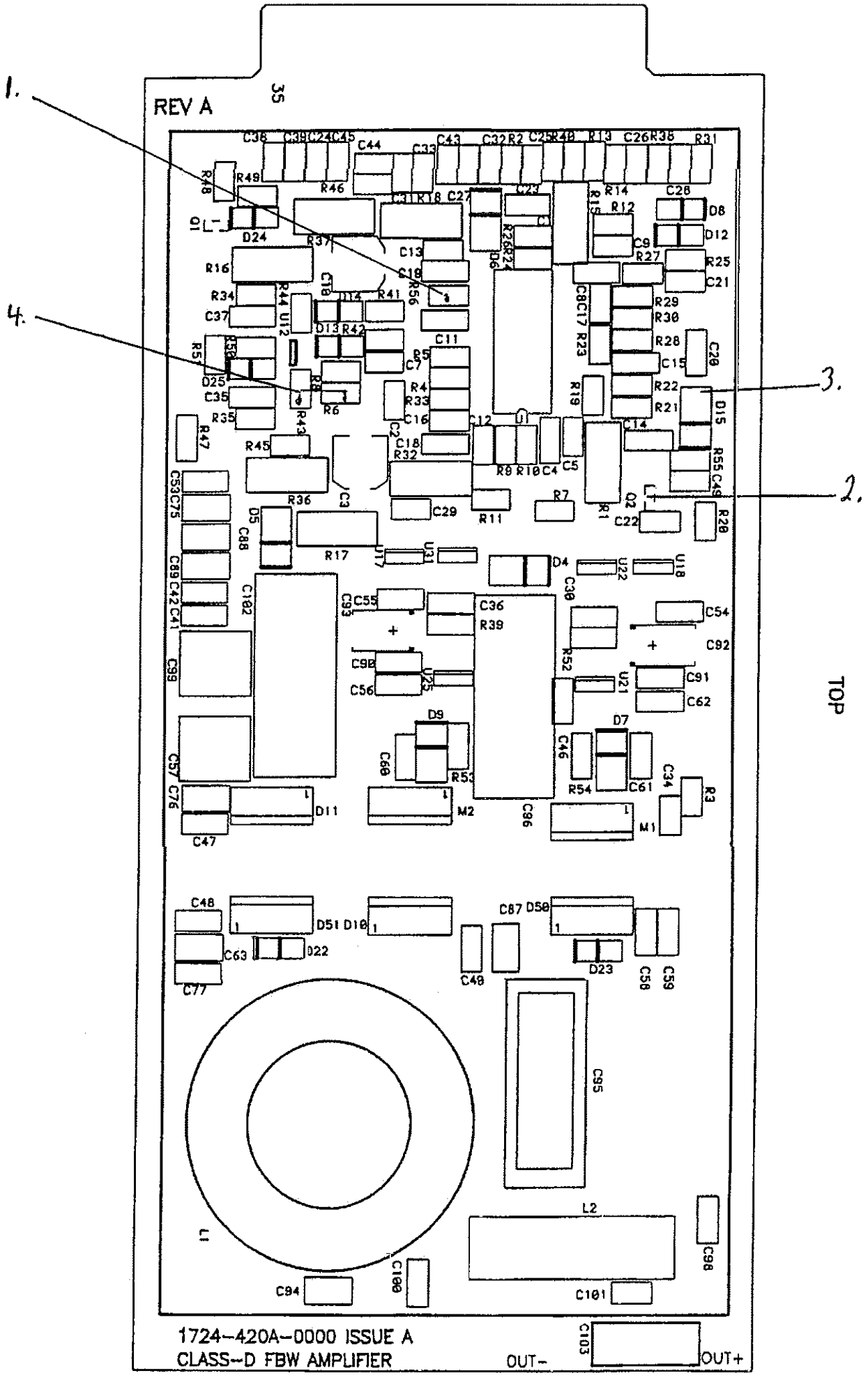
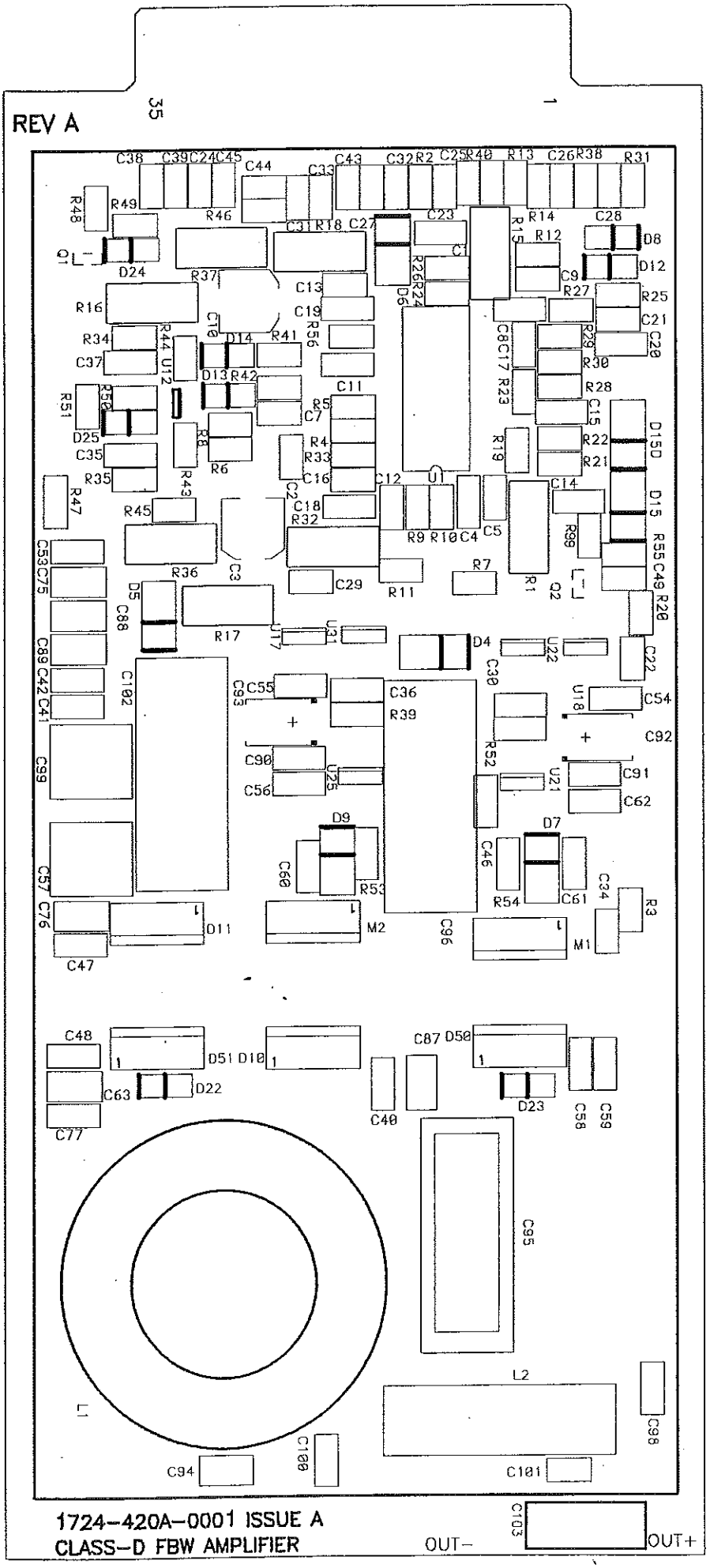
Celestion Qxa 122 & Qxa152 Amplifier Module
Service Pack

