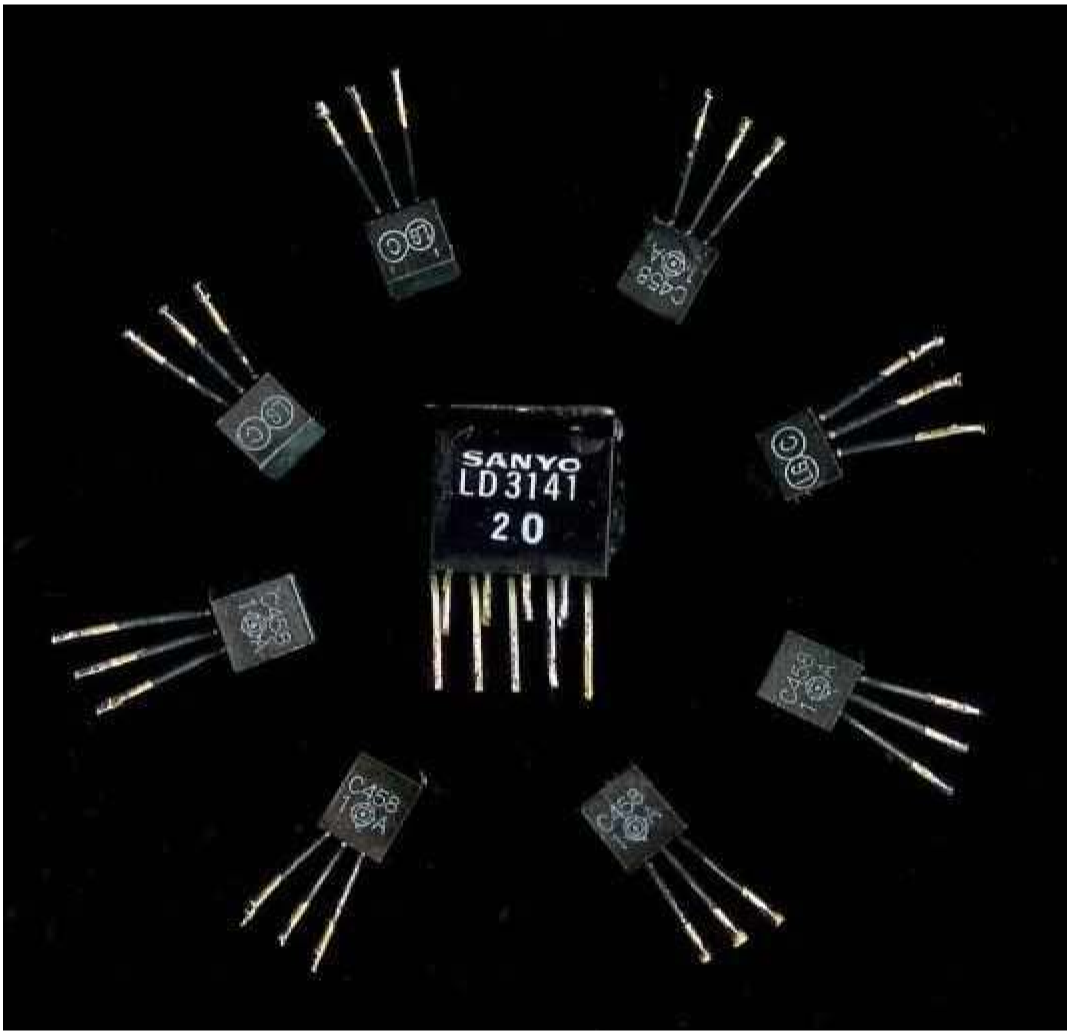
How to fix a noisy Akai 1730D-SS or possibly any model employing the obsolete Sanyo LD3141 Linear Amplifier IC



Applicability of These Instructions

The information in this document is the result of my experience with an Akai 1730D-SS 4-track, 4-channel deck. This particular deck, which was a flagship of the Quadraphonic era, utilizes removable/replaceable Playback and Record amplifier boards (four of them). It is my understanding that these boards are similar, if not identical, to those employed in some other Akai models of the same vintage. Therefore, much of the information in this document may also apply to those units. If you have information concerning which Akai models fall within this category, or a schematic/service manual you'd like to contribute, please contact me so that I can revise this document.

Possibly similar models: 202D-SS 4400D 4000D GX-M11 GX-220D GX-280D

The Usual Suspects

- LD3141

The Sanyo LD3141 is a preamp IC in a ZIP package. It is a very simple chip, basically comprising a two-transistor amplifier. In Akai's application it is powered by a single 24V supply. This IC requires no input bias, and it's output is biased internally. It also has a reputation for being noisy. However, as you will see elsewhere in this document, that reputation may be unfounded. There are at least two versions of the LD3141, differentiated by their sub-code, 10 or 20. I have no idea how they may differ otherwise, although I believe the 10 contains three transistors (in the 1730D-SS 20's are used on the P.B. Amp boards, 10's on the Rec.).

- C458

  The (CS)C458 is an NPN silicon transistor suitable for audio frequency signal amplification. Vintage versions of these transistors have a reputation for going noisy that I can personally vouch for. The the noise is produced at the base of the transistor and is temperature sensitive. In Akai's design, noise produced at the base of the first C458 in the two-transistor power amp stage is injected back into the negative feedback loop of the LD3141 through the latter's output. This results in a somewhat non-intuitive behavior as the noise level grows when the LD3141's gain is increased, which would normally imply that the noise source was at the LD3141's input, or, after eliminating that possibility, within the LD3141 itself. The implication is misleading: the LD3141 is only amplifying the noise produced by the faulty transistor at its output.

