Adcom's GFP 565 Preamp Mods, Part 3

Now it's time to add a new line stage to the mods described in Parts 1 and 2. **By Gary Galo**

In Part 2 of this series, we completed the installation of a new power supply based on Walt Jung's *Improved Regulator*. In this installment, we'll replace the line stage with a new, high-performance design. But, before beginning the line stage, there are a few other options to consider.

During Victor Campos' tenure at Adcom, they called him The Buffer Man, and with good reason. Every preamp Adcom produced under his direction had actively-buffered tape outputs to isolate the signal path from nonlinear loads. The GFP-565 preamp used a pair of dual op amps configured as unity-gain voltage followers to buffer the two pairs of tape outputs.

At that time, many of the IC op amps Adcom used were manufactured by Linear Technology, and bore the familiar LT logo. But, Adcom had its own part numbers printed on these devices to conceal their identity. Now that the preamp has been discontinued, I won't be giving away any trade secrets by identifying them. The tape output buffers—labeled Adcom 7A—were LT1057 FET-input dual op amps.

During my evaluation of the 565 preamp for *Stereophile* back in 1989, one of the LT1057 op amps in my review sample failed. The output of the device went to the negative supply rail (–18V DC), and the non-inverting input was at a potential of several volts negative. This produced a potentially dangerous thump when you moved the recording selector switch to the same position as the listening selector. Subsequently, another LT1057 failed in my other 565 preamp.

Linear Technology did failure analyses on both chips, and found that the positive supply connections had failed internally. This did not give me a great deal of confidence in the LT1057, so I replaced all of them with the Analog Devices AD712JN, one of the best dual op amps available at that time (www.analog.com).

The AD712 is still a solid performer for this application, but if you have really high-quality recording equipment, you may wish to use something even better. My first choice is the TI/Burr-Brown OPA2604AP (www.ti.com). Other high-end replacements include the TI/Burr-Brown OPA2134-PA.

Adcom used 7.5k pull-down resistors on the LT1057s, which forced the output stages into Class-A operation. Retain these resistors if you use the AD712. Op amp output stages have improved considerably since the AD712 was designed, so remove these resistors if you use any of the other devices. In particular, the OPA2604 is an all-FET device, including the output stage, so you should definitely remove the pull-down resistors for this device. The modified tape output buffer circuit is shown in *Fig. 5*.

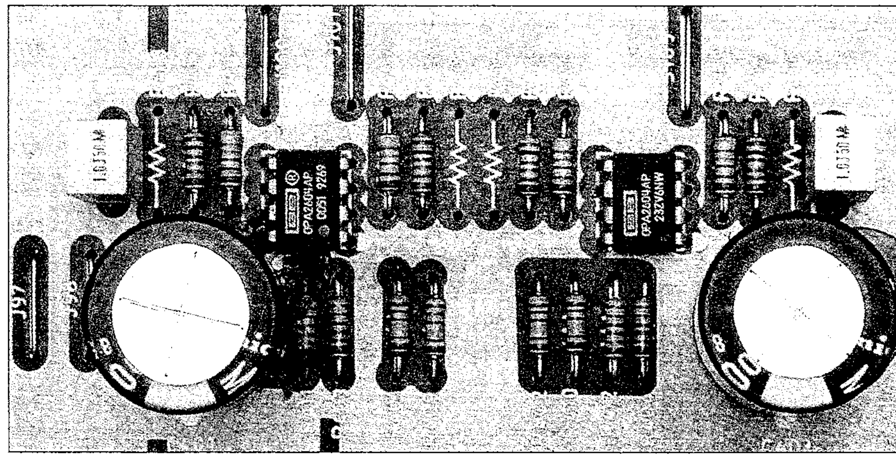


PHOTO 22: The modified tape output buffers, using OPA2604 op amps. The pull-down resistors are removed for the OPA2604.

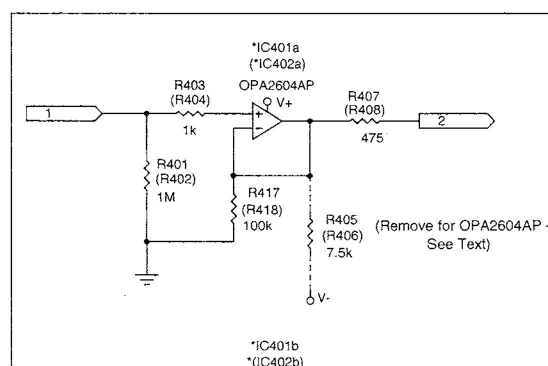


FIGURE 5: The modified tape-output buffers. OPA2604 dual op amps replace the original LT1057s, and pull-down resistors R405, R406, R413, and R414 are removed. The pull-down resistors should be retained if AD712 op amps are used.