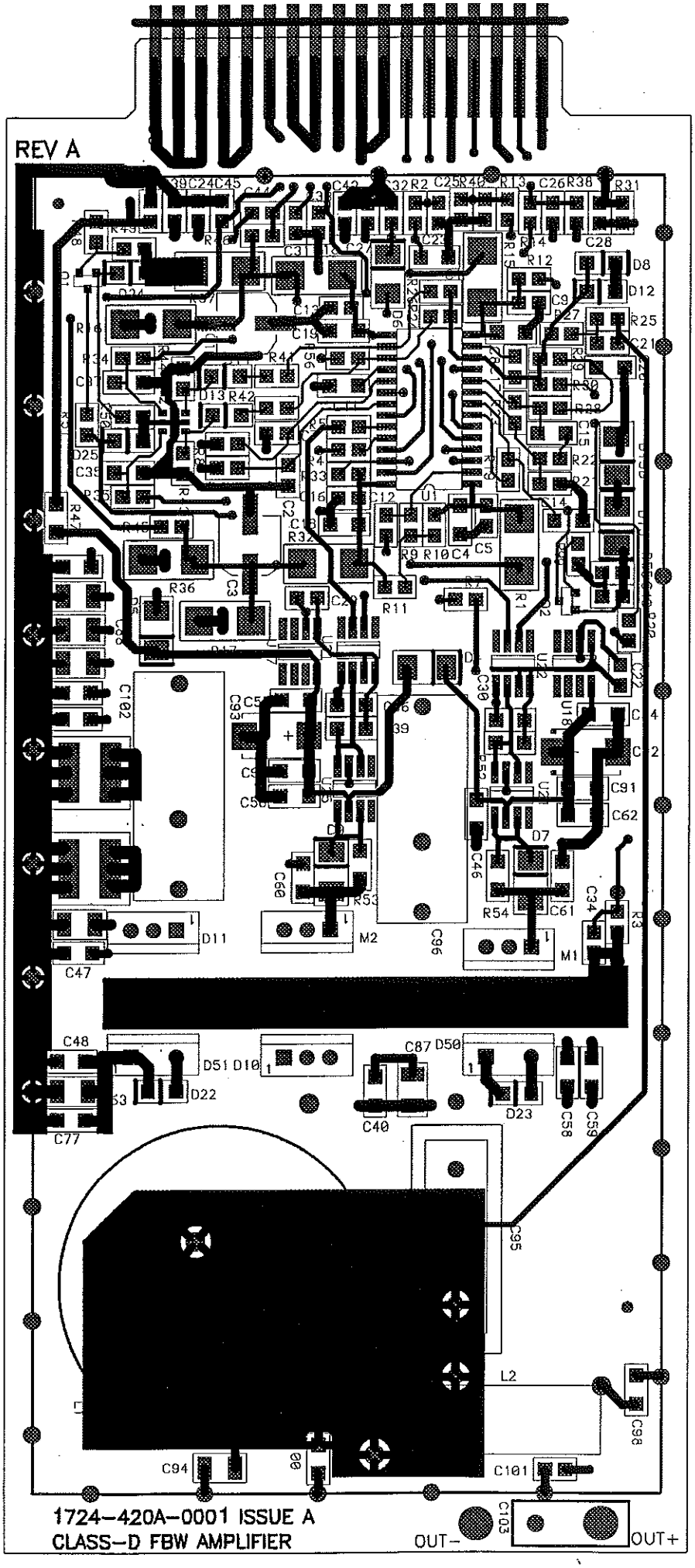
Contents:


1.
4.
3.
2.
REV A
35
TOP
1724-420A-0000 ISSUE A
CLASS-D FBW AMPLIFIER
OUT-
OUT+

COMING PRODUCTION WILL MODIFICATION PCB:



TOP
SILK SCREEN



TOP COMPONENT SIDE

CONTINUE PRODUCTION WITH MODIFICATION PCB :

HARRIS Semiconductor

HCA125ACREF

Data Sheet | December 1998 | File Number 4588

125/220 Watt Full Bandwidth Class D Amplifier

coolaudio™

The HCA125ACREF reference design delivers 125W RMS power into a 8Ω load and 220 watts into a 4Ω load. Since the efficiency is greater than 90%, no expensive, bulky heatsinks are required.

The design is part of Harris' Cool Audio program that supports customers to achieve a minimum time-to-market for audio end products. As part of this program, this design is offered after execution of a Licensing Agreement. At that time, Harris provides to the licensee a documentation package containing: 1) Circuit Description, 2) Schematics, 3) Test and Manufacturing Information, 4) A Bill of Material with all vendors and vendor part numbers, 5) Harris' Engineering Support Contacts, 6) and One Evaluation Unit.

For more information, see us on the web, home page http://www.semi.harris.com. For technical assistance, call Central Applications at 1-800-442-7747, or email us at centapp@harris.com.

Ordering Information

Contact Harris licensing agents, Continental Far East or International Operations. See contact information provided in this document.