Replacing the C458's

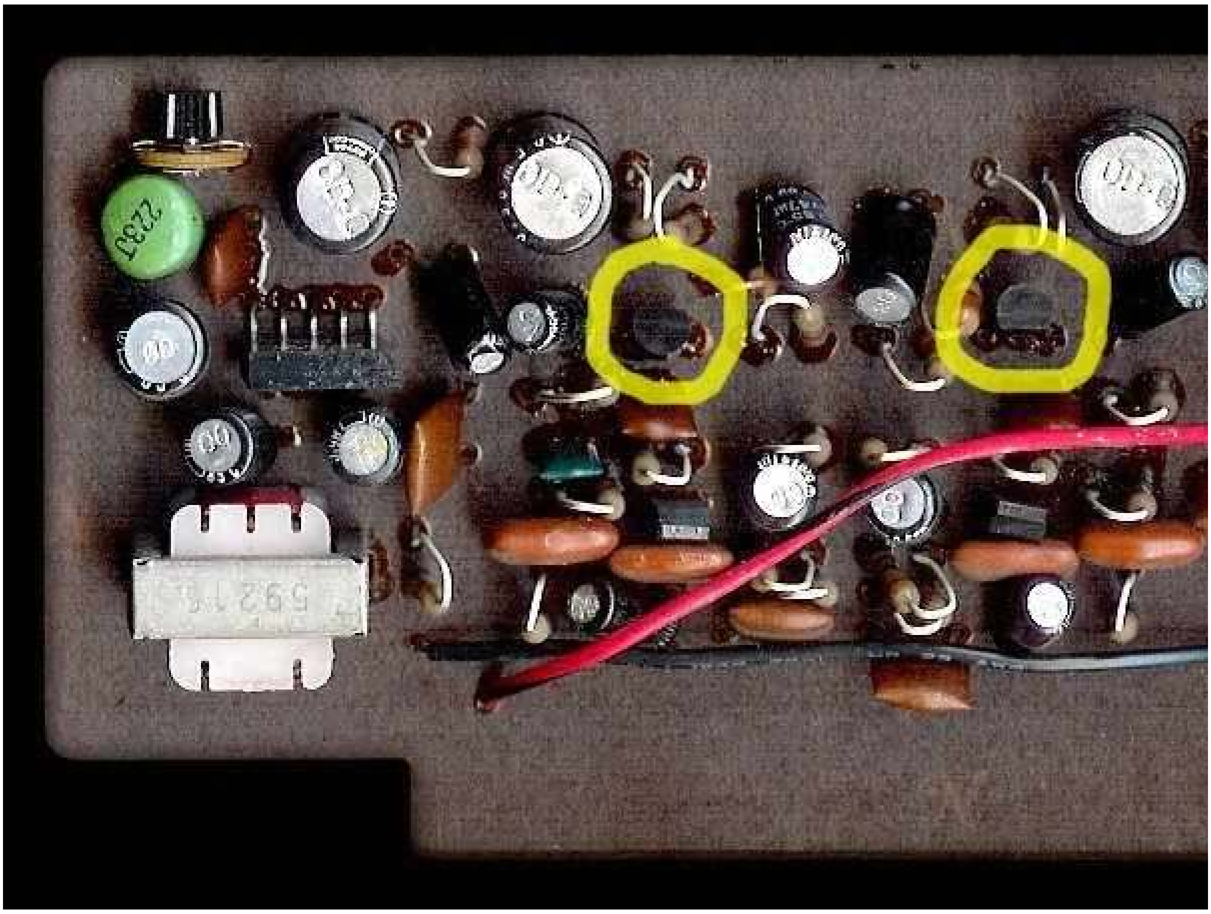
In the case of my unit, the noise was the fault of these transistors. Of course, thanks to the law of probabilities, I only discovered this after having bothered to devise a way to substitute an Op-Amp for the LD3141. If you are reading this because your Akai unit makes a rumbling noise in one or more channels which increases in volume as the unit heats up, resembles the sound of someone blowing on a microphone, and tracks in intensity as you adjust the gain pot on the playback board, then you can save yourself a lot of trouble by simply replacing these troublesome components.

Only the first C458 in a given channel, whose base is connected to the output of the LD3141 (although this isn't apparent when looking at the circuit), needs to be replaced in order to eliminate this annoying noise. If you have enough parts, however, you might as well replace them all. For this purpose I employed C1815-GR's, though C945's or any similar general purpose silicon NPN transistor should work--perhaps the most obvious substitute would be C458's of more recent manufacture. In any case, replacing these is easy. Take care, however, not to install the replacements backwards; the part number is on the BACK of the old C458's, whereas it will almost certainly be printed on the front of your replacements.

There are also C458's on the Rec. Amp boards (one per channel), but these don't appear to feed back any noise. Replace them if you feel like it.

Fig. 1 illustrates the location of these transistors (actually, their replacements) on the Akai LF-5022 P.B. Amp board.

Fig. 1. Location of C458 transistors.