- Remove IC401 and IC402. Replace these with OPA2406s, OPA2134s, or AD712s (*Photo 22*).
- Remove the 7.5k pull-down resistors—R405, R406, R413, and R414—if you use any of the recommended devices other than the AD712.

RESISTOR CHOICES

Before proceeding, you will need to decide what type of resistors you intend to use for the remainder of this project. Adcom used Roederstein/Resista MK2 resistors in the GFP-565, but they have steel end caps, and are now sonically outclassed by a number of other resistors. I recommend using non-ferrous resistors for all of the circuitry described later, and in Part 4 (which will cover the phono preamp).

The most cost-effective choice is the Vishay-Dale CMF Type RN60 sold by Mouser and Welborne Labs, which I discussed in Part 2. Ron Welborne says that he spot-checks the Vishay-Dale resistors to make sure that they are non-magnetic, and all that I have received from Mouser have also been non-magnetic. The Vishay-Dale RN60 resistors will drop right into the existing resistor footprints on the Adcom PC board.

Michael Percy Audio and Welborne Labs still have some old, all-copper Holco H4 resistors in stock. E-mail them to see whether they have old-stock Holcos in the values you need before purchasing. Holco H4 resistors will fit the existing Adcom footprints if stood on end, as shown in several of the photos later in this article. If you can get them, they are excellent.

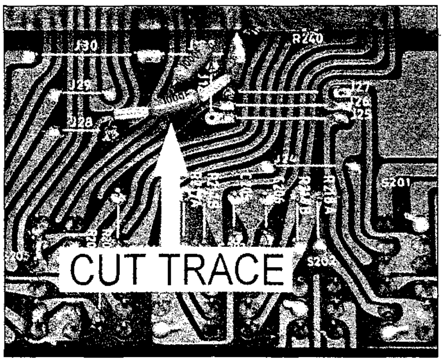


PHOTO 23: Output resistors for the optional Aux Outputs. These resistors connect the line stage outputs to PC traces previously used for the signal processor outlines.

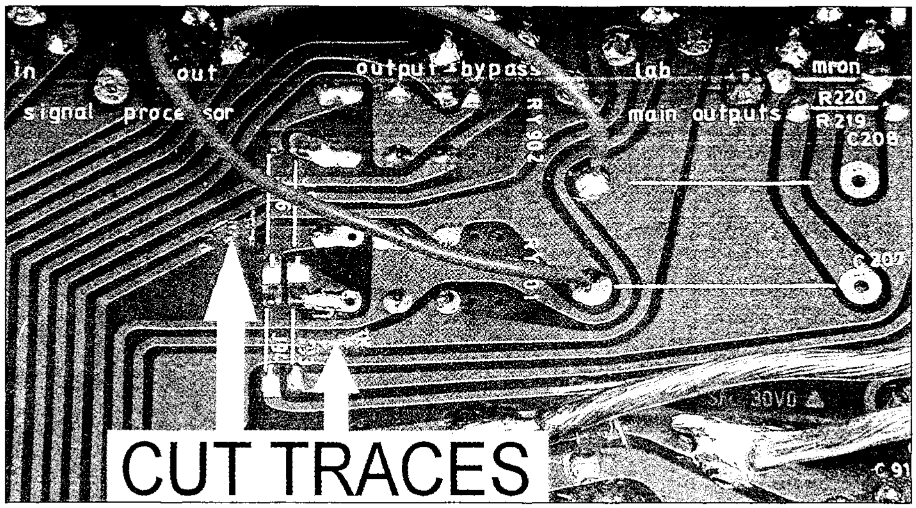


PHOTO 24: The modified output muting relay. Relay RY901, previously used to mute the Norm and Lab outputs, is now connected to the Aux Outputs with two insulated jumpers.