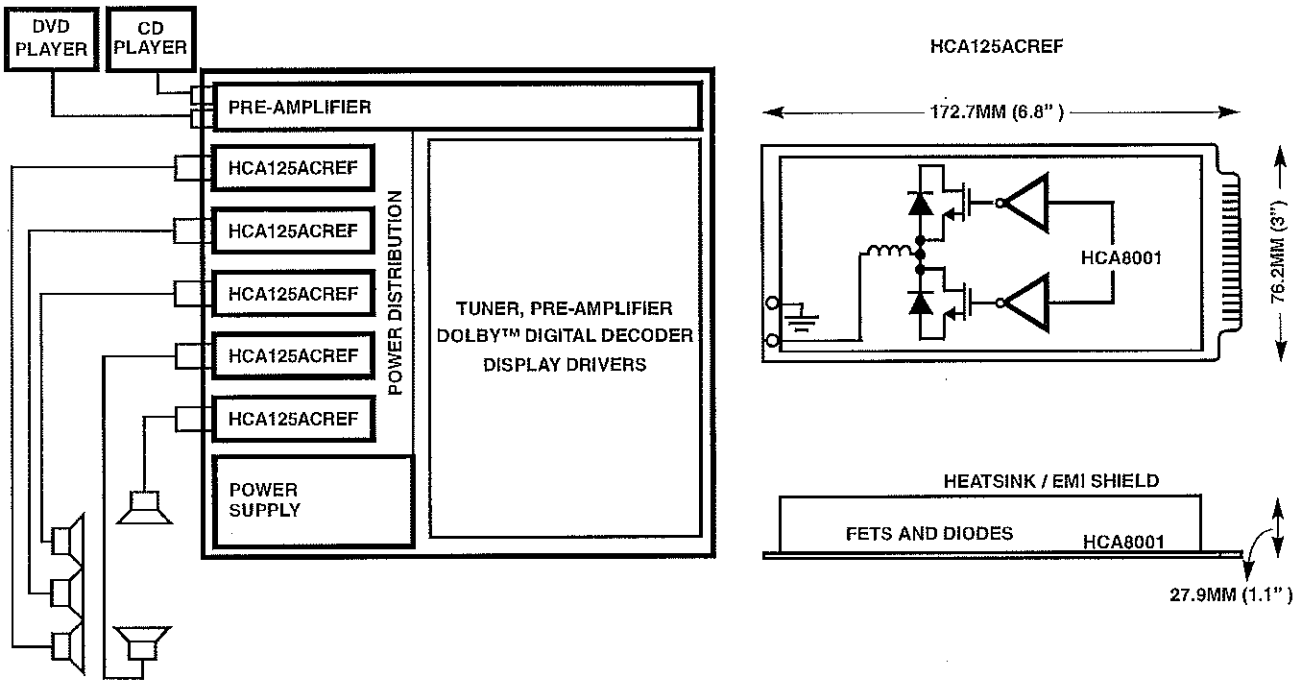
Features

- 125 Watts RMS Power into 8Ω
- 220 Watts RMS Power into 4Ω
- THD <0.07% at 1kHz and 110W into 8Ω
- SNR >100dB Relative to Full Power
- Output Noise . . . . . <110µV
- Constant Group Delay
- DC to 80kHz Small Signal Bandwidth
- Power Bandwidth 28kHz
- Slew Rate 8V/µs
- Efficiency >90% at 100W into 8Ω
- Meets FCC and EN55013 Requirements for EMC
- Based On the Harris HCA8001, Audio Specific IC
- Modular Design
- Differential Input
- Over-Current, Over-Voltage and Thermal Protection
- Soft Clipping
- Bridgeable up to 2000W

Applications

- Home Theater
- Hi-Fi Stereo

Reference Design Block Diagram



Absolute Maximum Ratings

Bus Voltage, V_{BUS} ..... ±70V
Audio Inputs ..... 12V Differential Peak to Peak Voltage

Operating Conditions

Bus Voltage, V_{BUS} ..... ±60V
Ambient Temperature Range ..... 0°C to 50°C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Specifications

R_{LOAD} = 8Ω, V_{BUS} = 60V Supply Source Resistance < 2.5Ω, Storage Capacitor > 22,000µF, 12V Bias Supply

PARAMETER	SYMBOL	TEST CONDITIONS	T_A = 25°C TYP	UNITS
SUPPLY SPECIFICATION				
Minimum Bus Voltage	$V_{S\ MIN}$	Full Output Power	±48	V
$\pm V_{BUS}$ RMS Current	$I_{V\ BUS}$	1kHz Sine Wave, Full Output Power (8Ω Load)	1.3	A
$\pm V_{BUS}$ RMS Current	$I_{V\ BUS}$	1kHz Sine Wave, Full Output Power (4Ω Load)	2.0	A
$\pm V_S$ Average Current	I_{VS}	Idle Current, No Signal	30	mA
12V Bias Supply Current	I_{BIAS}	Current supplied to power output gate driver circuitry.	120	mA
Rising Under Voltage Lock Out Voltage	$V_{UV\ Rising}$	Bus voltage that activates the amplifier.	±50	V
Falling Under Voltage Lock Out Voltage	$V_{UV\ Falling}$	Bus voltage that shuts down the amplifier.	±42	V
ENABLE Threshold Voltage	$V_{ENABLE1}$	Amplifier starts at this voltage, input amplifier muted.	1	V
ENABLE Threshold Voltage	$V_{ENABLE2}$	Input amplifiers active and entire amplifier active.	2	V
ENABLE Internal Source Current	I_{ENABLE}	Internal "Pull Up" Current	25	µA
OUTPUT POWER AND EFFICIENCY				
Maximum Output Power (Note 1)	$P_{MAX8\Omega}$	THD = 1%, 1kHz, R_{LOAD} = 8Ω	125	W
Maximum Output Power (Note 1)	$10\%THD_{8\Omega}$	THD = 10%, 1kHz, R_{LOAD} = 8Ω	160	W
Maximum Output Power (Note 1)	$P_{MAX4\Omega}$	THD = 1%, 1kHz, R_{LOAD} = 4Ω	220	W
Maximum Output Power (Note 1)	$10\%THD_{4\Omega}$	THD = 10%, 1kHz, R_{LOAD} = 4Ω	300	W
Efficiency	$PMAX_{EFF}$	P_{OUT} = 10W	63	%
	$PMAX_{EFF}$	P_{OUT} = 25W	76	%
	$PMAX_{EFF}$	P_{OUT} = 50W	85	%
	$PMAX_{EFF}$	P_{OUT} = 100W	90	%
AMPLIFIER PERFORMANCE				
Total Harmonic Distortion + Noise	THD+N	P_{OUT} = 100W, R_{LOAD} = 8Ω, 1kHz	0.05	%
Signal to Noise Ratio	V_{SNR}	Relative to full scale output, 125W into 8Ω.	103	dB
Output Noise	V_N	125W into 8Ω	110	µV
Intermodulation Distortion	IMD	SMPTE, 60Hz and 7kHz, 4:1, R_{LOAD} = 4Ω at 10W Output	0.03	%
PSRR ($\Delta V_{OUT}/\Delta V_{BUS}$)	PSRR	DC	300	µV/V
PSRR ($\Delta V_{OUT}/\Delta V_{BUS}$)	PSRRac	120Hz	-65	dB
Amplifier Output Offset Voltage	$\lvert V_{OS}\rvert$	DC voltage across the speaker, load = 8Ω	50	mV
Amplifier Output Impedance	Z_{OUT}	Measured at 1kHz and 10W Output	22	mΩ
Damping Factor	DF	Measured at 1kHz and 10W Output	350	
ADDITIONAL CHARACTERISTICS				
Cutoff Frequency, Referenced to 1kHz	F_{UPPER8}	-3dB, R_{LOAD} = 8Ω at 10W Output	80	kHz
Cutoff Frequency, Referenced to 1kHz	F_{UPPER4}	-3dB, R_{LOAD} = 4Ω at 10W Output	80	kHz

Electrical Specifications R_{LOAD} = 8Ω, V_{BUS} = 60V Supply Source Resistance < 2.5Ω, Storage Capacitor > 22,000µF, 12V Bias Supply **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS	T_A = 25°C TYP	UNITS
20kHz Response, Referenced to 1kHz	F_R at 20kHz	Output at 20kHz and 10W, R_{LOAD} = 8Ω	-0.4	dB
Power Bandwidth	P_{BW}	Maximum Frequency for Full Power R_{LOAD} = 8Ω	28	kHz
Slew Rate	SR	Maximum rate of change of the output voltage.	8	V/µs
Maximum Switching Ripple on Output	F_{PWM}	Full Output Power, R_{LOAD} = 8Ω	4.0	V
Input Gain	A_V	Either inverting or non inverting input. Unused input returned to analog ground.	26	dB
Input Impedance, Inverting Input	R_{IN}-	Differential amplifier input, other input grounded.	5	kΩ
Input Impedance, Non Inverting Input	R_{IN}+	Differential amplifier input, other input grounded.	10	kΩ
Output Signal Phasing	Phasing	Positive going signal on non inverting input results in negative going amplifier output.	180	Degrees
Over Temperature Shut Down	OT_{SD}	Rising temperature to shutdown amplifier. Set by an external thermistor.	110	°C
Over Temperature Hysteresis	OT_H	Difference between rising and falling temperature shut down and start up points.	10	°C
Amplifier Output Current Limit	I_L	Absolute Value	8	A
Amplifier Output Current Limit Time (Note 2)	T_{IL}	Time the amplifier must be in current limiting before shutdown.	50	ms

NOTES:

1. At this power level, the soft clipping circuitry is beginning to activate. It functions to "round off" peaks rather than hard limit as in most linear amplifiers. This helps to give this amplifier a pleasing sound during limiting. Moreover, this feature also makes the amplifier "sound louder".
2. This time allows the amplifier to reproduce large, sustained peaks without shutting down, yet is adequate to protect the amplifier output from shorted speaker lines.

