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Adcom GFP-555 Preamp Upgrade

In the best tradition of DIY audio, this author's modifications significantly upgrade a proven preamp design.

By Charles Hansen

I modified my Adcom GFP-555 in a manner similar to Gary Galo's GFP-565 project in his series of articles in *audioXpress*[1-5]. I did not do a "purist" upgrade like Gary—I kept the tone controls, which now supply a new set of output jacks, and all the available inputs but with an upgrade to gold jacks. I changed the tone control op amp from the original NJM2041 to the OPA2604. The LAB and NORM outputs are now both DC-coupled. I also removed the headphone amplifier, which was a mediocre design with an NJM4556 op amp, so I decided to save the available watts for the new AD744/AD810 output stage, which draws a lot of current. The GFP-555 has even higher gain (22.5dB) than the 565, so the volume control wiper is well down at normal listening levels.

The lower 14dB gain of Gary's line stage was a welcome change. The AD744/AD811 line stage was a bit more difficult to install because the -555 does not have the dual-composite op amps that the -565 has. Victor Campos recalled that the -555 was probably designed by Nelson Pass before Victor arrived at Adcom.

While I did not use an external power supply, I did upgrade the power supply, changing to a 36V CT 2A secondary, with a copper flux band and steel end plates. I fit in the larger transformer by removing the line voltage selector switch and its extra wiring.

FIGURE 1: Block diagram comparing original with modification.

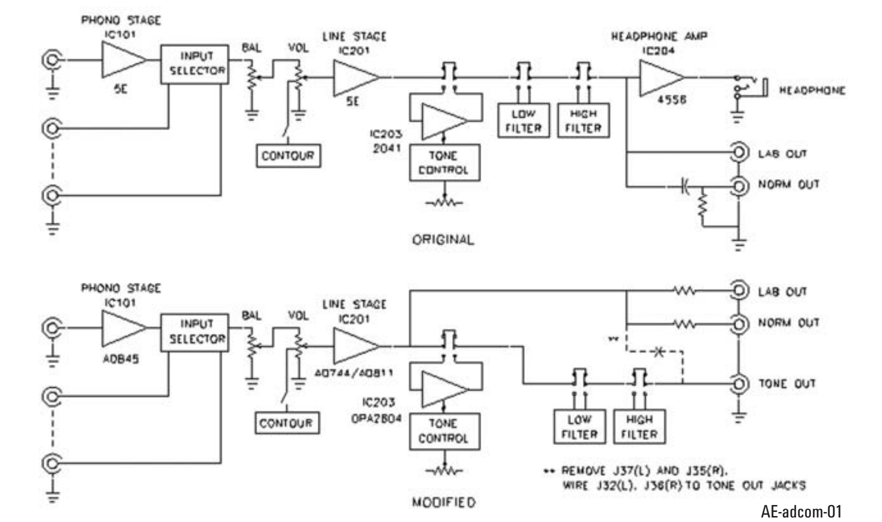
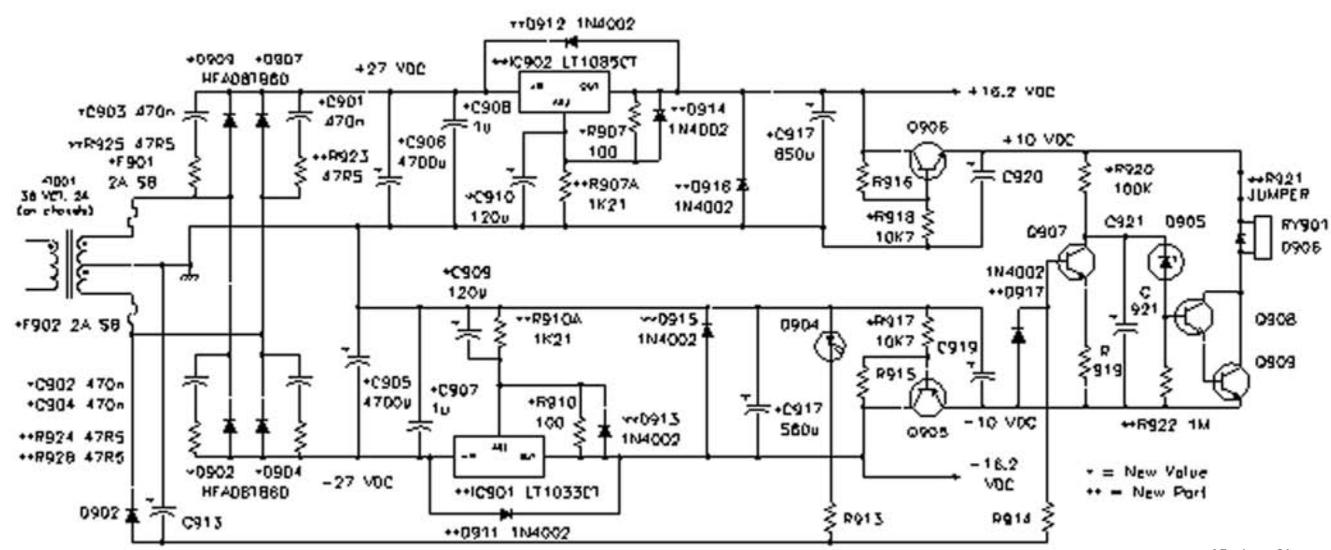


FIGURE 2: Power supply schematic.



I kept two of the existing plastic dual-dual phono jack modules, which make a desirable mechanical connection between the PC board and the rear panel. These are the Tuner In/Tape 1 In pair and the Signal Processor In/Out pair. The former two will be active, while the Processor pair will be strictly mechanical and bypassed with jumpers.

Parts cost for this upgrade was about \$115, based on the parts list in **Table 1**. I happened to have the GFP-555, but I recommend using the –565 if you are considering this type of upgrade. Follow Gary's articles for the purist version, but for a "less-than-purist" modification that retains the original I/O flexibility of the Adcom design, this article will provide guidelines.

I strongly suggest you obtain the service manual, for the model of preamp you are modifying (readily available as reprints on eBay). I mapped all the PC board jumpers onto the schematic so I could replace them with discrete components where necessary. I must thank Gary Galo for his comments on my proposed modifications; he was very helpful and provided some interesting insight into the Adcom preamp designs of that era.