Substituting the LD3141 on Playback Boards

Since this part has long been obsolete, it can be difficult to obtain. There are some people selling these on the Internet at outrageous prices. But if the LD3141 is really so prone to failure as some individuals claim, why would one replace it with a NOS part when a modern component could be substituted? The LD3141 is noisy by modern standards, but this is only broad-spectrum, white noise, and is probably insignificant in the presence of tape hiss. But if you're like me, and you actually use your deck for recording or dubbing (esp. to digital), rather than simply listening to those old Sinatra tapes, then you might benefit from replacing even a perfectly good LD3141 with a low-noise Op-Amp. At least that's what I've convinced myself of in order to justify all the trouble I went to figuring out how.

The substitution of an Op-Amp for the LD3141 is complicated by several factors. First, the LD3141 has 9 pins, eight of them used, the function of most of which is at best poorly defined. Second, since the input of the LD3141 requires no bias voltage, its feedback loop is AC coupled in Akai's circuit. This is incompatible with Op-Amps, which require a bias voltage at their input and throughout their external feedback loop (in situations such as this). For these reasons, substituting an Op-Amp requires the addition and replacement of a handful of passive components, as well as the exclusion of some existing connections.

Fig. 2. Modified LF-5022 schematic.

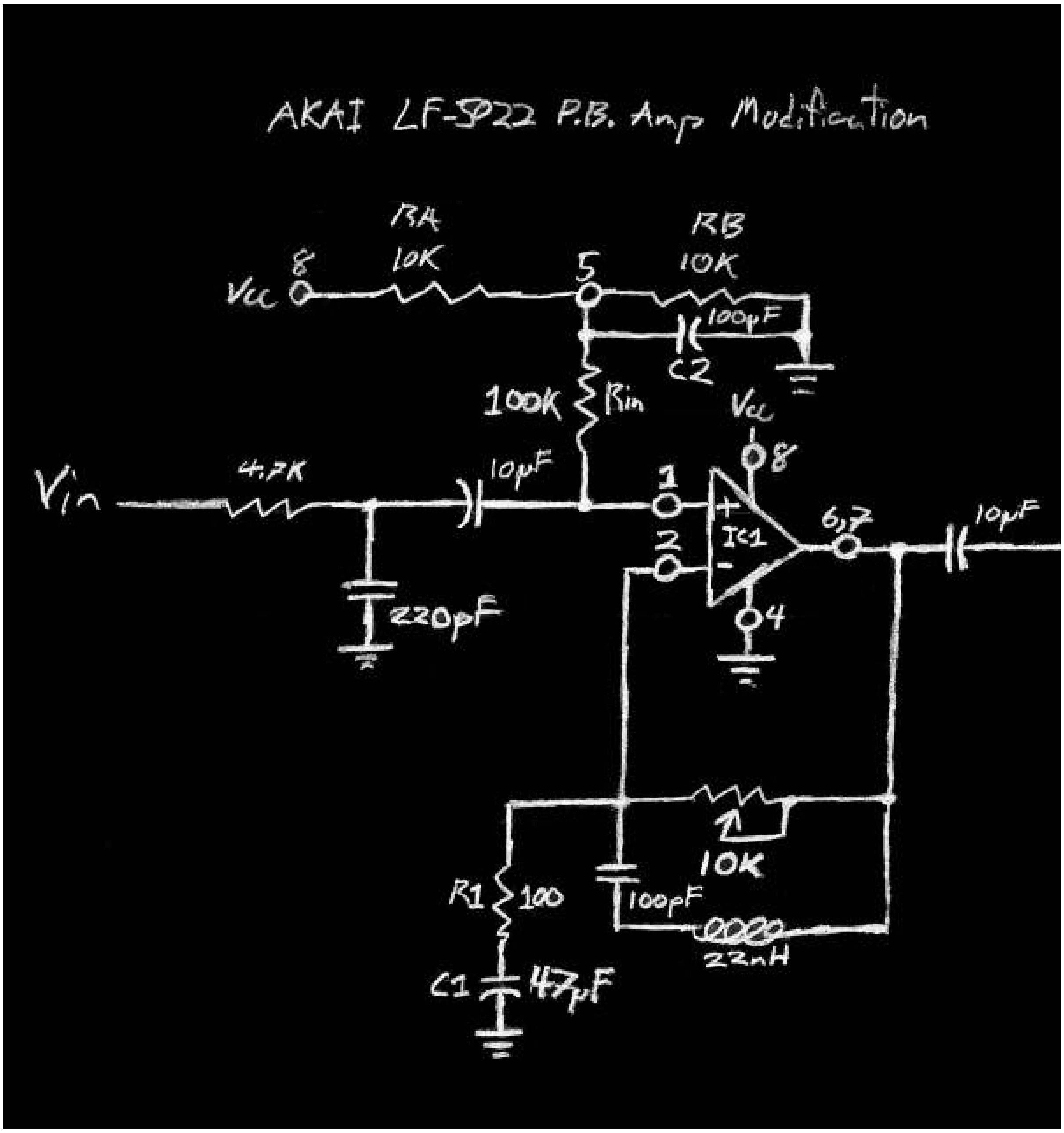


Fig. 2 is a schematic diagram of the LF-5022 P.B. Amp circuit modified to accept an Op-Amp (IC1) instead of an LD3141. The named components are additions or replacements, the unnamed shown for reference. The pin numbers refer to the LD3141 (see Fig. 3), not the pins of the Op-Amp (for information on which you should check your data-sheet). The parts list is as follows:

name	value
RA	10kΩ
RB	10kΩ
Rin	100kΩ
R1	100Ω
C1	25V 47μF

C2	16V 100µF
IC1	1/2 TL082

Fig. 3. LD3141 pinout.