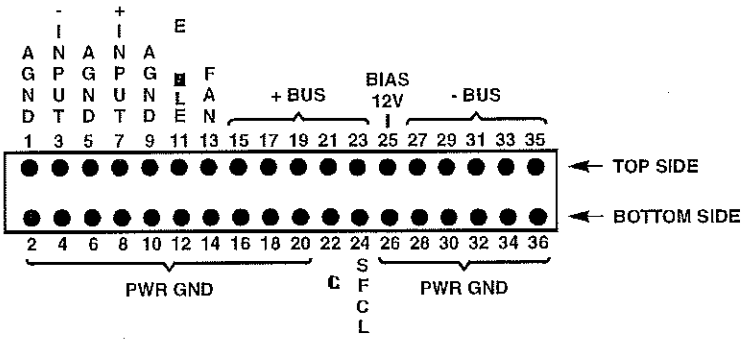


FIGURE 1. PC BOARD CONNECTOR SHOWN FROM THE BACK SIDE, LOOKING TOWARD THE HCA125ACREF BOARD

TABLE 1. HCA125ACREF BOARD TERMINAL DESIGNATIONS

TERMINAL	DESIGNATION	FUNCTION
1	Analog Ground	Input Ground
2	Ground	Power Ground
3	- Input	Signal Input
4	Ground	Power Ground
5	Analog Ground	Input Ground
6	Ground	Power Ground
7	+ Input	Signal Input
8	Ground	Power Ground
9	Analog Ground	Input Ground
10	Ground	Power Ground
11	ENABLE	Chip Enable
12	Ground	Power Ground
13	FAN	Driver Signal
14	Ground	Power Ground
15	+ BUS	Pos. Supply
16	Ground	Power Ground
17	+ BUS	Pos. Supply
18	Ground	Power Ground
19	+ BUS	Pos. Supply
20	Ground	Power Ground
21	+ BUS	Pos. Supply
22	CL	Drive Signal
23	+ BUS	Pos. Supply
24	SFCL	Drive Signal
25	12V	Bias Supply
26	Ground	Power Ground
27	- BUS	Neg. Supply
28	Ground	Power Ground
29	- BUS	Neg. Supply
30	Ground	Power Ground
31	- BUS	Neg. Supply
32	Ground	Power Ground
33	- BUS	Neg. Supply
34	Ground	Power Ground
35	- BUS	Neg. Supply
36	Ground	Power Ground

Typical Performance Curves

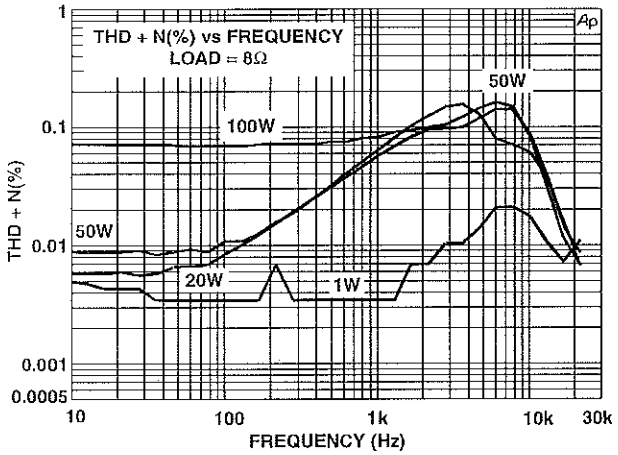


FIGURE 2. THD +N(%) vs FREQUENCY LOAD = 8Ω

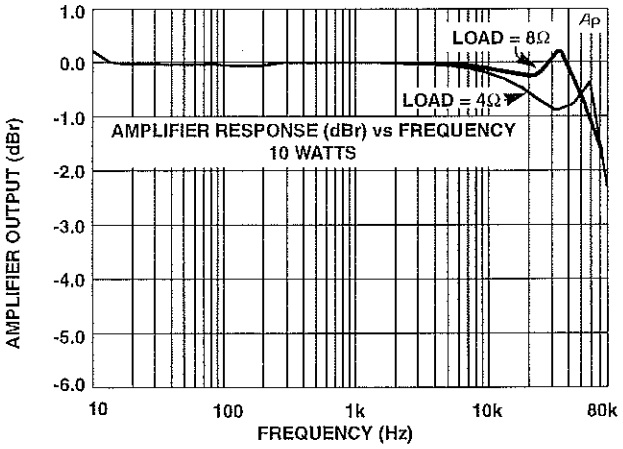


FIGURE 3. AMPLIFIER FREQUENCY RESPONSE AT 10W - LOAD = 8Ω

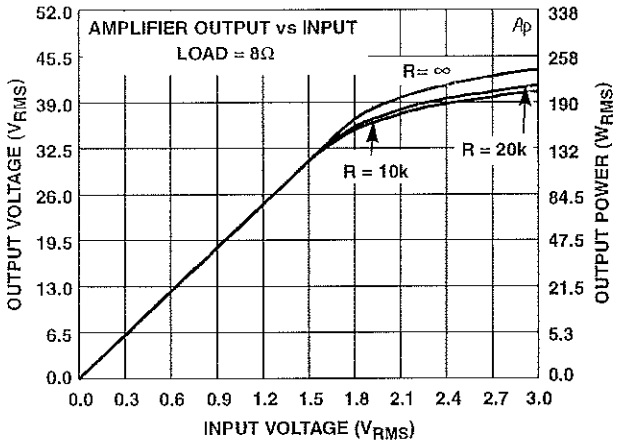


FIGURE 4. AMPLIFIER TRANSFER CHARACTERISTIC WITH VARIOUS SETTINGS OF SOFT CLIPPING RESISTOR

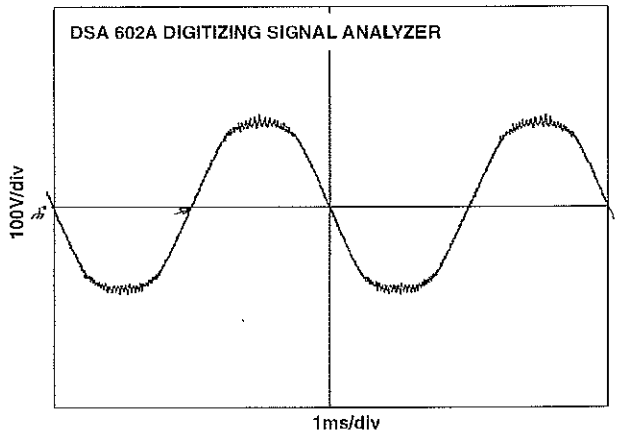


FIGURE 5. OSCILLOSCOPE DISPLAY OF AMPLIFIER OUTPUT WITH SOFT CLIPPING CIRCUIT ENABLED

Soft Clipping

Figures 4, 5 and 6 show the effects of the soft clipping circuitry within the amplifier. Figure 4 shows the transfer characteristic of the amplifier for various values of the soft clipping programming resistor. An important aspect of soft clipping is the apparent increase in sound level. As soft clipping is reached, the upper and lower envelope of the sinewave is gradually reduced. The "soft" clipping or rounding reduces the higher harmonics that would result if hard clipping as shown in Figure 6 was enabled. Soft clipping also results in an amplifier with a more pleasing sound. Figure 5 shows the rounding of the output with soft clipping, while Figure 6 shows the amplifier output without soft clipping.