MODIFICATIONS

Prior to making any modifications, I verified all the DC voltages shown on the schematic (it had sat unused for a few years), checked that all the controls and input/outputs were functional, gave the Adcom a listening session, and made a few measurements.

Figure 1 shows block diagrams for the original GFP-555 and for my modifications. In both cases the CD, Tuner, Tape 1, Tape 2, and Video/Aux inputs are processed through the Listening input selector switch, with the phono preamp section providing one of the inputs. There was also a separate Recording selector switch that coupled to the Tape 1 and Tape 2 tape loop jacks.

Audio signals proceed from the input switch to the Signal Processor I/O jacks, which are furnished with removable metal links. The next step is the Balance control, the Mono/Stereo switch, and the Volume control, which is equipped with a Contour switch to the tapped volume control that could select the loudness contour function for low listening levels. Finally, the selected audio signal was sent on to the active line stage.

The output of the line stage can then take a number of series paths. When the tone controls and filters are bypassed, the line stage is direct-coupled to the LAB output and capacitively-coupled to the NORM output. The headphone amp input receives this same signal. Three additional switches in the line output

PHOTO 1: GFP-555 original power supply rear.

PHOTO 3: GFP-555 mod power supply rear.

PHOTO 2: GFP-555 original power supply front.

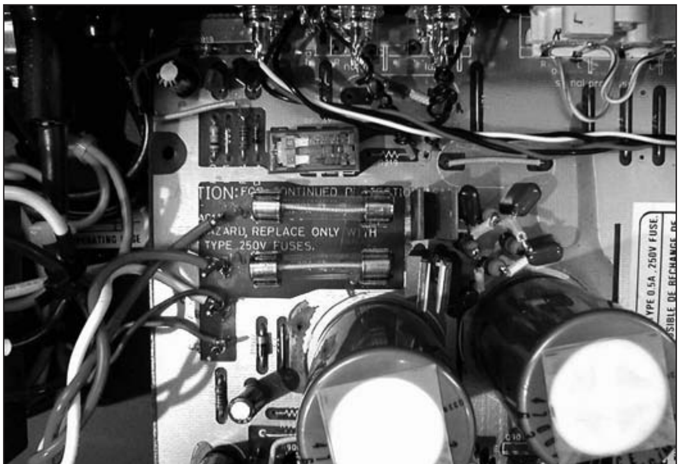


PHOTO 4: GFP-555 mod power supply front with new transformer.

signal path allow selection of the tone controls—a Lo filter and/or a Hi filter.

The original phono preamp and line stage ICs had a house number, "5E," which Victor thought was an OP37. This would make sense, because the OP37 is one of the few op amps whose maximum supply rail voltage was ±22V, and the Adcom schematic shows the 5E operating on ±21.5V rails. On the other hand, Gary observed that with the phono gain switch set to the lower gain position, the circuit does not satisfy the gain-of-5 stability requirement of the OP37, so maybe the "5E" was an OP27.

The modified block diagram at the bottom of **Fig. 1** is essentially the same up to the output of the line stage. At this point the amplified signal takes two distinct paths. The first is direct-coupled to both the LAB and NORM output jacks. The second path uses all the switched tone control and filter circuitry of the original unit, but goes to another set of output jacks that I added called Tone Out.

You can also see that I changed all the ICs to reflect improvements made over the intervening years. The phono preamp went from the 5E to an AD845. I replaced the line stage 5E with the aforementioned AD744/AD811 composite amplifier. The NJM2041 tone control IC became an OPA2604. Finally, I removed the 4556 headphone amplifier and all its passive parts, although I left the jack in place on the front panel. I tried unsuccessfully to fit my Headroom headphone module board[6] in the space between the transformer and the front panel.

POWER SUPPLY

Gary used a separate power supply chassis for his GFP-565 modification, which has the distinct advantage of lower phono stage hum and noise. However, I wanted to retain a one-box preamp. The original power supply regulators were composed of discrete transistors Q901 and Q902 that used ±32.5V raw DC rails to derive the ±21.5V DC op amp rails. Another set of transistor regulators, Q905 and Q906, further stepped this down to ±15.6V DC for the headphone op amp, and provided 31.2V DC for the output delay relay circuit.

Photos 1 and **2** show the front and rear views of the original supply. In the foreground of **Photo 1** I have already removed the components for the headphone amplifier.

My modified power supply is shown in **Fig. 2**. After mapping all the jumpers onto the schematic, I replaced all the power supply jumpers with larger wire gauges. Next, I removed all the power supply components from the PC board and I replaced the Jamicon bulk filter caps with Nichicon KZ and Panasonic HFQ types. I used LT1085CT and LT1033CT linear regulator ICs for the new ±16.2V DC op amp power supply rails.

Because the delay relay has a 24V coil, there was no need for 31.2V DC. The original design used a 274Ω series resistor to drop the coil voltage to 24V. I removed the resistor and dedicated Q905 and Q906 to a reduced ±10V DC, which saved some power dissipation in

FIGURE 3: Phono preamp schematic.