Obviously, an 8-pin DIP Op-Amp won't fit in the LD3141's footprint. You'll have to install it with wires. I wired the TL082 on the top the board, with enough slack to allow it to reach the midpoint, secured it with a dab of hot-glue, and installed the other components on the solder-side of the board as shown in Figs. 4a and 4b.

Fig. 4a. Modified playback board.

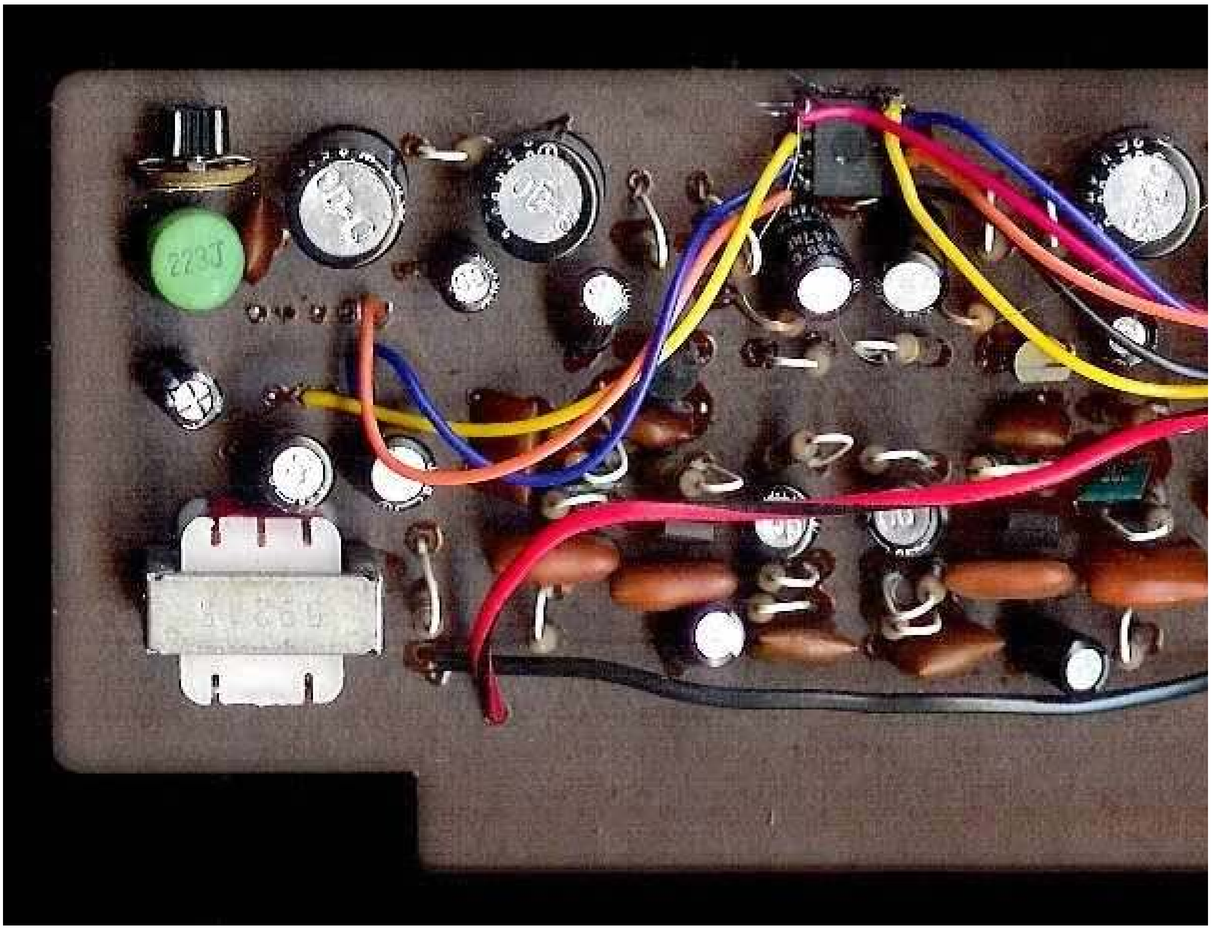
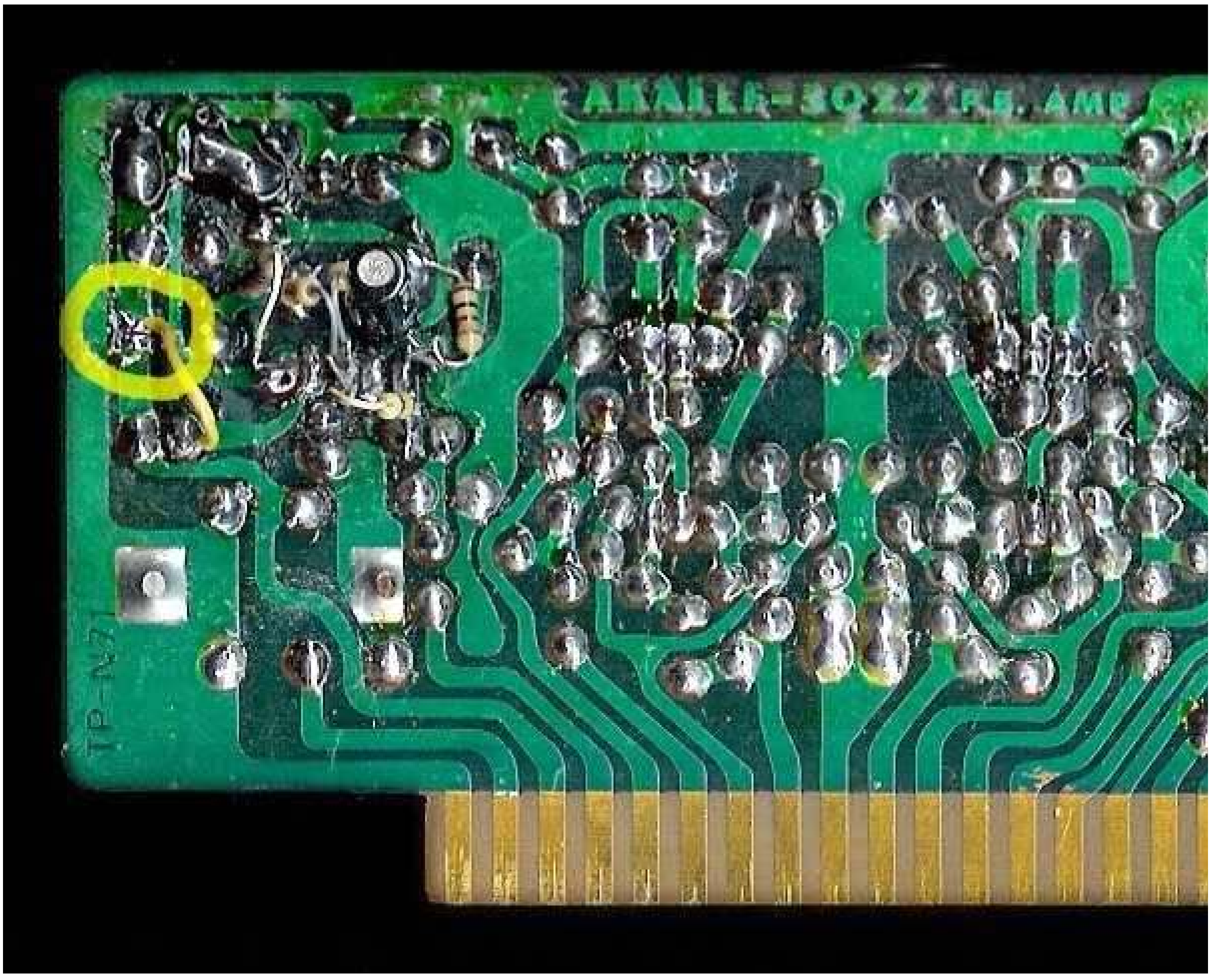