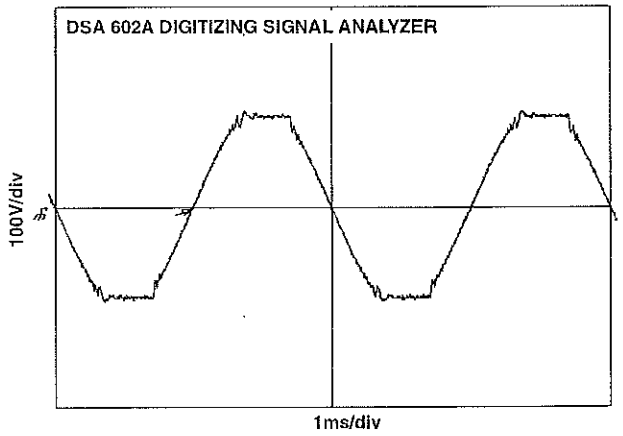
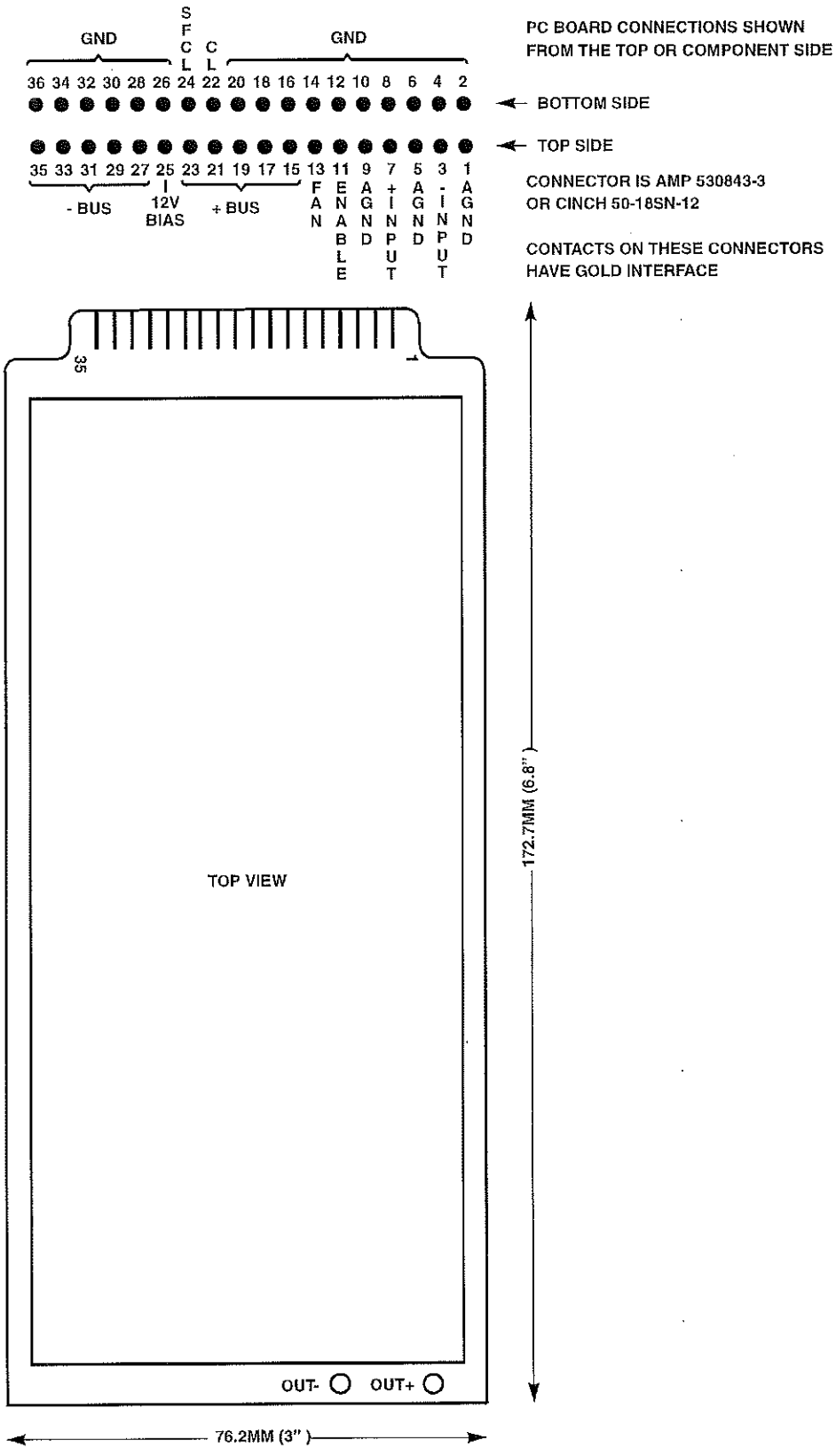