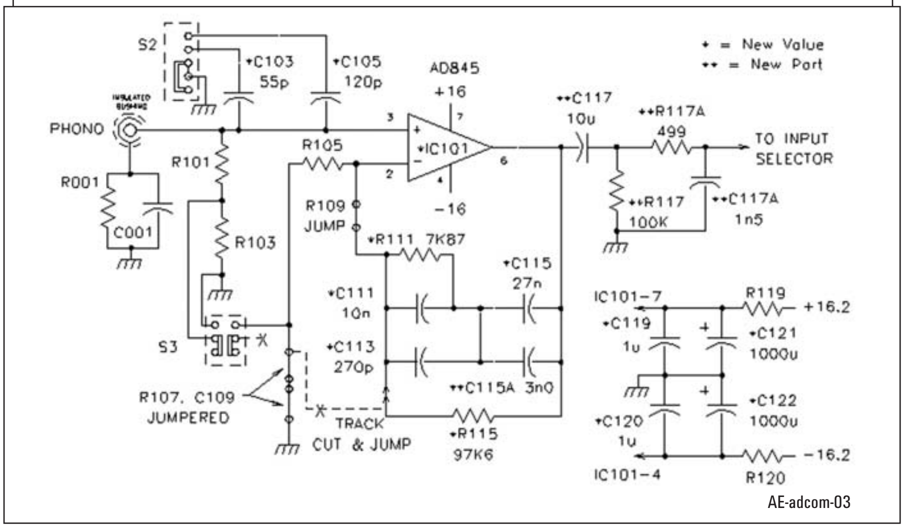
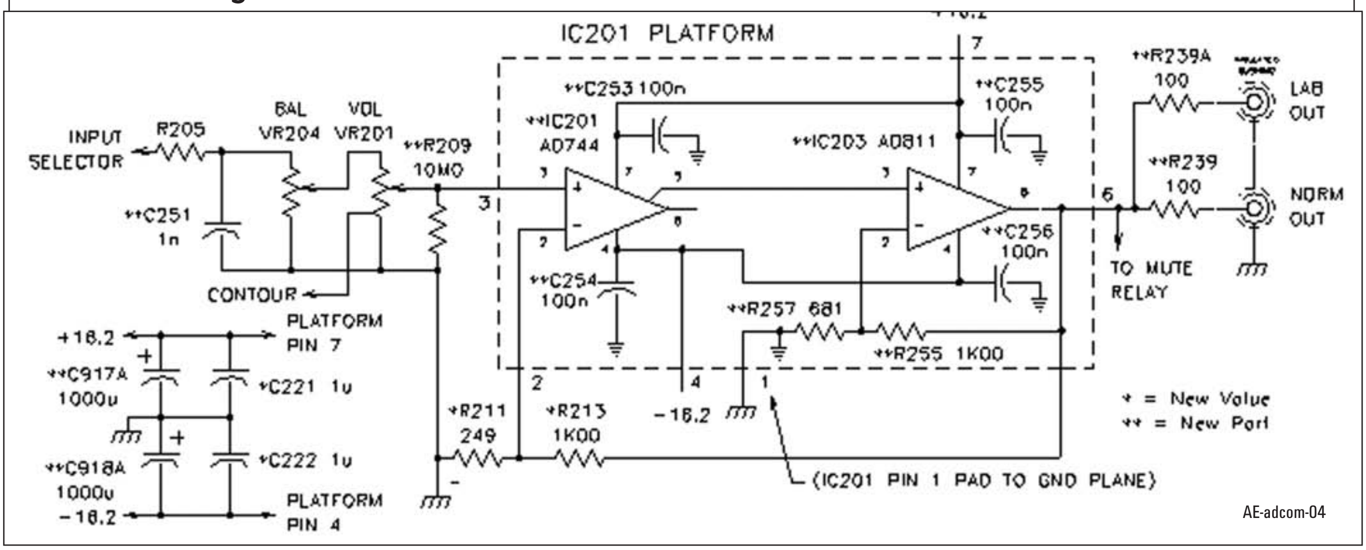


FIGURE 4: Line stage schematic.

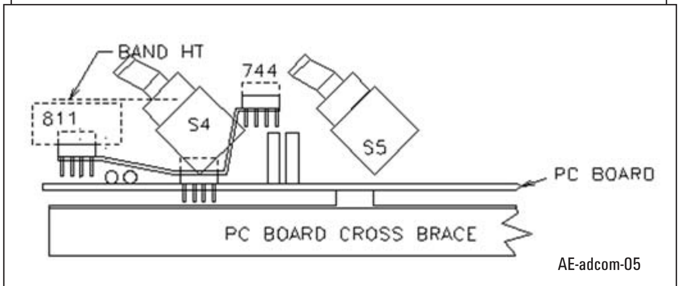


the relay coil. Gary increased the relay time delay, whereas I left it the same.

Photo 3 shows the front view of my new power supply. I placed adhesive-backed Mylar film across pairs of aluminum capacitors to provide them some additional mechanical ruggedness. The new transformer is on the left side. Note the TO-220 heatsinks mounted on the linear regulators. These are needed because of the higher current drawn by the AD744/AD811 composite line stages.

I installed the new HexFred diodes in the old snubber cap holes, and the new snubber resistor/cap combinations in the old rectifier bridge holes (**Photo 4**). Two of the TO-220 diode mounting tabs were facing each other, so I placed adhesive-backed Nomex on the tabs to keep them from shorting together.

FIGURE 5: Line stage IC socket assembly.



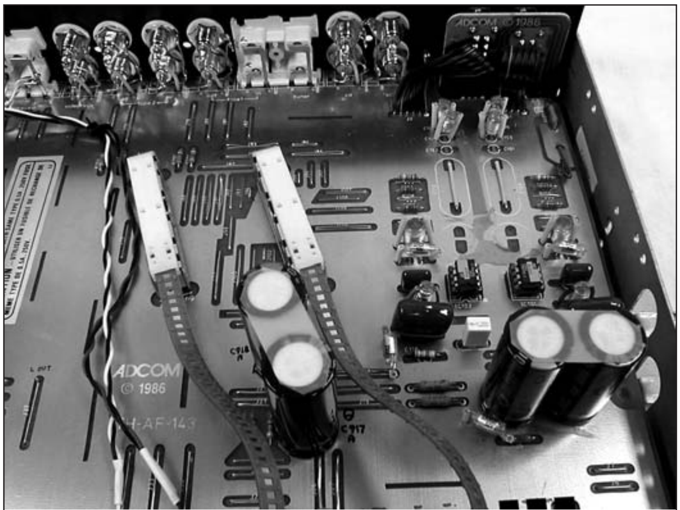


PHOTO 5: GFP-555 mod phono stage.

PHONO STAGE

The phono stage in **Fig. 3** is the one designed around the AD845 op amp by Walt Jung in Analog Devices' "Op Amp Applications,"[7] pp. 6–18. Walt also kindly provided me with two AD845KN op amps because the DIP package is no longer available (Rochester Electronics may have some NOS parts in stock). I replaced the two 1000µF Jamicon filter caps with Nichicon KZ, shown on the right in **Photo 5**.