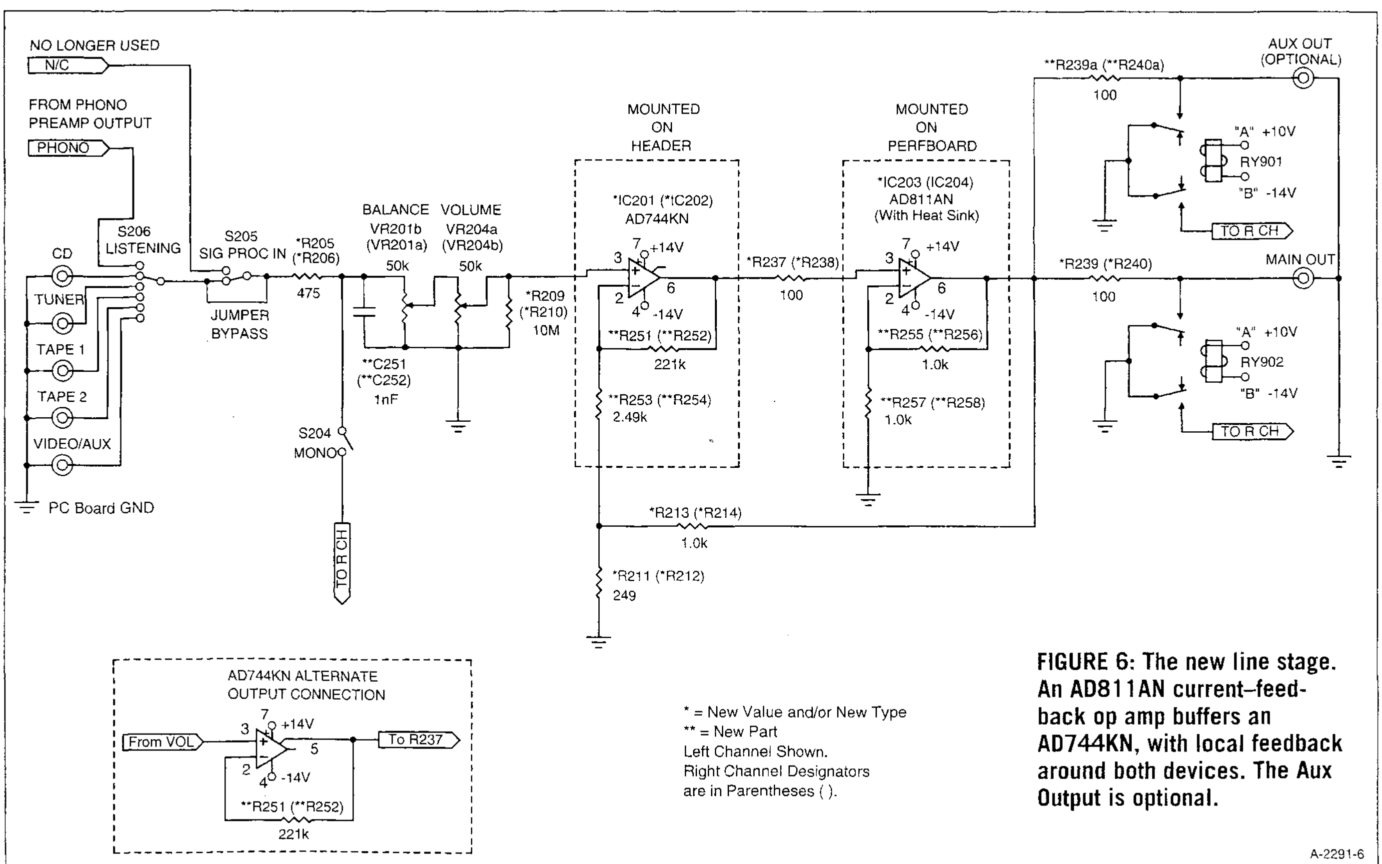


FIGURE 6: The new line stage. An AD811AN current-feedback op amp buffers an AD744KN, with local feedback around both devices. The Aux Output is optional.

I built my "Number 1" preamp with Caddock MK132 precision film resistors in all of the audio circuits. The price tag will be a deterrent for some builders, but on a high-resolution system they are well worth the expense. Michael Percy, Welborne, and Parts Connexion stock these. If cost is no object, the Vishay S-102-series bulk foils are considered by some to be the finest audio resistors available. But at over $11 a pop, this will be an expensive preamp project!

I won't refer to specific resistor types from now on (with one exception)—the final choice is yours, based on your listening requirements and budget. Michael Percy Audio stocks the Vishay resistors. To fit the Adcom resistor footprints, the leads on the Caddock and Vishay resistors should be bent out at a slight angle, and then bent straight down.

AUX OUTPUTS

In Part 1, I suggested adding a pair of Aux Output jacks for biamping. If you don't need the extra pair of outputs, you can skip this section. In the following steps, I assume that you have installed the jacks and connected them to the PC board as outlined in Part 1. Now add a second pair of output resistors and route them to the PC traces previously used for the signal processor outlines (*Fig. 6* and *Photo 23*).

- Remove jumper J28.
- Make a ¼″ cut in the PC trace between S205 and jumper J59 in the same front-to-back location as the J25 jumper. Be sure the cut area is completely clean and free of copper trace material.
- Scrape ¼″ of lacquer from the end of the cut trace leading to J59, and tin the bare copper.
- Solder a 100Ω resistor—R240a—between this tinned PC trace and the rear-most hole previously occupied by J124.
- Connect a second 100Ω resistor—R239a—between the hole left vacant by the removal of J28, and the nearest hole left vacant by the removal of J27. These are not the J27 and J28 holes that go to the switch bank—they're the other ones. Use sleeving on the resistor leads.