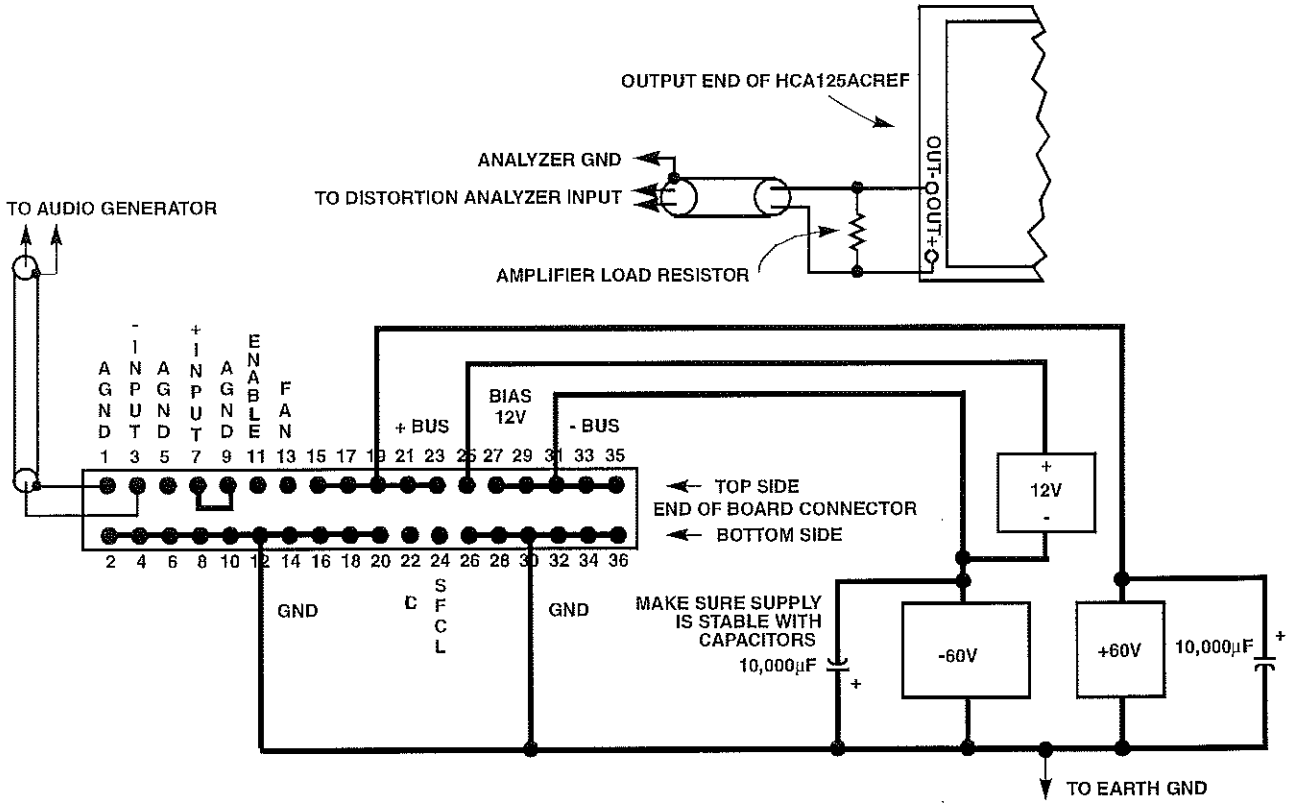
FIGURE 6. OSCILLOSCOPE DISPLAY OF AMPLIFIER OUTPUT WITH SOFT CLIPPING CIRCUIT DISABLED

Full Size Outline of HCA125ACREF Board

TOP VIEW



Schematic Diagram of HCA125ACREF Board Test Setup



CAUTION: Remove all POWER when INSERTING or REMOVING the AMPLIFIER board. MAKE SURE POWER SUPPLY CAPACITORS are DISCHARGED or DAMAGE to the AMPLIFIER may RESULT.

Board Test Equipment and Test Procedure for Harris HCA125ACREF Amplifier

Equipment required for evaluation of the Harris HCA125ACREF Amplifier is as follows:

1. Two 60V, 10A Power Supplies - Please read the next section, Test Procedure for Evaluation of HCA125ACREF, Item 1.
2. One 12V, 200mA Power Supply.
3. Distortion Analyzer such as the Audio Precision System One or System Two or equivalent.
4. Load resistors, 8Ω, 200W and 4Ω, 350W.
5. Associated connectors and cables.
6. HCA125ACREF Amplifier Board.

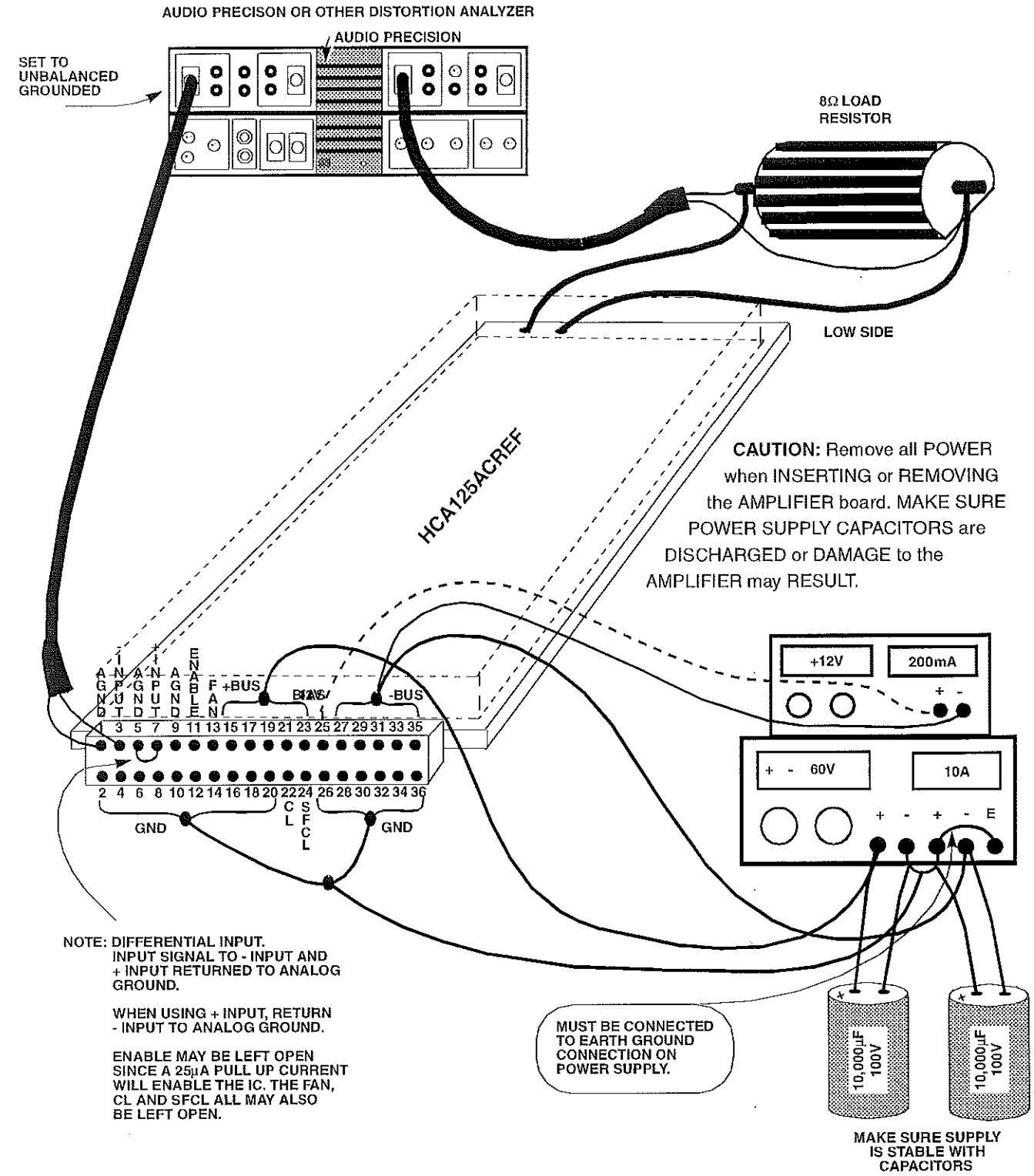
Test Procedure for Evaluation of HCA125ACREF

1. With no audio input signal, and the ±60V supplies current limit set at 1A and 10,000µF capacitors not connected, turn on the 12V amplifier bias power supply first. Next turn on both 60V supplies. The supply current with no input signal should be approximately 30mA. The 12V bias supply current should be about 120mA. After verifying that the supply current is normal, increase the current limit setting of the ±60V supplies to 3A and connect the 10,000µF capacitors (the actual amplifier current draw should remain constant with the supplies at ±60V at this point).

