INTEGRATED 5050 UL CLASS AB1 STEREO AMPLIFIER.

Updated 2012.
This page includes :-
Picture of 5050 stereo amp, general description and specification.
Schematics for 1 amp channel, power supply and protection. Full explanations.

Integrated 5050

This is an integrated amp which was custom built in 2000 for a client in Victoria. While I built the amp, my customer's father who lives near me here in Canberra made some very solid speaker enclosures using NSW north coast blue gum planks using the 'Sublime' design seen in my speaker pages. When the amp was finished I installed the drivers into the enclosures and carefully leveled the response with a week long testing process.

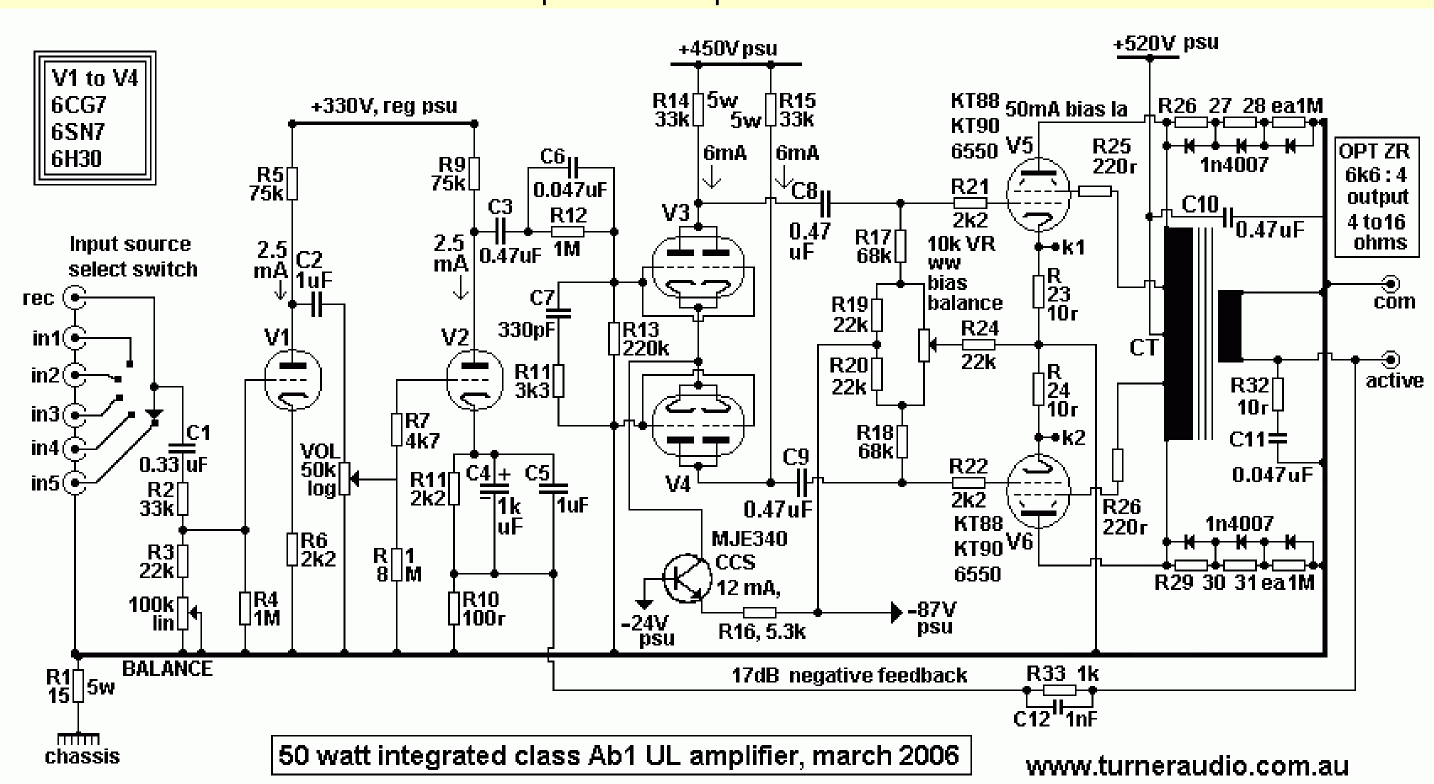
The amplifier has quite special output 5Kg transformers using excellent C cores which were available from a South Australian factory, AEM, at that time.