This completes the connection of the Aux Outputs. But, they have no muting relay. This is an easy problem to fix—simply connect the muting relay previously used for the Lab and Norm outputs (*Photo 24*).

- Make ¼″ cuts in the two PC traces that go from the left and right Lab output back to J62 and J63. Cut them between RY901 and J62/J63, as close as possible to relay RY901. Make sure to remove all copper material.
- Remove C207 and C208.
- Add jumpers made from insulated hookup wire between the processor out left and right PC pads (now the Aux Outputs) and the C207 and C208 hole closest to RY901.

The Aux Outputs will now be muted on turn-on and turn-off just like the main outputs.

VIDEO/AUX INPUTS

My system hasn't been biamped in several years, so I no longer need the Aux Outputs. I found another use for the pair of high-quality RCA connectors mounted in the old processor loop holes. I am now using a DVD player that plays regular CDs, SACDs, and DVD-Audio discs. The player must be used as a stand-alone when playing SACDs, but I use my outboard digital processor for CDs and all DVDs, including DVD-Audio discs. So, I need an additional pair of high-quality line input jacks.

I decided to replace the Adcom PC-mount Video/Aux jacks with the new jacks, connecting the new jacks to the Video/Aux traces on the Adcom PC board (*Photo 25*).

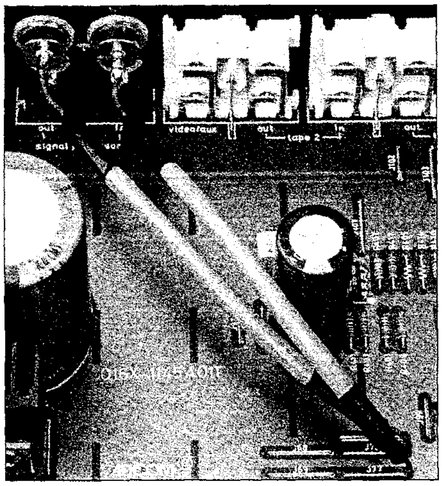


PHOTO 25: The Video/Aux inputs connected to new input jacks. This is an alternate use for the new RCA jacks if the Aux Outputs are not needed.

- Remove jumpers J76 and J77. This interrupts the signal paths between the Video/Aux jacks and the selector switches S206 and S207.
- Connect the new jacks to the selector switches using short lengths of D.H. Labs BL-1 interconnect. The shields and black center conductors are soldered to the ground washers on the new RCA jacks (the ground washers should already be connected to the PC board). On the other end, the shields and black center conductors should float—cut these leads short and use heat-shrink tubing to insulate them. Connect the red center conductors to the J76 (right) and J77 (left) holes closest to S207. You'll probably need to enlarge the holes slightly.

Note that the old PC-mount Video/Aux jacks are not removed from the PC board—they have simply been disconnected. The new jacks will allow you to connect your DVD player's output to the high-quality Video/Aux inputs, and your digital processor's output to the CD inputs, or vice versa.

THE LINE STAGE

Adcom's original line stage consisted of a Linear Technology LT1056 op amp (Adcom 6A) buffered by an LT1010 (Adcom 1A) placed inside the feedback loop. The LT1056 is an FET-input device with low enough DC offset to allow direct coupling of the output. This line stage was an excellent performer at the time it was designed, but there are a number of op amps and buffers that offer better performance today.

A complete schematic of the new line stage, including input switching, balance and volume controls, and output muting is shown in *Fig. 6*. This line stage is based on the Walt Jung design I published in the Philips DAC960 mod series in *TAA* back in 1992[1]. A high-performance op amp—IC201—provides the gain. IC201 is buffered by a high-speed, current-feedback opamp—IC203—placed inside the feedback loop, which provides 100mA of output current capability. In the original Adcom line stage, the voltage gain was set at 11. The new circuit has a voltage gain of 5, which is plenty due to the much-improved dynamics of the new line stage powered by the new supply regulators.

The design shown in *Fig. 6* has one important refinement: the addition of local feedback around the gain op amp, IC201. This circuit was first described by Walt Jung in his column "Walt's Tools and Tips," for a time a regular feature in *Electronic Design*[2]. More recently, Walt described this topology in the 2002 edition of Analog Devices' *Op Amp Applications*[3].

The local feedback around IC201 serves two purposes. First, the effective open-loop bandwidth of IC201 is increased. Second, resistor R253 is approximately equal to the impedance of the volume control, set to a normal listening level, at the non-inverting input of the op amp. This helps match the source impedances at the op amp's inverting and non-inverting inputs. Local feedback is also used around the AD811.