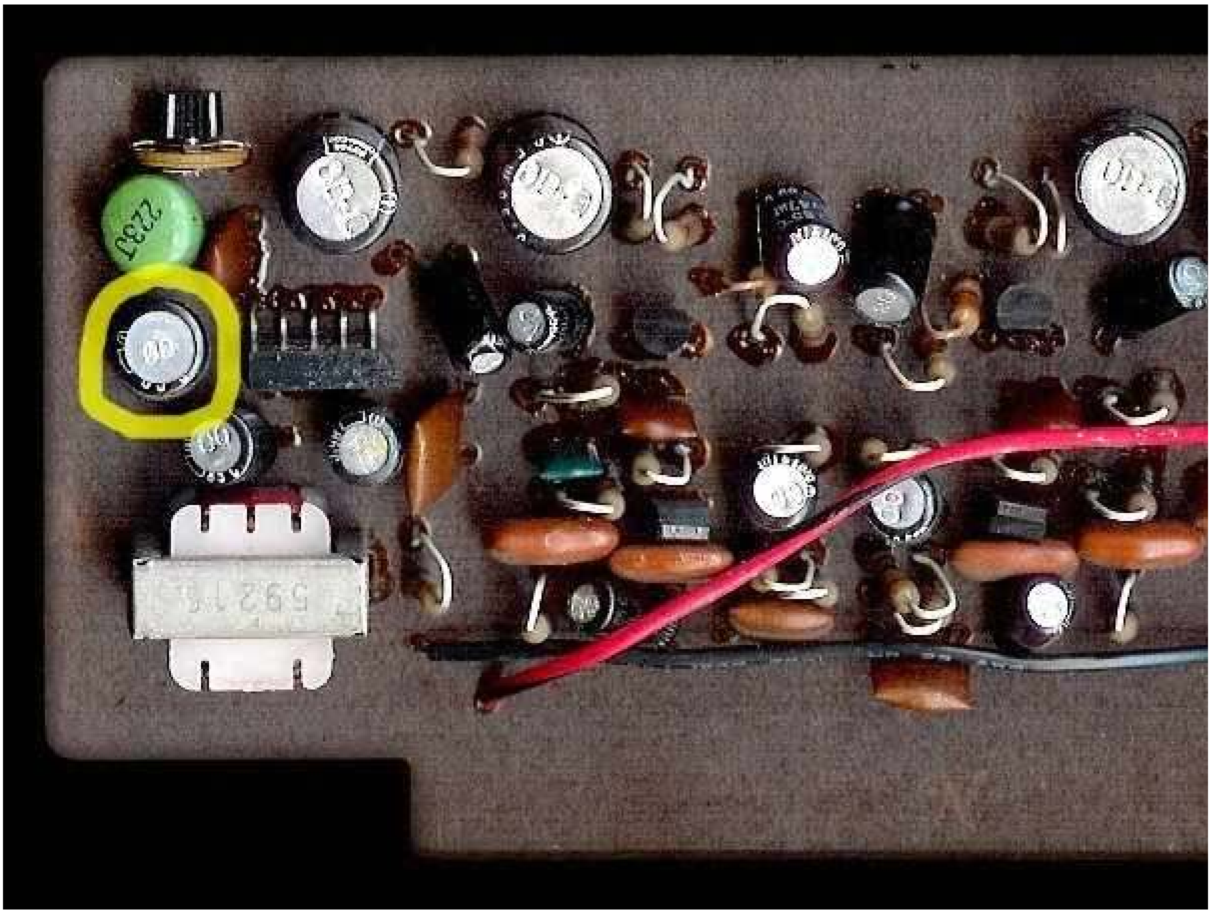
Fig. 4b. Cut and jumpered traces.