The circuit configuration has 5 selectable inputs, a line level pre-amplifier, and two Ultralinear output stages with famous NOS 6CG7 made in Australia and Russian Sovtek KT88.
There is a power output of 53 watts per channel class AB1 into 4 ohms, or 36 watts per channel class A1 into 8 ohms.
Finish is brass and aluminium chassis, painted aluminium box over the transformers.
Not shown is the perforated steel cover screw fixed over the tubes.

Specifications.
Size is 470 mm wide, 350 mm deep, and 220 mm high.
Weight is about 30 Kgs, and the performance is quite blameless using Sovtek KT88, but could use many other octal tubes such as Electro Harmonix EH6550/KT88/KT90, or 6L6GC or KT66 with slightly reduced bias.

Bandwidth at 40 watts into 6 ohms, 14 Hz to 68 kHz.
Distortion at 40 watts, less than 0.2%,
Distortion at 3 watts, less than 0.05%,
Output impedance less than 0.3 Ohms.
17 Db of global NFB.
Stability is unconditional, and the amp can be used with any type of speaker load.
Fixed bias is used with full active protection and bias balance led indicators are mounted for easy viewing on the front panel. When both are extinguished, bias current balance in each channel is set correctly.
No external preamp is required, unless a separate phono preamp is desired.

Schematic of 50 watt UL AB1 power amp....



This 2006 version has driver LTP stages V4,V5, so that each half of the LTP is a complete paralleled 6CG7 twin triode. The bias resistors R17, R18 have been reduced from 220k to 68k to give better dc stability since less Vdc is generated across the 68k as tube age.
The use of the extra twin triode to each channel improves the dynamics of the sound and reduces distortion.

The circuit works as follows :-
The input signal is selected by the rotary wafer input switch and is attenuated by about 4 dB by the C1, R2, R3, and balance control network.
V1 is 1/2 a 6CG7 working as a very simple SET preamp stage which amplifies the signal about 10 times, +20dB, and the anode output powers the 50k log Alps Black volume control pot. Preamps are rarely as simple as this but it works and sounds very well.
Because no long cables are used between the preamp and power amp the bandwidth remains wide.

V2 is the first triode of the power amp and is a SET stage acting as a differential amplifier to accept the signal input at its grid and the feedback signal at its cathode, so the difference between the feedback signal and input signal make up the drive voltage between grid and cathode. The anode output voltage of V2 is fed to the network formed by C3, C6, R12, and R13.
This network reduces gain and phase shift at below 20Hz to allow excellent LF stability when FB is used. C7 and R11 also act at high frequencies above 10kHz to reduce gain and phase shift so that stability is excellent when NFB is applied. The "gain shelving" networks in this group of components are known as critical damping components and are chosen to suit the characteristics of the output transformer with regard to its shunt capacitances, leakage inductance and primary inductance.
Also involved in the effort to make the amp unconditionally stable with NFB applied is the zobel network R32 and C11 across the output, and the phase advance capacitor C12, tied across the feedback resistance, R33.

Warning! Anyone else trying to build this circuit with different quality output transformers to mine will need to choose their own values of critical damping components very carefully lest their amp may oscillate.

The reason for critical damping is to reduce the amount of NFB applied at frequencies where it is not needed to be applied, ie, below 20Hz and above 20 kHz, because with heavy NFB applied outside the audio band there is a great tendency for oscillations due to the phase reversal character of the amplifier without NFB.

The output from V2 is applied through the network to the one active grid input of the differential amplifier, V3&V4. These are two 6CG7 with each triode wired in parallel, and V4 grid is grounded. This differential amp is also called a "long tailed pair", or LTP. V3 and V4 have exactly equal loads at their anodes and have a transistor constant current sink to pass the tube current from the common cathodes to the -87V bias supply. The ac impedance at the collector of the MJE340 is many megohms, so the transistor has no active signal controlling effect, and no sonic signature. I could have used a pentode tube for this CCS but there is no need since the tube would have no other function than providing a high ac impedance at the common cathodes.

The grid of both V3 and V4 are held at 0V potential via R13 at V3, and because V4 grid is taken directly to 0V. Incoming signals to V3 cause Ia current change which is mirrored in V4, because the sum of the positive and negative moving ac currents must always remain constant and equal to the constant current flow into the collector of the MJE340.