The active devices are the same as those used in the DAC960 project—an AD744KN op amp buffered by an AD811AN high-speed current-feedback amplifier. The AD711KN has a unique feature: the output can be taken from compensation pin 5, bypassing the Class-AB output stage. This is how the chip was used in the DAC960 project. Walt informed me that pin 5 is capable of driving the high-impedance local feedback network in the new topology. *Figure 6* shows this alternate output connection, in addition to the conventional connection to Pin 6.

In the Analog Devices *Op Amp Applications* article, Walt suggested the more recently designed AD825AR, which, on paper, seems to offer even better performance than the AD744. I don't yet have enough experience with the AD825AR in this design to recommend it, but I may report on it in a future issue.

OLD CIRCUIT REMOVAL

Begin by removing some of the old line stage components.

- Remove IC201 and IC203 in the left channel.
- Remove IC202 and IC204 in the right channel.
- Remove D201 (L) and D202 (R).
- Remove R235 (L) and R236 (R).
- Remove C201 (L) and C202 (R).
- Remove C223 (L) and C224 (R).

Now change the input and output series resistors (*Photo 26*).

- Replace R205 (L) and R206 (R) with 475Ω resistors.
- Replace R239 (L) and R240 (R) with 100Ω resistors.

Next, you must replace a few more resistors.

- Replace R237 (L) and R238 (R) with 100Ω resistors.
- Replace R213 (L) and R214 (R) with 1.0k resistors. Do not put the new resistors in the old locations. Instead, put the new resistors in the holes adjacent to the original R213 and R214 footprints. This will allow adequate clearance when you install the op amp assemblies. (These adjacent holes are electrically identical to the

ones marked "R213" and "R214.")

- Replace R211 (L) and R212 (R) with 249Ω resistors.

R209 and R210 are 10M bias return resistors for the op amps. These resistors keep the DC offset at safe levels in case the volume control wiper opens or becomes intermittent. The currents through these resistors are so small

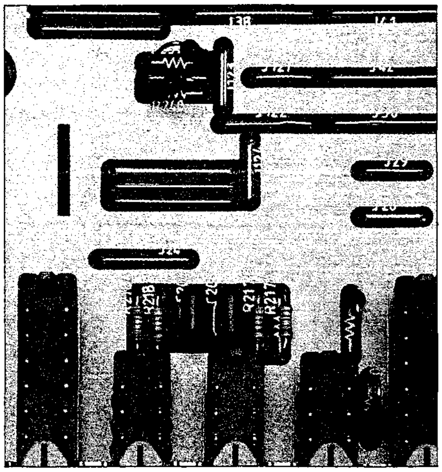


PHOTO 26: New 100Ω main output resistors are shown at the top of the photo. Replacement 475Ω input resistors are in the lower right, between two of the switches.

that the steel end caps in the original Roederstein MK2 resistors are probably quite benign. However, if you want to be a real purist, you can replace them with Vishay-Dale VMF type RN55 resistors (I did). Don't waste money on the expensive Caddock or Vishay resistors in these locations—they're unlikely to yield any further improvement.

- Replace R209 (L) and R210 (R) with 10M Vishay-Dale CMF type RN55.

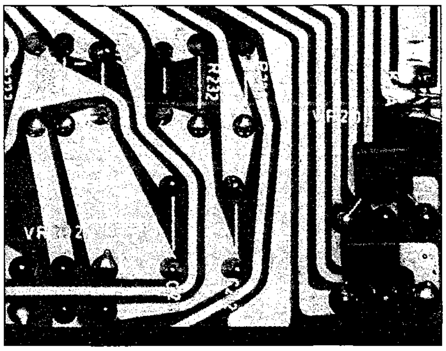


PHOTO 27: 1000pF capacitors are installed across the left and right sections of the balance control for bandwidth limiting. Wima FKP-2 polypropylene caps are shown here. Reliable MultiCap PPMFX types are an even higher-quality alternative.

Bandwidth limiting for the new circuit is set to 330kHz by the R/C network R205/C251 (R206/C252; in the assembly steps that follow, all components designators in parentheses refer to the right channel). C251 and C252 are soldered across the left and right sections of the balance control, on the bottom of the PC board (*Photo 27*). The best capacitor for this application is the Reliable MultiCap PPMFX polypropylene type; a lower-cost polypropylene alternative is the Wima FKP-2.

- Solder C251 (C252)—1nF—across the left and right sections of the balance control, on the bottom (trace) side of the PC board.

The new op amps and buffers won't simply drop into the existing PC footprints. Gain op amp modules IC201 and IC202 must be built up on an 8-pin DIP header with the local feedback resistors R251 and R253 (R252 and R254). I prefer the Tyco Plug Adapter Assembly sold by Allied, which has gold-plated pins. The Aries header sold by Digi-Key has tin-plated pins, and will also work. Both have forked contacts on the top, which facilitates soldering the op amp and resistor to the header. Assembling the headers is relatively easy (*Photo 28*).