The highlighted areas in Fig. 4b point out where a trace was cut and jumpered around. This is necessary to exclude the output coupling capacitor from the Op-Amp's feedback loop and corresponds in the schematic to moving the feedback connection from one side of the 10µF output capacitor to the other. Without this measure, the gain of the Op-Amp at DC will be, for all practical purposes, infinite, resulting in the output being railed to Vcc (24V), which might destroy your Op-Amp and would in any case result in extreme distortion the AC waveform.

Capacitor C2 in the schematic is actually a replacement of the existing 6.3V 100µF electrolytic on the board. The purpose of this capacitor is to decouple the bias voltage from power supply variation and eliminate the noise introduced by resistors RA and RB. Since our input bias voltage is 12V, this capacitor must be upgraded to a 16V version. Fig. 5 shows the location of this capacitor for each channel. It is interesting to note that the capacitor for my front right channel was installed backwards at the factory, severely impairing it, but apparently without noticeably affecting that channel's operation. When you replace this capacitor, be sure to double check its orientation; the side with the minus or stripe should face the more negative voltage, in this case ground.

Fig. 5. Location of C2 bypass capacitors.



As you saw in Fig. 4b, the rest of the components, four resistors and a capacitor, are wired point-to-point on the solder-side of the board. This is actually pretty easy if you use resistors having one long and one short lead, but it is still a tight fit. Be sure you check your work for solder-bridges before you try plugging it in. The wiring should be apparent from the pin-numbers in the schematic and Fig. 3, but I shall nonetheless attempt to put it into words:

1. Remove and set aside the LD3141 and the 1kΩ resistor installed across its pins 8 and 9.
2. Run a wire from the Op-Amp's non-inverting input to hole 1
3. "" inverting input to hole 2
4. "" Vcc to hole 8
5. "" Vee to hole 4
6. "" output to hole 6 or 7, whichever has a solder-pad
7. Solder resistor RA across hole 8 and hole 5
8. Solder resistor RB across hole 4 and hole 5
9. Solder resistor Rin across hole 5 and hole 1
10. Solder the minus side of capacitor C1 to hole 4
11. Solder one lead of resistor R1 to hole 2
12. Solder together the free leads of C1 and R1
13. Reinstall the original 1kΩ resistor across hole 8 and 9
14. Remove 6.3V 100µF capacitor C2 and replace with 16V 100µF
15. Cut and jumper the trace as shown in Fig. 4b

Since an 8-pin dual Op-Amp package like the TL082 has only two power connections, you can skip steps 4 and 5 for one of the channels on each board.