I removed 55pF caps C101 and C1023 from the PC board and reduced the capacitor values on the cartridge capacitive load switch to 55pF and 120pF. This allowed me the choice of no capacitor, or one of the latter two values. The MM/MC gain switch remained as it was.

LINE STAGE

The line stage (**Fig. 4**) consists of the AD744/AD811 composite pair that Gary used, which is itself based on another Walt Jung design that goes back to 1992[8-10]. I isolated the LAB and NORM outputs from each other with 100Ω resistors. I also drilled holes in the PC board to add two more 1000µF Nichicon KZ power supply filter caps for the line stages (C917A and C918A). These are shown in the center of **Photo 5**.

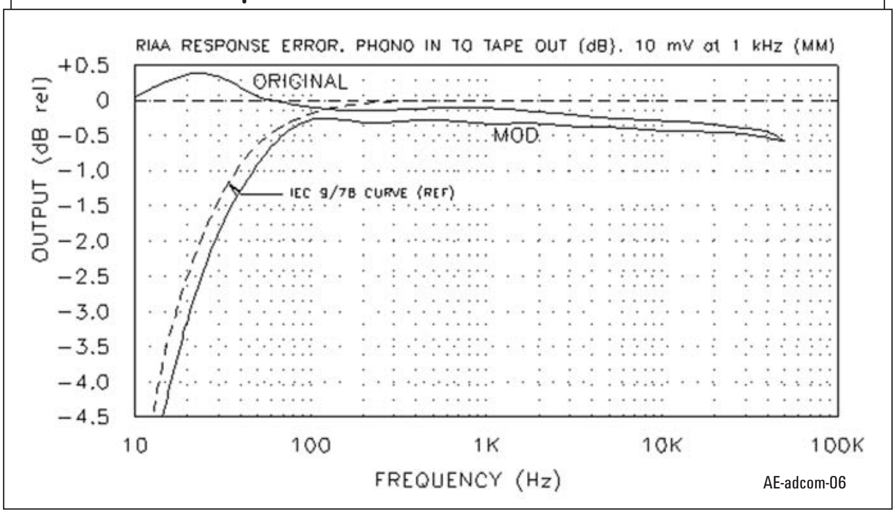
The line stage presented a real packaging problem. Because the GFP-555 did not use composite op amp stages, there was much less real estate available for the 744/811 combination. The plastic indexing control band for the Recording switch ran right over the top of the existing 5E op amps (**Photo 6**).

I needed to build a "flying bridge" plug-in module for the AD744/AD811 composite line amp by epoxying two 8-pin DIP sockets and an 8-pin DIP platform to a ⅛″ wide copper strip. I bent the strip upward at each end to allow the 744/811 assemblies to clear selector switches S4 and S5, and the exiting PC board components surrounding the original "5E" ICs. I grounded the copper strip via unused platform pin 1 so it formed a ground plane under the 744 and 811.

The clip-on heatsinks over the AD811s are shown on the right side in the photo. All the sockets and platforms are Garry Engineering machined low-profile gold-plated types we used in RF and switching circuit brassboards at work. A rear view drawing of the plug-in modules and their close clearances is shown in **Fig. 5**. In his newer designs[11], Walt has recommended using the AD845 in place of the AD744, but my construction was a bit too far along for that improvement because the wiring between the AD744 and AD811 was now firmly anchored in epoxy.

The tone controls, lo and hi filters, and the contour circuitry all remain the same as in the original unit, and I do not show them in this article. Of course,

FIGURE 6: RIAA response error.



much progress has been made in IC technology and cost since the original design, although the AD744 and AD845 op amps are both listed in my 1988 ADI catalog.

LISTENING AUDITION

Gary Galo suggested that I also try the OPA627AP in the phono stage, because it has slightly lower noise specifications than the AD845 and is readily available in the DIP package, making it easier for readers to install. However, one of the weaknesses of the one-box design is the power supply noise induced by having the phono stage inside the same enclosure as the power supply, especially the power transformer. At full volume, the hiss and low-level hum were quite noticeable. Once I started the first LP and dialed down the volume to a comfortable listening level, the modified preamp proved quieter than the original by a fair margin. I could not really discern any difference in the noise level between the two candidate phono stage op amps, but I did prefer the sound of the AD845 just a bit.

The original GFP-555 phono section was a touch tubby in the bass and had a higher hiss level than the modified unit. The line inputs tended to-

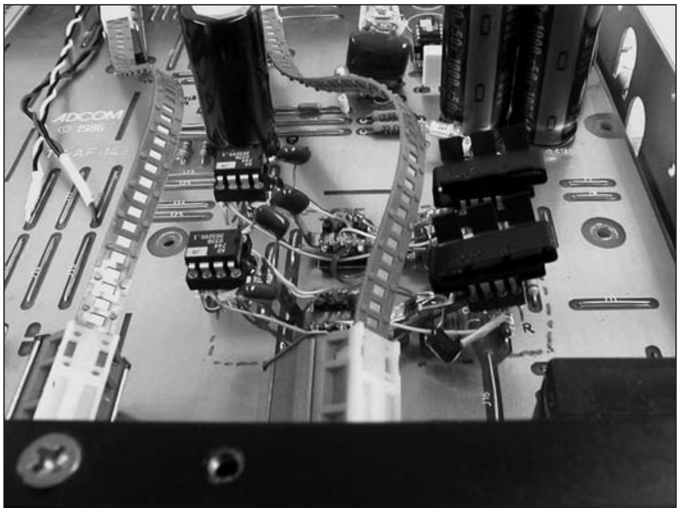


PHOTO 6: GFP-555 mod line stage.

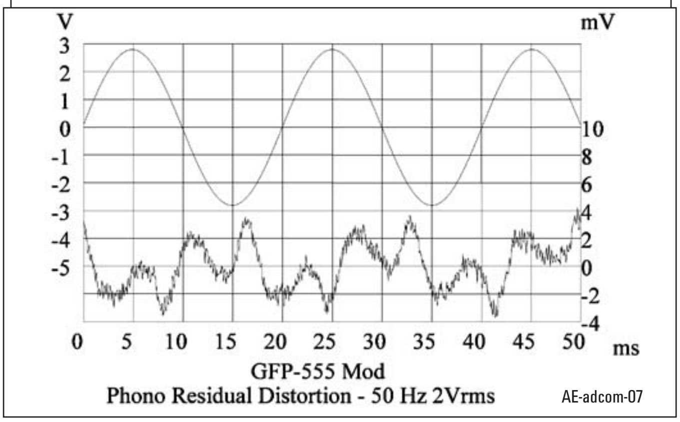


FIGURE 7: Phono preamp 50Hz residual.