- Cut off the thin part of the lead from pin 2 of the AD744 op amp. Leave the wide portion of the lead intact.
- Solder the op amp to the header, except for pin 2.
- Solder R251 (R252)—221k—between pin 6 and pin 2 of the op amp.
- Solder R253 (R254)—2.49k—between pin 2 of the component carrier and the R251 (R252) lead that is already soldered to pin 2 of the op amp.
- Solder the two assemblies in the IC203 and IC204 footprints. Pay careful attention to orientation, which is the same as the original op amps.

If you decide to try the AD744 with the output taken from pin 5, you can easily move R251 (R252) from pin 6 to pin 5 of the op amp. In this case, I suggest putting 100Ω resistors R237 and R238 on the bottom of the PC board. This will make the output connection to pin 5 easier. Note that the 221k feedback resistors must be connected to the same pin as the output, as shown in *Fig. 6*. After the line stage is completed, you may wish to conduct some listening experiments to see which connection you prefer.

You can build the AD811 modules on two small pieces of perfboard, $\frac{5}{8}'' \times \frac{15}{16}''$, or 6 solder pads wide by 9 solder pads long (*Photo 29*). Here's how to build the modules:

- Solder unused pins 1, 5, and 8 of the AD811 op amps to pads on the perfboard. This will hold the op amp in place while you connect leads to the other pins. Orient the op amps along the length of the perfboard, leaving two rows of holes between pins 4

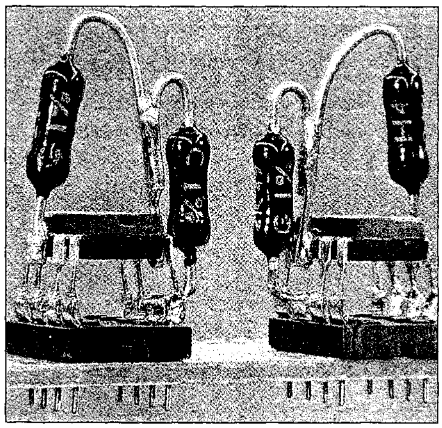


PHOTO 28: Two views of the AD744 op amp modules using Holco H4 resistors. The op amps are soldered to a header, along with the local feedback resistors. R253 (R254) is soldered between pin 2 of the op amp and pin 2 of the header.

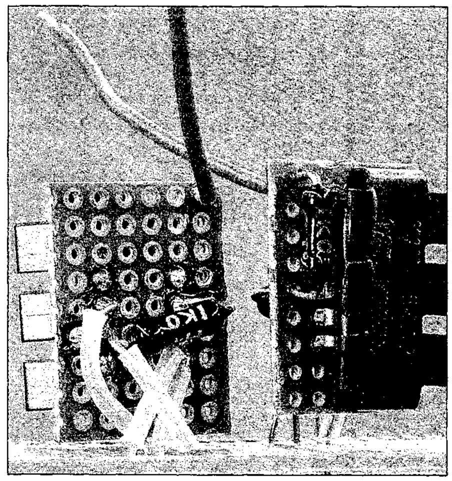
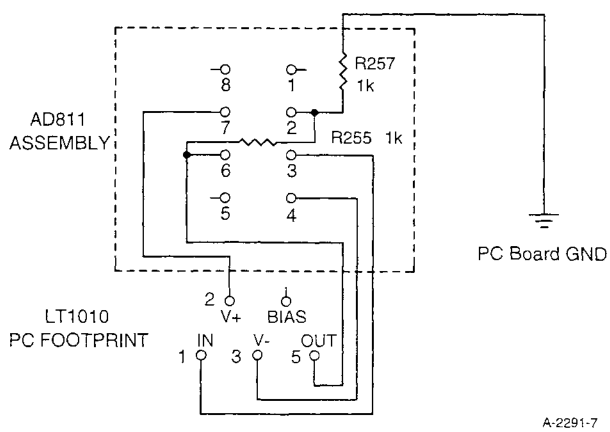


PHOTO 29: Front and back views of the AD811 modules, showing the local feedback resistors. A clip-on DIP heatsink is used on the AD811.

FIGURE 7: Diagram showing connections from the AD811 modules—assembled on small perfboards—to the LT1010 footprint on the Adcom PC board. The bias connection for the LT1010 is not used.



and 5, and the edge of the perfboard.