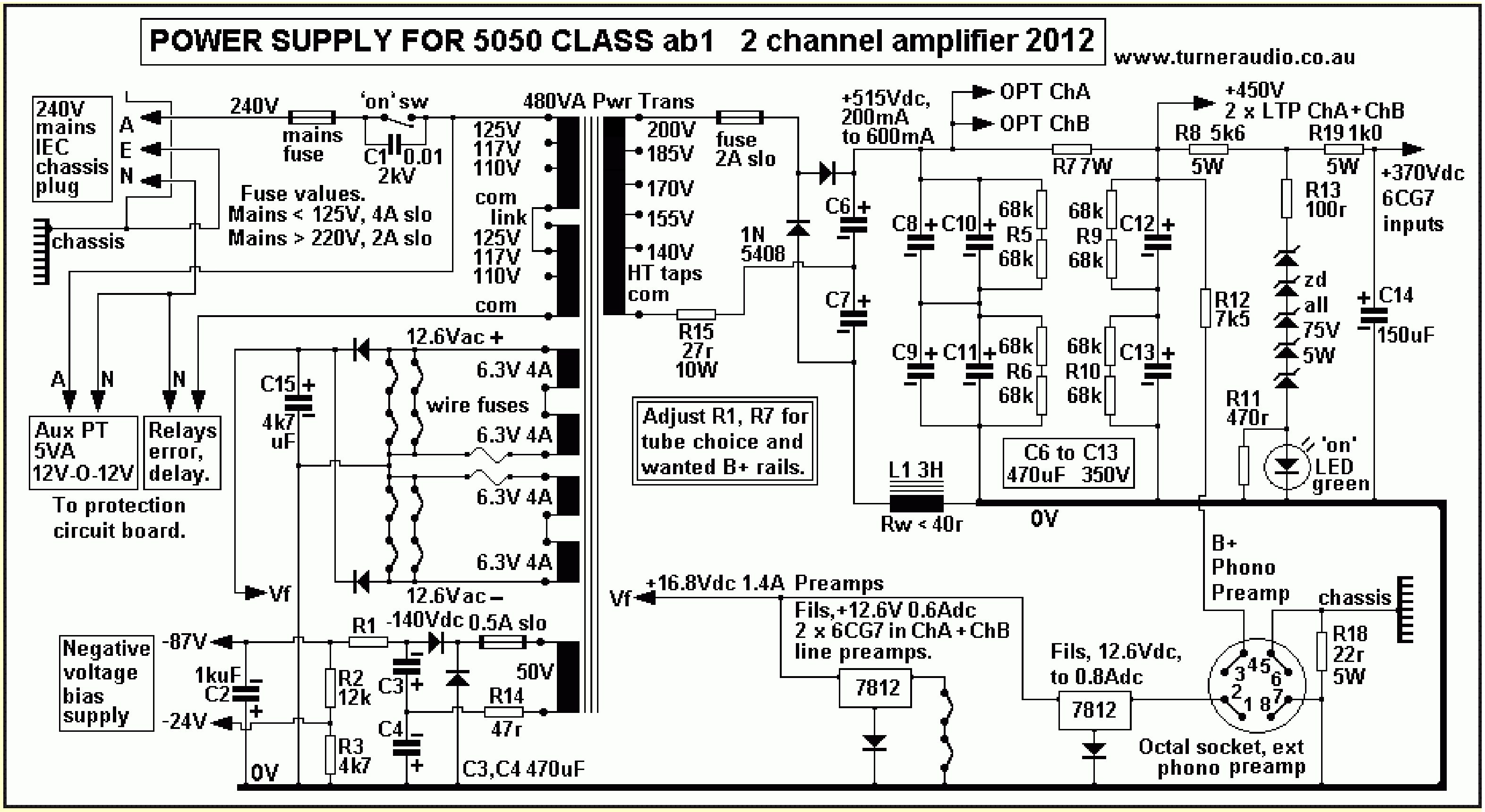
Because signal currents in V3, V4 are automatically made equal in the LTP, although of opposite phase, it follows that if the RLa load of V3, V4 have identical ohm values, then the voltage outputs at V3 and V4 anodes will have exactly the same amplitude but with opposite phase, ie, they are 180 degrees different, ie, while one anode travels +50V, the other travels -50V. There is no need to used matched tubes for the two triodes for this type of LTP, and nothing to adjust to get the ac signal output voltages to balance. Balance depends solely on the equality of the resistance loads on each 1/2 of the LTP, and modern metal film resistors allow balance to be better than 0.5%.