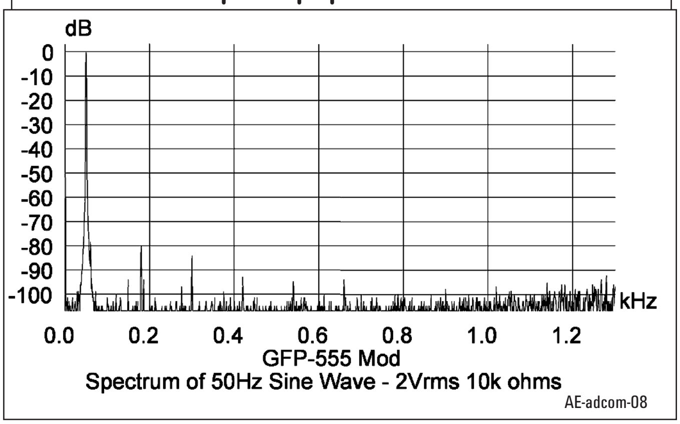


FIGURE 8: Phono preamp spectrum of 50Hz sine wave.

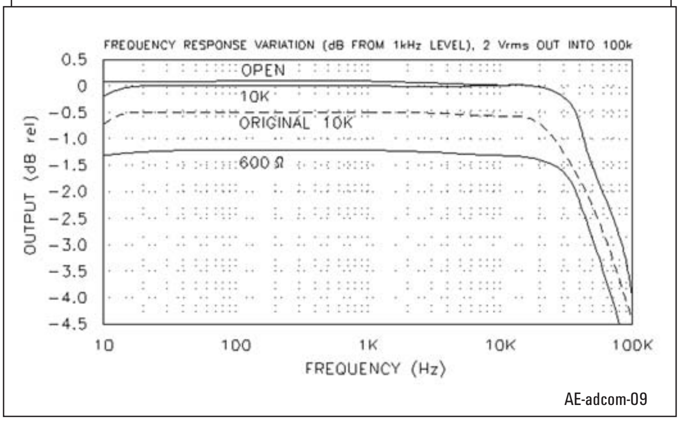


FIGURE 9: Line stage frequency response.

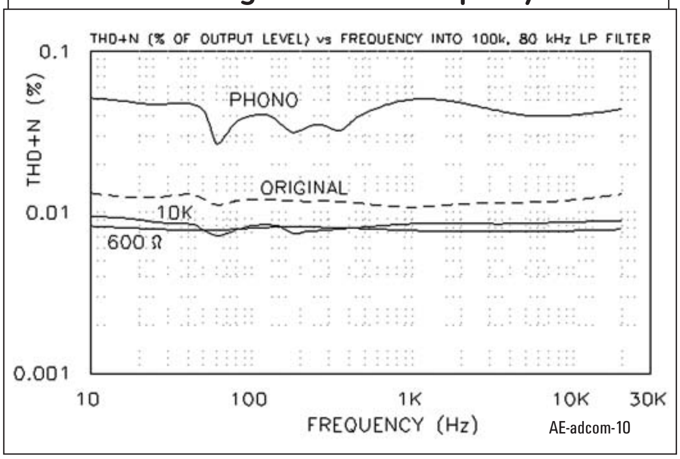


FIGURE 10: Line stage THD + N vs. frequency.

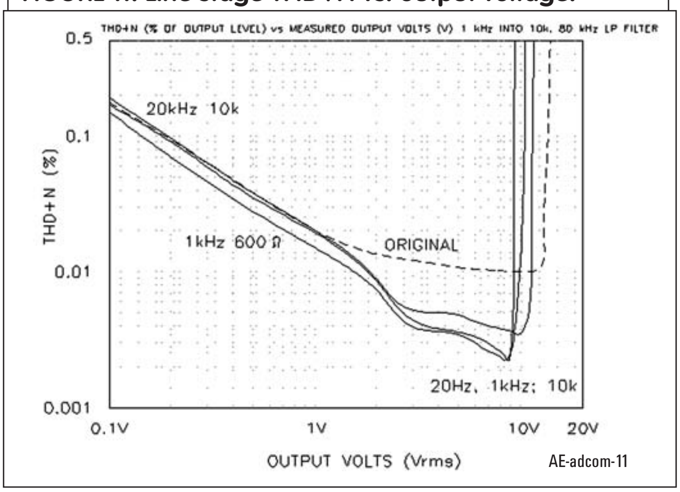
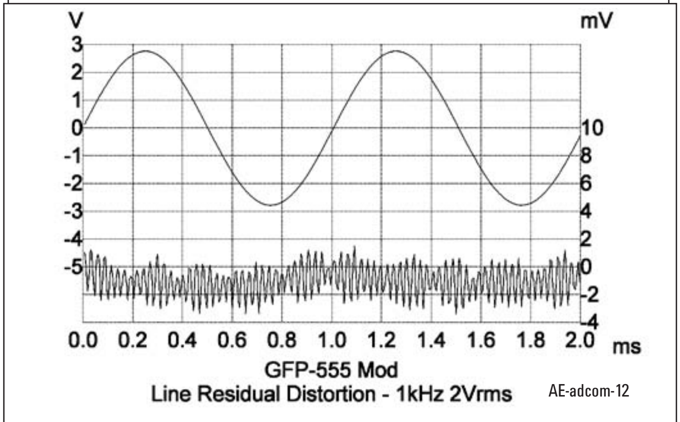


FIGURE 11: Line stage THD+N vs. output voltage.

ward a more muted high frequency response that became strident when I used the tone controls to compensate. With both CD and LP sources, the modified unit is much easier to listen to than the original. The midrange especially is more detailed and open, with better imaging and a wider and deeper soundstage. It has also made listening to classical music on my FM tuner more enjoyable.