   It is important to note that many linear power supplies do not function properly with the peak current demands of these amplifiers at low frequencies. This is the reason for the 10,000µF capacitors applied across the two supplies. It is also important to make sure the supplies are stable with these capacitors.

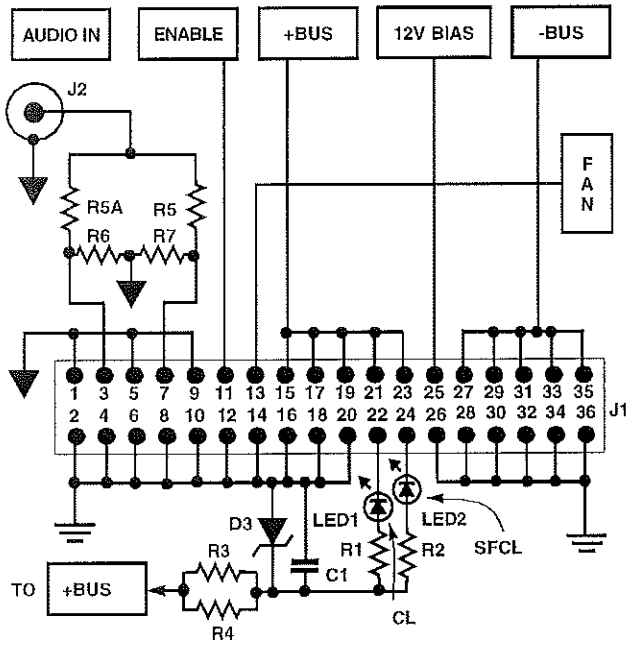
   A strong indicator of inadequate supply capacity is rising distortion at low frequencies. The amplifier distortion does not increase at low frequency. Transformer supplies with 10,000µF capacitors, for a single amplifier, are the most stable, providing the transformer can provide the required current.
2. Depending on the type of testing to be conducted (Output Power, Frequency Response, THD, etc.) select the menu and control panel settings on the Audio Precision Analyzer or other distortion analyzer to conduct the test. Input frequency should be set between 20Hz and 20kHz and input voltage level should be increased until desired output power is achieved. Conduct the desired tests in accordance with the Audio Precision or other analyzer test procedures. Power levels of 10W, 20W, 50W and 100W should be selected.
3. Power down audio signal input and turn off the ±60V power supplies before turning off the 12V bias supply.

Block Diagram of HCA125ACREF Test Setup



NOTE: The +60V and -60V supplies must be capable of supplying peak currents up to 13A.

Amplifier Test PC Board Interface Connector



SCHEMATIC DIAGRAM OF PC INTERFACE BOARD

INTERFACE PC BOARD COMPONENTS

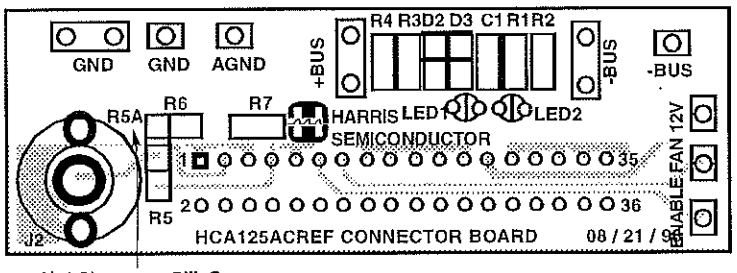
COMPONENT	VALUE	FOOTPRINT
R1	3.3k, 5%, 0.25W	1206
R2	3.3k, 5%, 0.25W	1206
R3	13k, 5%, 0.25W	1206
R4	13k, 5%, 0.25W	1206
R5	0Ω	1206
R5A	0Ω	1206
R6	0Ω	1206
R7	0Ω	1206
C1	0.1µF, 50V,10%	1206
LED1	LED	T1
LED2	LED	T1
D2	Not Populated	-
D3	12V, 5%, 0.25W	1206
J1	36 Pin Connector	-
J2	RCA Connector	-

PC BOARD CONNECTIONS FOR AUDIO INPUT

FUNCTION	R5	R5A	R6	R7
Inverting	Open	0 Ω	Open	0 Ω
Non-Inverting	0 Ω	Open	0 Ω	Open

The above tables show the method of connecting the amplifier audio input interface PC board connector, J2, to either the positive or negative input of the amplifier board. Note not all components need to be populated. For example, only two resistors are used for connection to the input amplifier. If the LEDs are not used, then the zener diode and associated resistors are not needed. The FAN output is available for an optional fan controller.

Holding the ENABLE terminal low by sinking the internal 25µA pull up current to ground will disable the amplifier output stage. Removing this ground shunt will restore normal amplifier operation. Both the ENABLE and FAN terminals may be left open.



Not Shown on Silk Screen

Component side locking towards end of amplifier module.

NOTE: Not all parts are populated. Refer to tables for components and options.

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Notes

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PRODUCT PERFORMANCE SPECIFICATION

A. REVISION HISTORY

Iss. Date	Revisions	Description
4/13/1999	A	Pilot Run Release
6/08/1999	B	Mass Production Release - **Item B (1)** updated, was 110V~120V 60Hz for UL version & 220V~240V 50Hz for Euro version - **Item C (iv)** updated, was 250mV 15kHz input signal for Class-AB amplifier testing - **Item C (1) & (2)** added to use 80kHz LPF for measuring data - **Item C (4)** updated, was 240mV±10mV in HF LINE mode & 5.5V±0.5mV in LF MIC mode - **Item C (6)** updated. For LF from 20Hz to 10kHz, was 15.5, -6.7, 0.2, 4.2, 5.0, 4.2, 3.5, 2.5, 1.2, 0.7, 0, -2.5, -6.7, -10.5, -15.5, -33.0. For HF from 1 to 20kHz, was -46.7, -26.2, -16.7, -11.2, -8.5, -2.0, -1.5, 0, 1.0. - **Item C (7)** added, 1.7kV, 5mA, 2sec for HI-POT test - **Item D (3), (4) & (6)** modified on testing procedures, was using DIN-WTD filter for noise floor measurement - **Item E (6)** added on limiter circuitry functionality

PRODUCT PERFORMANCE SPECIFICATION

B. GENERAL ITEMS

1) **Operating voltage**
   UL/CSA version AC 115V +/- 10% 60Hz
   Euro version AC 230V +/- 10% 50Hz

2) **Power Amplifier**
   (a) Low Frequency: Class-D amp module, 200W rms into 4ohm speaker load
   (b) High Frequency: Class-AB amp, 40W rms into 8 ohm speaker load

3) **Input** Balanced XLR female socket for line and mic inputs

4) **Output** Balanced XLR socket, direct out, no crossover

5) **Control**
   (a) Gain control knob
   (b) Mic / Line input switch

6) **Mains Input and control**
   (a) AC power switch
   (b) IEC AC socket with fuse holder
   (c) Voltage selector switch (115V / 230V)

7) **Indicator**
   (a) Red LED for power on indication
   (b) Green LED for Mic input selection
   (b) Yellow LED for output clipping

8) **Amplifier Protection**
   Overcurrent, overvoltage & thermal protection provided on LF amp module

9) **Construction**
   Electro-galvanised steel plate with black spray is used for the panel for mechanical strength

10) **Safety**
    AC 220~230V version : meets EN 60065 1993 European

11) **EMC**
    EN55013, EN55020, EN61000-3-2 & EN61000-3-3

PRODUCT PERFORMANCE SPECIFICATION

C. GENERAL SPECIFICATION

Testing conditions:

(i) Power source: AC 230V

(ii) Settings: Voltage selector set to 230V. MIC / LINE switch NOT pushed (LINE input). MIC LED is OFF. VOLUME set to minimum when start.