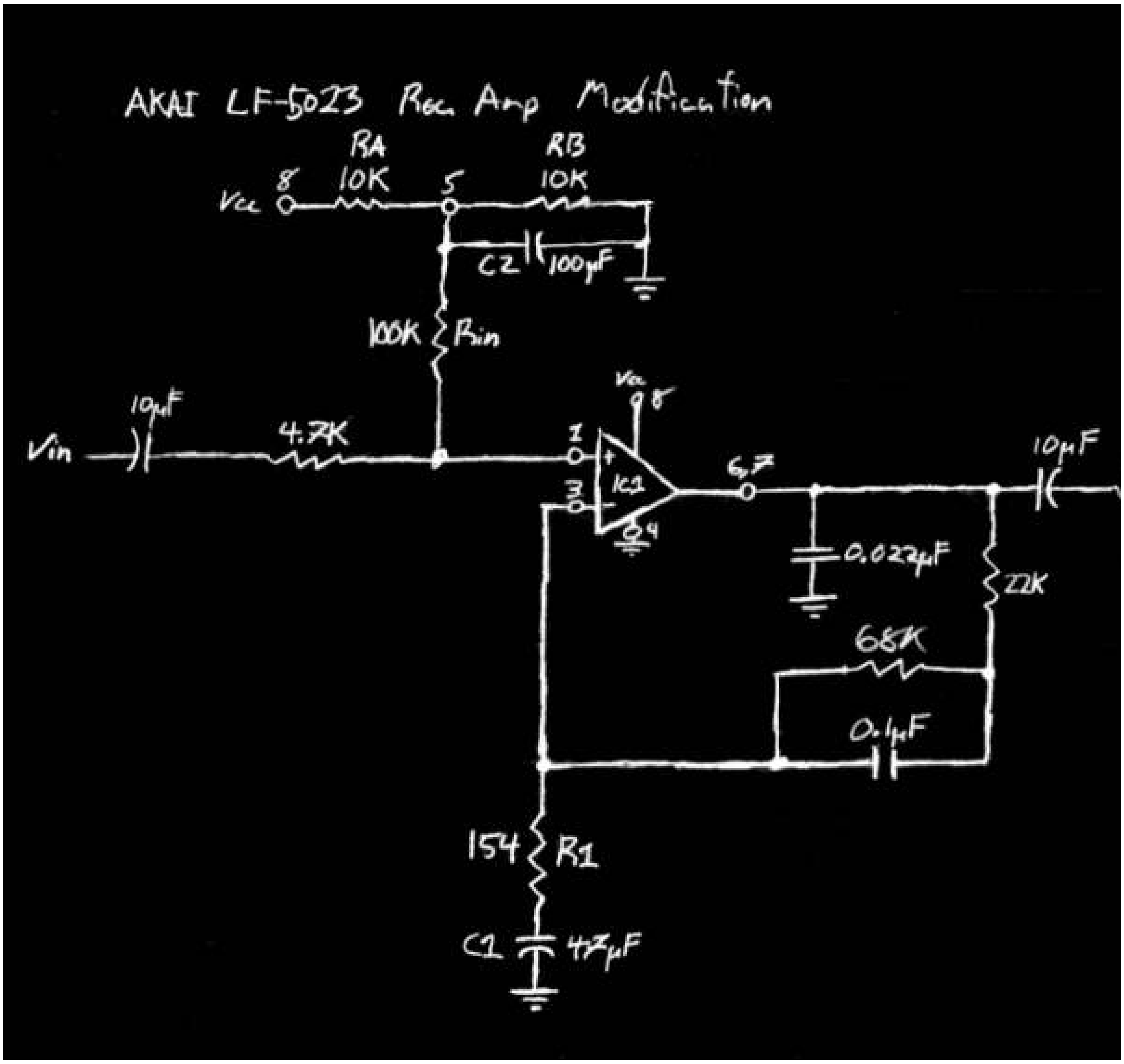
If everything is connected properly, then the board will function as normal when it is reinstalled; ie. the gain trim-pot will behave as it did with the LD3141 installed and the frequency response should be just as close to (or far from) the NAB curve as Akai designed it to be. The gain, however, will be slightly higher than it was before the substitution; I find this makes calibrating the playback levels easier. You may substitute a 150Ω resistor for R1 if you decide you don't need the extra gain.

Once you've converted all the channels you like--I did them all--you'll have to recalibrate the unit for proper playback and record levels. If you have the manual, I'm sure it will tell you the proper way to do this. I didn't have the luxury of manufacturer's instructions or an MRL tape, so I inductively coupled a 1kHz sine-wave to the reproduce head via a coil, adjusted the level of the induced signal so that the voltage at the input of the playback Op-Amps measured 125mV, then trimmed the gain pots on the playback boards until all the meters read 0 VU in TAPE mode. I then connected a 40mV 1kHz sine-wave the line-ins and trimmed the attenuator pots on the record boards until until all the meters read 0 VU in SOURCE mode. The above procedure should result in a rough approximation of the playback calibration you might get from a 250nW/m alignment tape. To calibrate the record levels you can either compromise between lowest-distortion and hottest-signal on the record bias voltage adjustment, or install the record gain pot suggested in the section on modifying the record circuitry. When attempting record level calibration be aware that you will not be able to get exactly the same record level in 4-channel mode as in 2-channel mode; this because some aspect of the switching process reduces the bias voltage and, to a lesser extent, frequency when in 2-channel mode. This effect may or may not be a peculiarity of my unit. Perhaps someone with the service manual could offer more insight.

Substituting the LD3141 on Record Boards

Unfortunately the above procedure does not apply exactly to the record circuitry; in order to substitute the LD3141 with our Op-Amp here we must modify our approach. Fig. 6 is a schematic diagram of the relevant portions of the record circuit. The previously stated rules of notation also apply to this diagram and the pin layout on the board is identical. Also, recall that the LD3141-10 used on the record boards is subtly and mysteriously different from the LD3141-20, although I believe the that versatility of an Op-Amp allows us to safely ignore those subtleties. I should state that I found nothing wrong with the record boards in my unit and undertook to upgrade them only out of a sense of completeness. It is also entirely possible that the design of the record circuit makes it immune to noise feedback from any following stage.

Fig. 6. Modified LF-5023 schematic.



Take note that the inverting input of IC1 is connected to hole 3 on the Rec. board, while we had it going to hole 2 on the P.B. board--this is due to differences in the circuits. Otherwise, the Op-Amp connections are identical and the above wiring instructions should apply.

Here is the parts list:

name	value
RA	10kΩ
RB	10kΩ
Rin	100kΩ
R1	154Ω
C1	25V 47µF
C2	16V 100µF
IC1	1/2 TL082

The record circuit, unlike the playback, is a fixed-gain configuration. The 2kΩ trim-pot attenuates the portion of the signal fed to the headphone/line-out amplifier and the VU meters, leaving the record level unaltered. This means that in Akai's design it is impossible adjust the record level and the record bias voltage independently (perhaps a common 'feature' on consumer decks). Therefore, you must either choose the value of R1 very carefully or install a variable gain-control resistor in series with the 22kΩ feedback resistor shown in the diagram--50kΩ should be a suitable value. I'm not sure how Akai calibrated the record levels at the factory, or how they intended servicemen to do so; perhaps this is all explained in the service manual.