FIGURE 12: Line stage 1kHz residual.



MEASUREMENTS

Once my listening sessions were over, I swapped the AD845 for the OPA627 and ran the whole preamp on a ±24V DC lab supply that was located across the room. Even with the power supply connected to the raw DC rails via three alligator clips and long lead wires, I could measure a slightly lower noise floor with the OPA627, so you might want to consider it for a two-box design like Gary's.

Phono stage hum and noise (with the AD845 op amps back in the sockets and the inputs terminated with 1.33k) measured –71dB. Switching in the A-weighting filter reduced this to –82dB. Crosstalk measured –76dB L-R and -78dB R-L, phono in to tape out.

Figure 6 shows the RIAA equalization error that I measured using an inverse-RIAA network, with the equivalent of 10mV input at 1kHz and a 10k load at the Tape 1 output. The original response has a +0.4dB peak at 25Hz, while the modified unit follows the IEC 9/76 modification and has 0.2dB lower gain at 1kHz.

Figure 7 shows the residual distortion for the phono preamp in response to a 50Hz sine wave. The fundamental sine wave is at the top, while the residual distortion after the test set notch filter is at the bottom (not to scale). The residual is predominantly third harmonic with noise riding on it.

You can get a sense of the phono stage hum pickup from the power transformer in **Fig. 8**, the spectrum of response to the same 50Hz sine wave. The THD+N measures 0.043%, while the THD calculated from the 50Hz harmonics alone is just 0.0039%. These first five harmonics are all below –93dB.

However, the 60Hz AC line induces a –78dB component into the spectrum followed by a decreasing series of odd harmonics of 60Hz. The two-box approach would doubtlessly eliminate this problem. I was pleased to see that the even harmonics, which occur due to rectification of the AC line, were noticeably absent with the new transformer, rectifier/snubbers, and regulators.

The line stage output impedance was 97Ω over the entire audio band. The Tape 1 and Tape 2 line output impedances were 1k due to the series discrete resistors of that value. Hum and noise measured –80dB, improving to -88dB after engaging the A-weighting fil-

TABLE 1: PARTS LIST.

Symbol	New Value	Description	Vendor	Part No.	Qty	Circuit	Old value
C001	47n	ceramic disk			1	chassis gnd	same
C101, C102	10p	NPO			2	phono stage	55p
C103, C104	55p	polystyrene			2	phono stage	120p
C105, C106	120p	polystyrene			2	phono stage	180p
C107, C108	delete				0	phono stage	470u 50V
C109, C110	jumper				0	phono stage	4u7 63V
C111, C112	10n	polystyrene	Mouser	23PW310	10	phono stage	1000p
C113, C114	270p	polystyrene			2	phono stage	30p
C115, C116	27n	MPP			2	phono stage	3600p
C115a, C116a	3n	polystyrene			2	phono stage	R113, R114
C117, C118	63k4	metal film			2	phono stage	R117, R118
C117a, C118a	1n5	polystyrene			2	phono stage	new
C119, C120	1u 50V	film, Mallory 168	Newark	89F1692	2	phono stage	100n 100V MPP
C121, C122	1000u 50V	cap, alum, Nichicon KZ	Percy		2	phono stage	1000u 25V
C201, C202	delete				0	line stage	47p ps
C203, C204	680n	MPP			2	lo filter	same
C205, C206	15n	MPP			2	hi filter	same
C207, C208	delete	C207 --> jumper			2	line out normal	4u7 63V MPP
C209-C212	56n	MPP			4	tone control	same
C213-C216	8n2	MPP			4	tone control	same
C217-C218	47p	polystyrene			2	tone control	same
C219, C220	220n	mylar film			2	contour	same
C221, C222	1u 50V	film, Mallory 168	Newark	89F1692	2	line stage	100n 100V MPP
C221a, C222a	1000u 50V	cap, alum, Nichicon KZ	Percy		2	line stage	new
C251, C252	1n5	polystyrene (across BAL)			2	line stage	new
C301, C302	delete				2	headphone	4u7 10V ta
C303, C304	delete				2	headphone	220p ps
C305, C306	delete				2	headphone	220n my
C901-C904	470n 100V	Stacked film-V	DK	P4733-ND	10	dc sply snubber	10n 250V ceramic
C905, C906	4700u 63V	cap, alum, Nichicon KG	Percy		2	dc supply	4700u 50V al
C907, C908	1u 50V	film, Mallory 168	Newark	89F1692	2	dc supply	100n 100V MPP
C909, C910	120u 50V	aluminum HFQ			2	dc supply	470u 50V
C911, C912	1k21 1%	becomes R907a, R910a			2	dc supply	
C913	22u 50V	aluminum			1	dc supply	
C914	delete	aluminum			0	dc supply	220u 50V al
C915, C916	100n 50V	aluminum			2	dc supply	
C917, C918	560u 50V	cap, alum, Pana HFQ			2	dc supply	470u 50V
C917A, C918A	1000u 50V	cap, alum, Nichicon KZ	Percy		2	dc supply	new, line stage
C919, C920	1000u 16V	aluminum			2	relay delay	same
C921	100u 16V	aluminum			1	relay delay	same
D901a-D901d	HFA08TB60	HexFred	DK	HFA08TB60-ND	4	dc supply	PB135M FW bridge
D902	1N4003	diode			1	dc supply	same
D903	delete				0	dc supply	12V zener UZ12B
D904		Red LED T-1 3/4			1	dc supply	same
D905	9V zener	UZ9JB			1	relay delay	same
D906	1N4148	500mA 75V			1	relay delay	same
D907-D910	1N4002	diode 1A 100V			4	dc supply	new
D916	1N3595	diode 125mA 150V			1	relay delay	new
F001	0.5A 3AG	Fuse			1	ac line	same

FIGURE 13: Line stage spectrum of 50Hz sine wave.