The LTP output voltages are applied to the V5, V6 output tube grids. These are biased through R17, R18 , 68k, which are fed a negative voltage from the adjustable network R19, R20, R22 plus a balancing potentiometer to adjust the balance of dc current in each output tube.

The biasing system has a fixed grid voltage bias supply which is adjustable only by balancing the applied grid bias so that if the 10k pot is turned, V5 grid will rise in dc voltage while dc voltage in V6 grid will fall, and the effect on the idle anode currents of each tube is monitored by the two LEDs at the front of the amplifier which normally stay extinguished. If one LED starts glowing, it means more current is in that tube than the other, so the balance can be correctly adjusted when both LEDs remain extinguished.
Anode idle dc current in each output tube are within 3mA of each other when both LEDs are extinguished. No special tools, voltmeters or technical expertise is need for adjusting the bias of this amp. The LEDs will also indicate a fault with an output tube. If an owner cannot balance the bias because there appears to not be enough turn available on either of the adjust pots to extinguish the pair of LEDs for each channel then there is a problem with bias.
Thus an owner knows if he has a tube problem or other problem well before any serious damage occurs. But he must know he cannot ignore a red glowing LED.

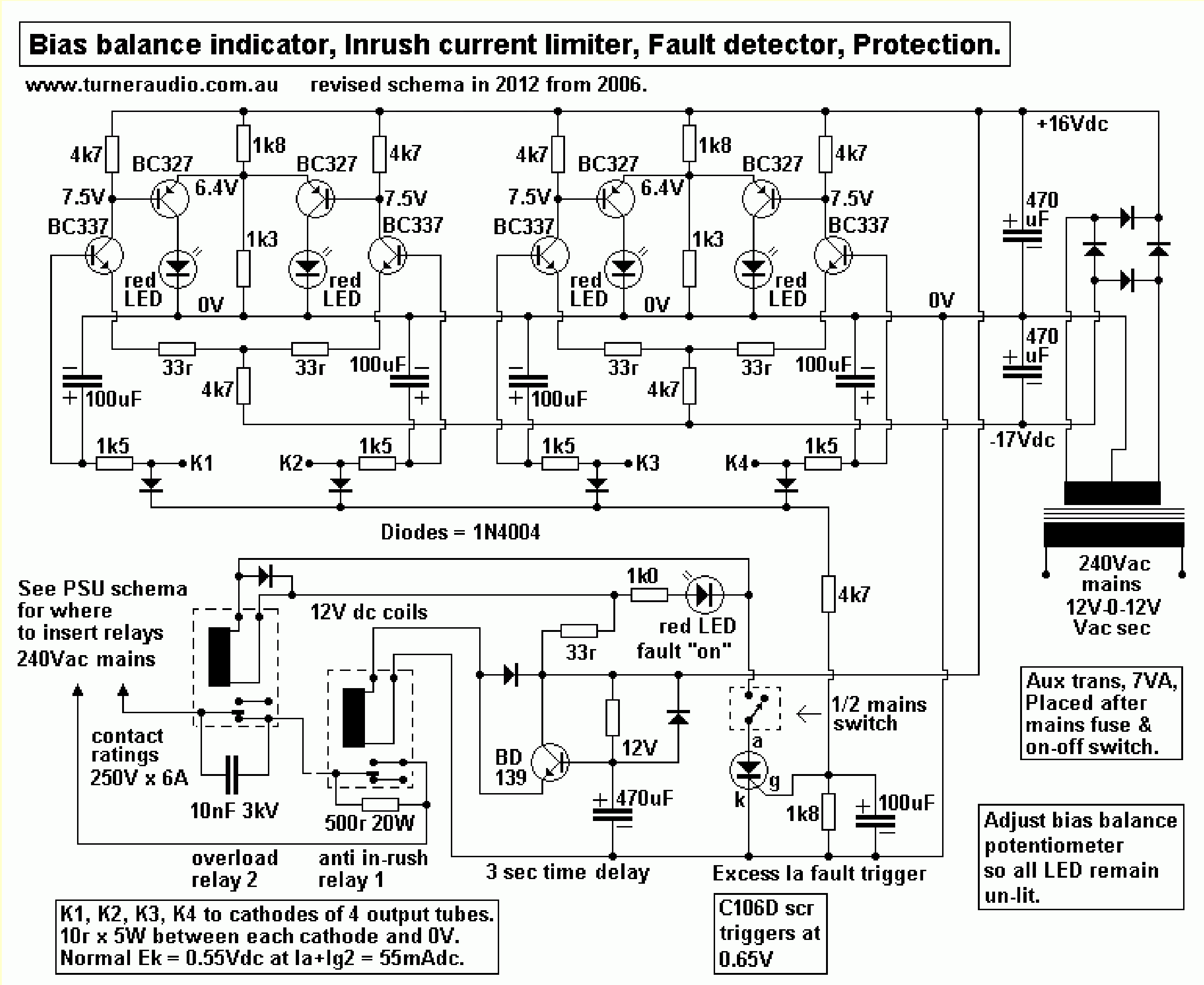
The output stage is a traditional "Ultralinear" stage with 50% screen taps. This set up has been used for over about 60 years to linearize the operation of the output tubes and lower their effective anode resistance to about 1/4 of the beam tetrode Ra. It is difficult to improve on the smooth, silky, detailed, but dynamic sound of a well engineered UL output stage. The amp is fully actively protected against excessive cathode current in one or more of the output tubes.