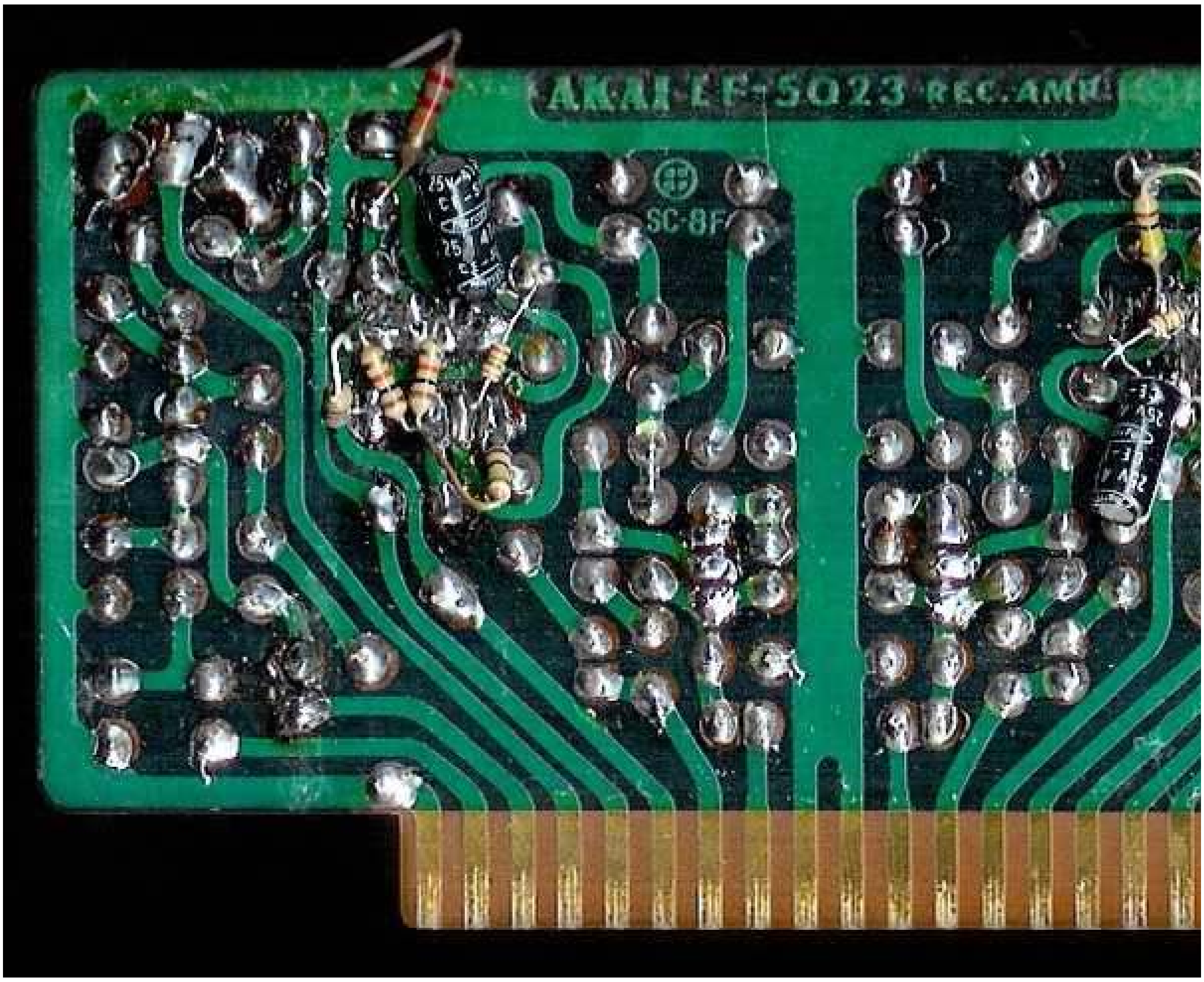
Fig. 7. Location of C2 bypass capacitors on record board.

Fig. 7 shows the locations for C2 on the Rec. Amp board. As in the playback circuit, these must be replaced with 16V 100µF electrolytic capacitors.

To remove the output capacitor from the feedback loop, instead of having to cut a trace, we can simply lift one leg of the 22kΩ resistor seen in the schematic and bend it over to the back of the board. Fig. 8a shows this part's location on the unmodified board. In Fig. 8b you can see where the free leg of this part has been connected on the solder-side of the board. For the right channel you'll have to use a jumper wire to reach your target.

Fig. 8a. Location 22kΩ feedback resistors on record board.

Fig. 8b. Solder-side of modified record board.



Alternatives to the TL082

One could probably eliminate the biasing resistors and trace cutting necessary to replace the LD3141 with a TL082 by choosing a self-biasing Op-Amp like the LM386, but the parts saved in the biasing might then be required elsewhere in order to lower the supply voltage to the 15 volts or so the LM386 can handle--and the result might not show any improvement over the LD3141 noise-wise. I encourage those willing to try.

The truth is, I chose the TL082 for this project out of convenience--as I happened to have a few of them on hand; any similar Op-Amp should work, even the lowly 741.

Conclusions

I sincerely hope someone will find this information useful. I searched high and low for something like it before deciding to dive into this project on my own. Perhaps these instructions will put to rest a few rumors surrounding the LD3141 and the Akai decks containing it. Don't let some fool tell you your deck is worthless just because it uses a now obsolete part--a normal person would consider any reel-to-reel machine obsolete and worthless in this iPod era anyway. These and other simple modifications and repairs have made my 1730D-SS a quiet, effective, and reliable--not to mention beautiful--part of my audio system.

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Fig. 9. The author's 1730D-SS.