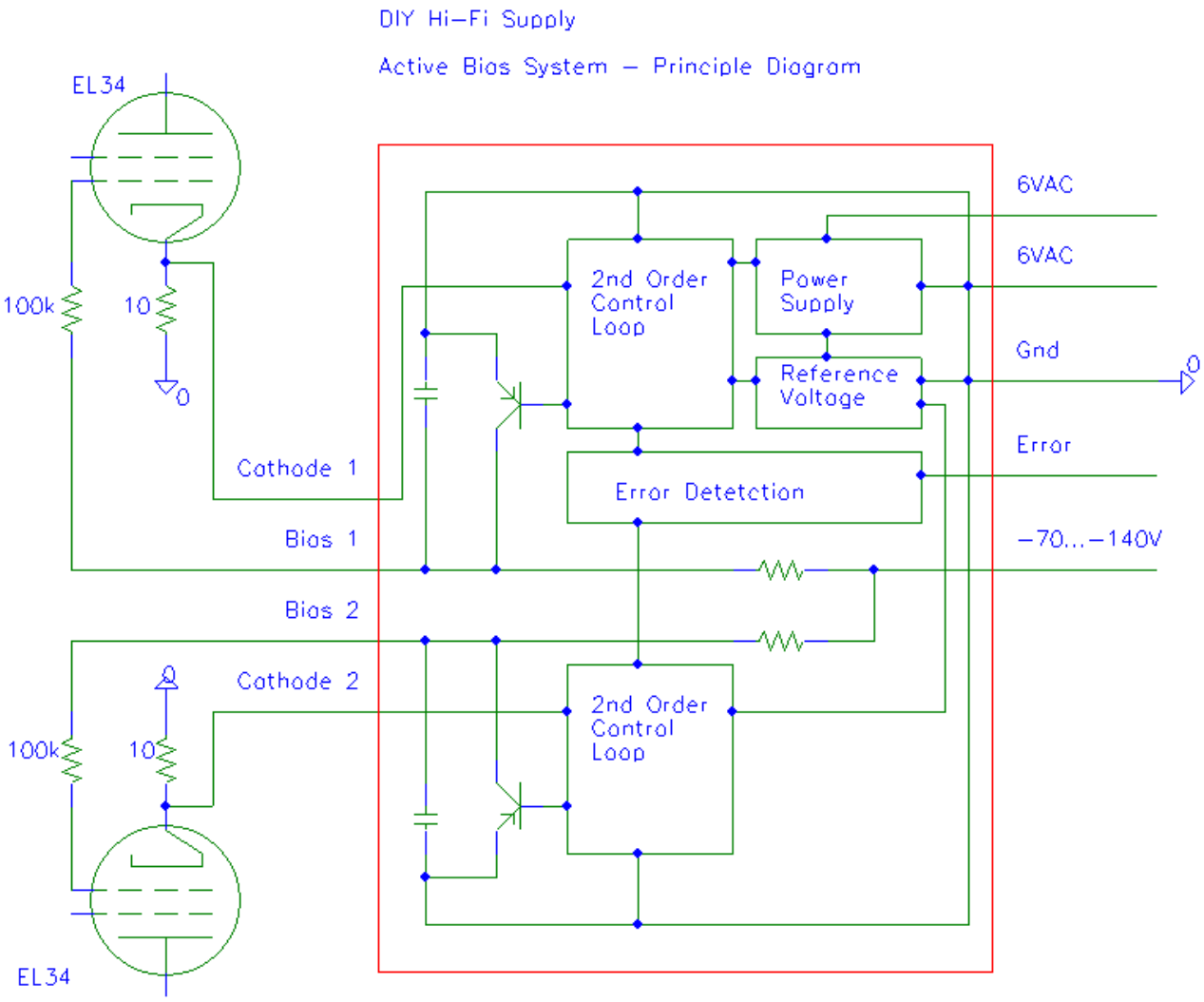
Bias 1
Cathode 1
Cathode 2
Bias 2
1. -70V...-130V
2. Protection
3. GND
4. 6.3V...12V AC
5. 6.3V...12V AC
RCA
50K
1K
470
470
470
42K
22uF
1M
0.47uF
51K
42K
B+ (2)
0.1uF
15K
0.1uF
100K
22K
22K
100K
30K
100pF
1K
1K
10
10
220
220
B+ (1)
0.22uF
24



ABS Supply Principle

- The reference voltage is developed across an exchangeable resistor which can also be an external adjustable resistor
- The control loop adjusts the bias such that current through the sampling resistor (10R) produces the same voltage as the reference voltage, but it does so extremely slowly, to reject the dynamic variations introduced by the music.
- During startup the Active Bias System is set to apply the maximum bias and is locked into this stage for around 15 Seconds. During this time the "Error" Leds are lit up (they may briefly flicker on/off as the control loops stabilises).
- The the Active Bias System starts ramping up the Bias voltage slowly, reaching full bias within around 45 Seconds.
- If any one Valve connected to the Active Bias System cannot be biased to achive nominal current, but continues to have increased current, the "Error" LED will re-light and the "Error" output will be pulled low (open collector) to allow external protection circuitry to protect the Amplifier from the defective tube.

Iref	Vref	Rref R14 E48	Rref R14 E24
mA	V	Ohm	Ohm
10	0.10	750	750
15	0.15	1100	1100
20	0.20	1540	1500
25	0.25	1960	2000
30	0.30	2370	2400
35	0.35	2870	2700
40	0.40	3320	3300
45	0.45	3830	3900
50	0.50	4420	4300
55	0.55	4870	4700
60	0.60	5620	5600
65	0.65	6190	6200
70	0.70	6800	6800
75	0.75	7500	7500
80	0.80	8250	8200
85	0.85	9090	9100
90	0.90	10000	10000

Iref	Vref	Rref R14 E48	Rref R14 E24
mA	V	Ohm	Ohm
95	0.95	11000	11000
100	1.00	11500	12000
105	1.05	12700	13000
110	1.10	14000	------
115	1.15	15000	15000
120	1.20	16200	16000
125	1.25	17800	18000
130	1.30	18700	------
135	1.35	20500	20000
140	1.40	22600	22000
145	1.45	23700	24000
150	1.50	26100	------
155	1.55	28700	27000
160	1.60	30100	30000
165	1.65	34800	33000
170	1.70	36500	36000
175	1.75	40200	39000

Iref	Vref	Rref R14 E48	Rref R14 E24
mA	V	Ohm	Ohm
180	1.80	44200	43000
185	1.85	51100	51000
190	1.90	56200	56000
195	1.95	61900	62000
200	2.00	71500	68000
205	2.05	78700	75000
210	2.10	90900	91000
215	2.15	110000	110000
220	2.20	127000	130000
225	2.25	162000	160000
230	2.30	205000	200000
235	2.35	274000	270000
240	2.40	422000	430000
245	2.45	866000	820000
250	2.50	open	open