(iii) Loading: 4Ω to Class-D (low frequency) amplifier output
8Ω to Class-AB (high frequency) amplifier output

(iv) Frequency and level: 800mV 1kHz for Class-D amplifier and 260mV 15kHz for Class-AB amplifier, unless otherwise specified

	Unit	Typical	Limit
1) Output power (80kHz LPF)			
for LF Amp @ 4Ω @ 0.5%	W	200	>200
for HF Amp @ 8Ω @ 0.3%	W	40	>40
2) Total harmonic distortion (80kHz LPF)			
for LF Amp @ 200W (4Ω)	%	0.2	0.5
for HF Amp @ 40W (8Ω)	%	0.15	0.3
3) S/N (DIN-AUDIO WTD, at MAX VOL.)			
for LF Amp @ 200W (4Ω)	dB	90	88
for HF Amp @ 40W (8Ω)	dB	82	80
4) Input sensitivity			
In LINE mode			
for LF Amp	mV	745	±20mV
for HF Amp	mV	250	±10mV
In MIC mode			
for LF Amp	mV	6.0	±1.0mV
for HF Amp	mV	2	±0.2mV
5) Hum & noise (DIN-AUDIO WTD, short-circuit termination)			
At Min. Volume			
for LF Amp	mV	0.6	0.8
for HF Amp	mV	0.6	0.8
At Max. Volume			
for LF Amp	mV	0.8	1.0
for HF Amp	mV	1.5	2.0

6) Frequency Response
for LF Amp (0dB ref. at 1kHz)

Frequency (Hz)	Unit	Typical	Limit
20	dB	-13.7	±0.5
30	dB	-5.3	±0.5
40	dB	1.1	±0.5
50	dB	4.9	±0.5
60	dB	5.3	±0.5
70	dB	4.6	±0.5
80	dB	3.8	±0.5
100	dB	2.8	±0.5
200	dB	1.4	±0.5
500	dB	0.8	±0.5
1k	dB	0	±0.5

PRODUCT PERFORMANCE SPECIFICATION

2k	dB	-2.8	±0.5
3k	dB	-6.7	±0.5
4k	dB	-10.9	±0.5
5k	dB	-15.1	±0.5
10k	dB	-32.8	±1.5

for HF Amp (0dB ref. at 15kHz)

Frequency (Hz)	Unit	Typical	Limit
1k	dB	-45.8	±2
2k	dB	-25.6	±1
3k	dB	-16.0	±0.5
4k	dB	-11.2	±0.5
5k	dB	-8.3	±0.5
10k	dB	-2.3	±0.5
11k	dB	-1.7	±0.5
15k	dB	0	±0.5
20k	dB	1.2	±0.5

7) HI-POT TEST - 1.7kV, 5mA, 2sec

PRODUCT PERFORMANCE SPECIFICATION

D. Testing Procedure

1) Power Testing - referring to **Item C (1)**
1kHz input signal level set to 800mV, other settings as stated before. Adjust the VOL. VR until the required output level on LF amp (28.3Vrms) is attained. Note that there should be no output clipping. Similarly for HF side, 15kHz input signal level set to 260mV first. Check and make sure no output clipping on HF side also when it is at full power condition (17.9Vrms).

2) THD Measurement - referring to **Item C (2)**
1kHz input signal level set to 800mV, other settings as stated before. Adjust the VOL. VR until the full power conditions is attained on LF side and the THD is recorded. For HF side, use 260mV 15kHz signal and repeat the similar procedure to get the THD.

3) S/N Measurement for LF Amp - referring to **Item C (3)**
1kHz input signal level set to 500mV, other settings as stated before. Turn the VOL. VR fully clockwise and gradually increase the input signal level until output attains 28.3Vrms on LF side. Signal Levels are recorded in dB. After that, use a short-circuit terminator at the input instead and measure the output noise level in dB by using a noise meter with DIN-AUDIO WTD filter. Calculate the S/N at full power by taking the difference of these two data measured.

4) S/N Measurement for HF Amp - referring to **Item C (3)**
15kHz input signal level set to 150mV, other settings as stated before. Turn the VOL. VR fully clockwise and gradually increase the input signal level until output attains 17.9Vrms on HF side. Signal Levels are recorded in dB. After that, use a short-circuit terminator at the input instead and measure the output noise level in dB by using a noise meter with DIN-AUDIO WTD filter. Calculate the S/N at full power by taking the difference of these two data measured.

5) Input sensitivity Measurement - referring to **Item C (4)**
First measure the input sensittivity in LINE mode. For measuring the input sensitivity of LF amp, first set the input signal (1kHz) to 500mV and turn the VOL. VR to maximum. Then by increasing the signal level until full power condition attained, obtain the input sensitivity (the voltage difference between pin 2 & 3 of the XLR socket). Similar procedure for HF side except that the input signal (15kHz) is set to 150mV at start. For MIC mode measurement, first push the MIC/LINE switch and make sure the MIC LED goes on. Start at 4mV 1kHz at LF amplifier and 1mV at HF amplifier and repeat the whole procedure above to take the data.

6) Hum and Noise Measurement - referring to **Item C (5)**
Short-circuit the input and measure the output noise level by using a noise meter with DIN-AUDIO WTD filter at minimum and maximum volume level.

7) Frequency Response Measurement - referring to **Item C (6)**
Set either amplifier to about 1/8 full power (20dBV for LF amp, 15dBV for HF amp) at reference frequencies (1kHz for LF amp, 15kHz for HF amp) first and measure the output signal level in dB. Vary the frequency and record the magnitude correspondingly. Normalize the frequency response by adjusting the magnitude of the reference frequency to be 0dB.

8) Voltage Selector Circuitry Testing
Switch the voltage selector to 115V position. Use a variac to give a 115V supply voltage to the amplifier module and confirm the same performance as at 230V supply.

PRODUCT PERFORMANCE SPECIFICATION

E. Functional Test

1) MIC / LINE SWITCH - when Mic / Line switch is pushed in, Mic input is selected and green LED should be turned on. If pushed out, Line input is selected and green LED goes off.

2) RED POWER ON LED - this should be lit on when the whole module is powered on.

3) YELLOW CLIPPING LED - this should be lit on when maximum power is exceeded.

4) BAL OUT - the signal should be the same as the BAL IN signal.

5) DELAY CIRCUITRY - set a 3kHz input signal with level 1Vrms. Turn the VOL. VR until a readable output waveform can be observed on both amplifiers. Power off the unit and then turn it on again. Check whether the output waveform from both amplifiers can come up at the same time (within 1s), after an about 4s of delay time.

6) LIMITER CIRCUITRY - set a 2Vrms 1kHz input signal. Turn the VOL. VR to maximum. The LF output at that time should be around 40Vrms. After an about 40s time, the LF output should drop to around 31Vrms.