The power supply for 5050.



Silicon rectifiers are used to give the best efficiency, and regulation and trouble free operation.
C-L-C filtering of the +500v anode supply is used to keep noise to extremely low levels.
12V regulators 7812 are used with an 1N4004 in the adjust leg to get close to 12.6V for
dc heater supplies. The power supply uses a large conservatively rated power transformer
with a low temperature rise, and excellent self regulation.

The active protection schematic and bias balance indicator amps :-



I hope everyone appreciates the above now tidied schematic updated April 2012 to show an effective bias balance indicator, 3 second delayed turn on, and active protection in case of excessive Ik in one or more output tubes. This schematic should be read in conjunction with 5050 amp and PSU schematics. The operation is as follows :-

The mains switch for the amp should have two poles, one for the 240Vac Mains Active line in, and the other to operate as a commutator switch in series with +16Vdc auxiliary PSU rail and SCR C106D anode.

At turn on, the mains is connected to the large mains transformer via the two relays.

Also, the protection circuit auxiliary transformer is turned with 240Vac, but its primary is connected without the relays in series.
Because of large capacitors in the PSU, mains inrush current is limited by the 500 ohms in series, seen at Relay 1 above. The 500Vdc rail will rise to approximately 350Vdc in 3 seconds. At this time the Relay 1 closes, and shunts the 500 ohms thus allowing the B+ and heater voltages to reach full values shown. This stepping up of the supply voltages halves the otherwise high initial input current at turn on so a lower useful value of mains fuse is possible.

The current in each OP tube cathode will begin to flow and will reach about 55mAdc after 20 seconds, and generate Ek = +0.55V at tops of 10 ohm current sensing Rk.

Any Vac or noise voltages at each 10 ohms is filtered away by 1k5 and 100uF. Each of four Ek voltages are applied to 4 bases of 4 x BC337 npn arranged to make 2 differential amps. The collector output of each BC337 then feeds a following direct coupled differential amp with BC327 pnp, which then operate a pair of red LEDs. The LED can only be turned on if there is a significant difference on the pair of Ek voltages from each pair of OP tubes in each channel. The circuit is arranged to turn on an LED if one tube of a pair conducts about 5mAdc more than the other. The LED are arranged so they indicate which tube has more Ik than the other, and such imbalance is noticed by an owner from across the room. He may then operate the small balance pot for each channel and rotate one way or other to alter the grid bias voltage so that BOTH LEDs remain unlit. My experience is that bias balance adjustments are rarely ever needed. The LEDs will turn on and flicker during warm up, and then again at turn off when momentary Idc imbalances occur. If there is a shorted speaker cable, the amp will have unbalanced Idc, and LEDs will flicker, warning an owner that something is wrong.

If excessive volume is used with a speaker which has low impedance less than 3 ohms, or if teenagers try to remove roof tiles and break windows with audio power, or if for any other reason one or more output tubes sustains Idc which is excessive, then the signal at the SCR gate may reach 0.65Vdc and the SCR will latch on. This will turn on relay2, and the large mains transformer will be turned off, and stay that way indefinitely until someone resets the amp by turning off the mains switch, waiting 2 seconds, then turning back on. If the problem with high Idc remains, the amp will turn itself off again, and an owner will know he needs technical help.

My protection circuits have saved owners from paying high repair bills.

People are mad if they build a wonderful 5050 amp without a board with a circuit like this to manage the behavior of the amp, which needs to learn it shouldn't upset anyone.

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