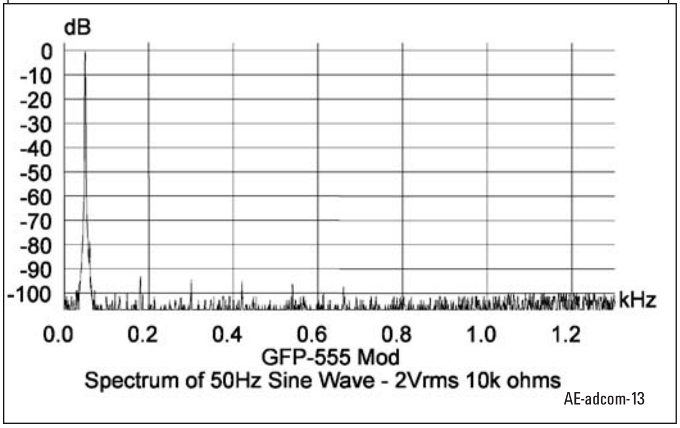
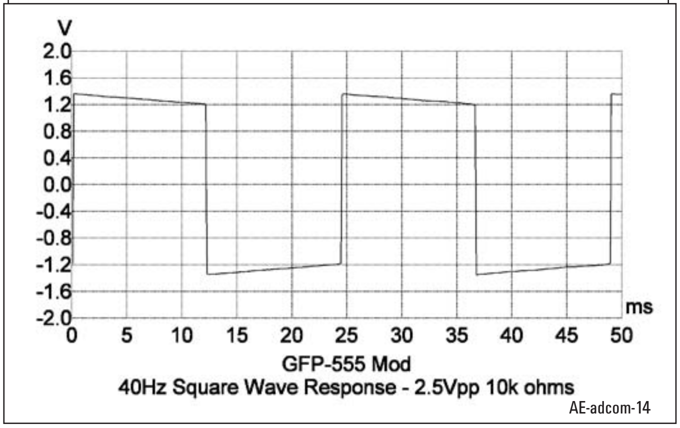


FIGURE 14: Line stage 40Hz square wave response.



ter. Output DC offset measured about +1.5mV in both channels. Crosstalk at 10kHz was -61dB R-L and -65dB L-R, line in to tape out. Unity gain occurred with a volume control setting of 2 o'clock, and the worst-case volume control tracking error was 0.4dB.

Figure 9 shows the line stage frequency response at 2V output into an open circuit (top) and also for loads of 10k and 600Ω. The response of the original preamp with the 5E op amps is also shown in a dashed line with a 10k load. There is a 0.5dB improvement in output and a flatter HF response with the lower impedance composite line stage. My Tone Output (not shown) is almost identical in response to the original.

The line stage THD+N versus frequency is shown in **Fig. 10** for both line and phono inputs. The dips in the otherwise flat response at 60, 120, and 180Hz are where the distortion test set notches out the AC line hum pickup within the preamp circuitry. The THD+N versus output voltage is shown in **Fig. 11**, where once again the measurements for the original unit are shown as a dashed line in both figures. The greater final output voltage for the original unit is a result of the higher power supply rails (±21.5V versus ±16.2V).

Figure 12 shows the line stage residual distortion at 1kHz. The residual after the notch filter (not to scale) is mainly low-level noise. The spectrum of a 50Hz sine wave in **Fig. 13** shows a similarly low level of hum and noise, with the 180Hz component at –93dB. The THD+N measures 0.0086% with a calculated THD based on the 50Hz harmonics of only 0.0017%, all the harmonics being below –98dB.

The response to a 40Hz square wave in **Fig. 14** shows very little tilt in this direct-coupled design. The response to the 1kHz square wave in **Fig. 15** is just about perfect, as is the 10kHz square wave (not shown).

Finally, the modified preamp response to an equal-value 19kHz + 20kHz CCIF intermodulation test signal (**Fig. 16**) shows the 1kHz, 18kHz, and 19kHz IMD products to be less than –100dB (0.001%). *aX*

Symbol	New Value	Description	Vendor	Part No.	Qty	Circuit	Old value
F901, F902	2A SB 3AG	Fuse			2	dc supply	0.5A FB
IC101, IC102	AD845KN	op amp (or OPA627)			2	phono stage	Adcom 5E
IC201a, IC202a	AD744KN	op amp	Newark		2	line stage	Adcom 5E
IC201b, IC202b	AD811AN	op amp, CFB	Newark		2	line stage	Adcom 5E
IC203	OPA2604	op amp, dual	Digi-Ke	OPA2604AP-ND	1	tone control	NJM2041D
IC301	delete				1	headphone	NJM4556D
IC901	LT1085CT	Reg, +Adj, 3A, TO220	Percy	LT1085CT	1	dc supply	new
IC902	LT1033CT	Reg, -Adj, 3A, TO220	Percy	LT1033CT	1	dc supply	new
J, left phono		IC101 pin 2 --> R115 out			1	phono stage	
J, rt phono		IC102 pin 2 --> R116 out			1	phono stage	
J20, 21, 26-30, 38, 39, 46		MWT-20 jumper			11	dc supply	MWT-22, line stage
J31, 35, 37, 40, 41, 43, 50, 51	delete				0	line stage/tone	MWT-22
PC001		Headroom module board			1	headphone	
Q901	delete				1	dc supply	2SB633 PNP
Q902	delete				1	dc supply	2SD613 NPN
Q903	jumper b-c				1	dc supply	2SA608K PNP
Q904	jumper b-c-e				1	dc supply	2SC536 NPN
Q905		2SA984K PNP			1	relay delay	same
Q906		2SC2274 NPN			1	relay delay	same
Q907-Q909		2SC945 NPN			3	relay delay	same
R001	10 1/2W	metal film			1	chassis gnd	same
R101, R102	100 1%	metal film			2	phono stage	same
R103, R104	47k5 1%	metal film			2	phono stage	same
R105, R106	100 1%	metal film			2	phono stage	same
R107, R108	jumper				0	phono stage	825 1%
R109, R110	jumper				0	phono stage	2k00 1%
R111, R112	7k87 1%	metal film			2	phono stage	73k2 1%
R113, R114	2n7	polystyrene			2	phono stage	887k 1%
R115, R116	97k6 1%	metal film			2	phono stage	332k 1%
R117, R118	470n 50V	MPP			2	phono stage	825 1%
R117a, R118a	499 1%	metal film (replace J6, J17)			2	phono stage	new
R119, R120	33 1/2W 1%	metal film			2	phono stage	same
R201-R204	1k00 1%	metal film			4	tape in/out	same
R205, R206	1k00 1%	metal film			2	line stage	475 1%
R205, R206	475 1%	metal film			2	sig proc in	same
R207, R208	3k09 1%	metal film			2	contour	same
R209, R210	10M 1%	metal film, Roederstein MK3	Percy	71-RN55D-10M	2	line stage	100k 1%
R211, R212	1k00 1%	metal film			2	line stage	2k21
R211a, R212a	665 1%	metal film (on AD811 platform)			2	line stage	new
R213, R214	4k02 1%	metal film			2	line stage	27k4
R213a, R214a	1k00 1%	metal film (on AD811 platform)			2	line stage	new
R215, R216	20k0 1%	metal film			2	lo filter	same
R217, R218	475 1%	metal film			2	lo filter	same
R219, R220	20k0 1%	metal film			2	line out normal	20k0 1%
R221, R222	22k1 1%	metal film			2	tone control	same
R223, R224	6k81 1%	metal film			2	tone control	same
R225, R226	1k00 1%	metal film			2	tone control	same
R227, R228	6k81 1%	metal film			2	tone control	same
R229, R230	1k00 1%	metal film			2	tone control	same