- Solder R255 (R256)—1k—between pins 2 and 6 on the back side of the perfboard.
- Mount R257 (R258)—1k—on the op amp side of the perfboard. Solder one lead to pin 2 of the op amp, or the corresponding lead of the R255 (R256). Solder the other lead to a spare solder pad, and solder a 4″ length of insulated hookup wire to this lead.
- Solder four 2″ leads of 22AWG solid hookup wire to pins 3, 6, 4, and 7 of the op amp.
- Slide clip-on DIP heatsinks onto each AD811. 8-pin DIP heatsinks are fine, but they are hard to attain from most distributors. I used the Aavid heatsinks made for 14-pin DIP applications. Center the heatsink on the AD811 and use a dab or two of five-minute epoxy to keep the heatsink in place. Allow the epoxy to cure before proceeding.

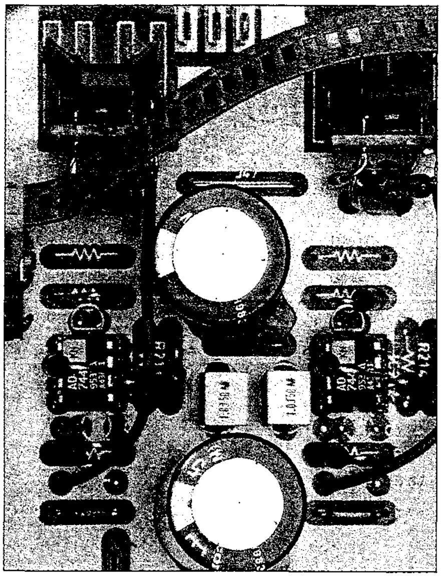


PHOTO 30: The completed line stage using Holco H4 resistors. The insulated wires from the AD811 local feedback resistors are soldered to the ground pads previously occupied by C201 and C202.

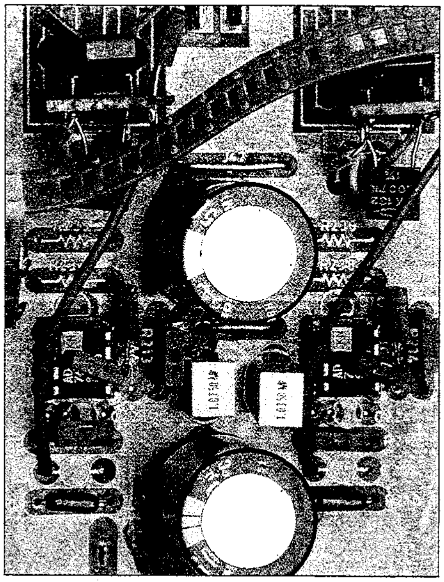


PHOTO 31: The completed line stage built with Caddock MK132 resistors. R237 and R238 have been soldered to the bottom side of the PC board, allowing easy connection to pins 5 or 6 of the AD744.

Now, install the modules on the Adcom PC board. *Figure 7* shows how the modules connect to the LT1010 footprint.

- Bend the four bare leads of the modules as shown in *Photo 29*. Put short lengths of sleeving over the leads and install the leads in the LT1010 PC footprints, making sure that the connections match the wiring diagram in *Fig. 7* (*Photo 30*). Solder the four leads to the bottom of the Adcom PC board. Note that the bias connection in the LT1010 footprint is not used.

- Connect the insulated leads from R257 and R258 on the AD811 modules to the ground holes on the Adcom PC board previously occupied by C201 and C202. These are the C201 and C202 holes closest to the preamp's front panel. Trim the leads so that they are just long enough to reach comfortably. Solder the leads in place (*Photo 30*).
- Alternately, you can route these leads through screw holes in the PC board that were used to hold the LT1010 heatsinks in place and sol-

TABLE 1
MODIFIED GFP-565 PREAMPLIFIER

MEASUREMENTS ON SAMPLE BUILT FOR C. VICTOR CAMPOS
S.N. AC14755

LINE STAGE THD – LEFT	**WIDEBAND**	**w/80kHz LP FILTER**
(2V in > 2V out)		
20Hz	0.0037%	0.0017%
1kHz	0.0037%	0.0018%
10kHz	0.0042%	0.0028%
20kHz	0.0055%	0.0046%
LINE STAGE THD – RIGHT	**WIDEBAND**	**w/80kHz LP FILTER**
(2V in > 2V out)		
20Hz	0.0037%	0.0017%
1kHz	0.0037%	0.0018%
10kHz	0.0043%	0.0031%
20kHz	0.0055%	0.0048%
LINE STAGE IMD	**SMPTE (4:1)**	**1:1**
60Hz + 7kHz		
(2V in > 2V out)		
LEFT	0.0014%	0.0013%
RIGHT	0.0015%	0.0012%

LINE STAGE FREQUENCY RESPONSE
–0.2dB @ 10Hz, –2.1dB @ 100kHz (Left and Right Channels Identical)

All measurements made with Sound Technology 1700B
by Gary Galo, 11/2/2002

PARTS LIST

TAPE OUTPUT BUFFERS:

(2)	TI/Burr-Brown OPA2604AP op amps, Digi-Key OPA2604AP-ND,—or— TI/Burr-Brown OPA2134PA op amps, Digi-Key OPA2134PA-ND,—or— Analog Devices AD712JN op amps, Newark 05F7277, or Analog.com

LINE STAGE:

(2)	10M, ¼W resistors, Vishay-Dale CMF Type RN60, Mouser 71-RN55D-10M (R209, R210) All other resistors are builder's choice: Vishay-Dale CMF Type RN60 (Welborne Labs, Mouser 71-RN60D-Value) Holco H4 (older non-ferrous type, if available, Welborne Labs, Michael Percy Audio, Parts Connexion) Caddock MK132 (Welborne Labs, Michael Percy Audio, Parts Connexion) Vishay S-102 (Michael Percy Audio)
(2)	475Ω (R205, R206)
(2)	221k (R251, R252)
(2)	2.49k (R253, R254)
(6)	1.0k (R213, R214, R255, R256, R257, R258)
(2)	249Ω (R211, R212)
(4)	100Ω (R237, R238, R239, R240) (six are needed if you add the Aux Outputs, R239a, R240a)
(2)	1nF (1000pF, 0.001µF) Polypropylene Capacitors, Reliable MultiCap PPMFX (Welborne Labs, Parts Connexion)—or— Wima FKP-2 (Welborne Labs) (C251, C252)
(2)	Analog Devices AD744KN op amps, Newark 05F7342, Analog.com
(2)	Analog Devices AD811AN op amps, Newark 05F7667, Analog.com
(2)	Aavid/Thermalloy DIP Heatsink, Digi-Key HS179-ND
(2)	Tyco 8-pin Plug Adapter, Allied 905-3114—or— Aries 8-pin DIP Header, Digi-Key A101-ND

MISC.
Insulated hookup-wire
22AWG bare hookup wire
Sleeving
Perfboard with solder ringed holes (Radio Shack 276-147)
5-minute epoxy (local hardware store)
D.H. Labs BL-1 Interconnect for optional Aux Inputs

der them to the main ground traces on the bottom of the PC board. You'll need to scrape enough lacquer off the PC traces to make the ground connection.

Photos 30 and *31* show the completed line stage with both Holco and Caddock resistors. At this point, check all wiring and component placements very carefully. Be particularly careful in checking the wiring of the AD811 modules and the connections from these modules to the Adcom PC board. Carefully clean the Adcom PC board around the line stage components with the CaiKleen TRP DG7S-6 cleaner recommended in Part 2.

TESTING

Power up the preamp and check the DC-offset at the Main output jacks, after the muting relays have timed out. Offset will normally be 1.25mV or less. Analog Devices specifies the typical input offset voltage for the AD744KN as 0.25mV, and the line stage has a voltage gain of 5. Maximum offset is specified as 0.5mV, so the worst-case situation in this line stage should be 2.5mV at the output.

Check the voltage gain with a 1kHz sine wave. Set your generator output to 0.5V RMS and check the output of both channels with the volume control fully clockwise. It should be 2.5V RMS. If you have a distortion analyzer, set the generator output to 2V RMS, and advance the preamp volume control for an output level of 2V RMS. This is the "unity-gain" setup that Victor Campos used to measure preamp THD when he worked at Adcom.

This setup minimizes the effects of noise on the THD measurement. *Table 1* gives the measurements of the GFP-565 preamp that I modified for Victor Campos. They were made on my Sound Technology 1700B analyzer, and are typical of what you should measure with this preamp. These measurements are quite close to the Adcom original, and I don't believe that they are much help in quantifying the sonic performance of the modified preamp. But, they will tell you whether you have made any serious errors in performing these mods.

I suggest "cooking" the preamp on the bench—with the cover and bottom plate installed—for 24 hours and re-checking the measurements. If all is well, hook the preamp up to your system, and enjoy! We plan to have at least one third-party evaluation of the modified preamp in a future issue of *aX*, and I welcome your comments and reactions. Part 4 will feature the new, servo-controlled phono preamp. ❖

REFERENCES

1. Galo, Gary. "Pooge 5: Rite of Passage for the DAC960"–Part II. *Audio Amateur*, 3/1992, pp. 34–39, 58.

2. Jung, Walt. "Op-Amp Audio: Minimizing Input Errors," *Electronic Design*, Dec. 14, 1998, pp. 80–82.

3. Jung, Walt. "Composite Current Boosted Line Drivers," *Op-Amp Applications*, Analog Devices, 2002, pp. 6.62–6.64.

SOURCES

Allied Electronics
7410 Pebble Drive
Fort Worth, TX 76118
817-595-3500
817-595-6444 (FAX)
http://www.alliedelec.com/

(Remaining sources are listed in Part 1)