FIGURE 15: Line stage 1kHz square wave response.

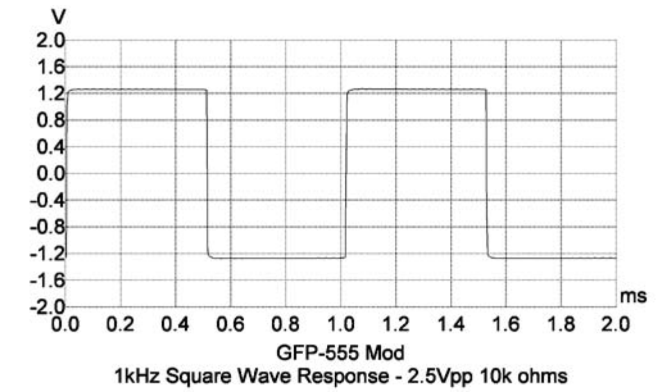


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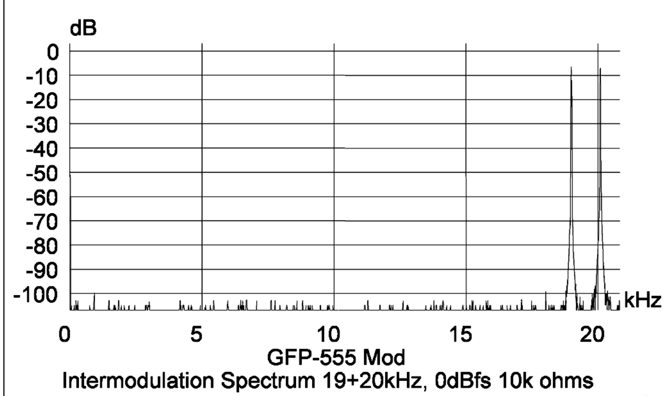
FIGURE 16: Line stage CCIF IMD.



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Symbol	New Value	Description	Vendor	Part No.	Qty	Circuit	Old value
R231, R232	6k81 1%	metal film			2	tone control	same
R233, R234	1k00 1%	metal film			2	tone control	same
R239/a, R240/a	100 1%	metal film			4	line stage	new
R301, R302	delete				2	headphone	47k5 1%
R303, R304	delete				2	headphone	100k 1%
R305, R306	delete				2	headphone	1k00 1%
R307, R308	delete				2	headphone	10k0 1%
R309, R310	delete				2	headphone	150 1%
R901, R902	jumper				0	dc supply	22 1/2W
R903, R904	delete				0	dc supply	3k32 1%
R905, R906	jumper				0	dc supply	332 1%
R907	100 1%	metal film (with 1N4002 parallel)			1	dc supply	2k21 1%
R907A, R910A	1k21 1%	metal film			2	dc supply	new
R908	100 1%	metal film (with 1N4002 parallel)			1	dc supply	8k25 1%
R909	delete				0	dc supply	12k1 1%
R910, R912	delete				0	dc supply	10k0 1%
R911	delete				0	dc supply	681 1%
R914	10k0 1%	metal film			1	relay delay	same
R915, R916	4k75 1%	metal film			2	relay delay	same
R917, R918	10k7 1%	metal film			2	relay delay	same
R919	475 1%	metal film			1	relay delay	same
R920	100k 5%	metal film			1	relay delay	56k2 1%
R921	jumper	jumper			1	relay delay	
R922	1M 5%	carbon film			1	relay delay	new
R923-R926	47.5 0.6W 1%	metal film	DK	BC47.5ZCT-ND	5	dc sply snubber	new
RY901	DPDT 1A	Relay 24V RZ24W, 1k ohm			1	relay delay	same
T001	36VCT 2A	SR5-5002-1			1	dc supply	TT-210GF
tw-pr/wh-blk		tone out left			1	tone control	
tw-pr/wh-blk		main out left, IC201 pin 6 at R			1	line stage	
tw-pr/wh-blk		vol control at R			1	headphone in	
tw-pr/wh-red		tone out rt			1	tone control	
tw-pr/wh-red		main out rt, IC202 pin 6 at R			1	line stage	
tw-pr/wh-red		vol control at R			1	headphone in	
TX438		headphone jack, 1/4" stereo			1	headphone	same
Txleft		Gold phono jacks, black		MCM 20-2110	9	input/output	
Txright		Gold phono jacks, red		MCM 50-2105	9	input/output	
VRbalance	50k dual	balance control, Alps			1	line stage	
VRbass	20k B dual				1	tone control	same
VRtreble	20k B dual				1	tone control	same
VRvolume	50k dual	volume control, Alps			1	line stage	same
		heat sink, DIP, Avid	DK	HS179-ND	10	line stage	
		heat sinks, TO220	DK	HS303-ND	4	dc supply	
		dip socket			7	all	
		dip platform			2	line stage	