ALPHA 9500 HF Power Amplifier
Test Report for Grant of Certification for Use in Part 97 Amateur Service under the Rules of the Federal Communications Commission

DGVPA-77DF

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Submitted by:
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Preliminary
Ver. 1.16A

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1.0 Introduction

This report details the results of the tests performed to demonstrate compliance of the design and manufacturing configuration of the ALPHA 9500 amplifier with the FCC Part 97 Section 97.317 "Standards for certification of external RF power amplifiers."

Two compliance matrices listing the applicable FCC regulations and the corresponding section of the test report that address these rules are provided as Appendices A-1 and A-2 in this report.

The Applicant/Manufacturer under the FCC rules is:

RF Concepts, LLC.
6185 Arapahoe Road
Boulder, CO 80303
FCC Grantee Code: DGV

The Applicant's point of contact for questions regarding this report is Gordon E. Hardman, Vice President and Chief Technical Officer. His phone number is 303.473.9232, and his e-mail address is gordon@rfconcepts.com.

2.0 Description of Amplifier

The ALPHA 9500 is fully assembled and tested at the factory prior to shipment to a customer. Because of the mass of the AC transformer and the concern of damage to the chassis during shipment, the unit is shipped in two packages – one containing the power transformer and the second containing the rest of the fully assembled amplifier. After unpacking, the transformer is installed by the user by mounting it inside the cabinet into four pre-drilled PIM-reinforced mounting holes and is connected electrically to the Amplifier using two factory-installed molex-type connectors. No other assembly is required by the end-user.

After installation of the A/C transformer by the user, the entire Amplifier is contained in one enclosure. The band-switching is either automatic or manual as the Amplifier is designed to operate as a "multiband amateur HF amplifier" within band segments from the 1.800 MHz to 29.6 MHz Amateur band. The output stage of the amplifier is designed around a 3CX1500A7 (8877) triode, a vacuum tube manufactured by Eimac in San Carlos, CA. The data sheet for this tube is provided in Appendix B.

2.2 Design Features

A block diagram illustrating the general configuration of the ALPHA 9500 is provided in Appendix C. The amplifier has input and output bypass switching which permits the driving source (transmitter or transceiver) to be directly connected to the load. This

allows reception of signals if the load is an antenna and the source a transceiver, or direct transmission from the transmitter without the amplification afforded by the ALPHA 9500 if the source is a transmitter. An input matching and input RF detect board detects (in an analog fashion) the presence or absence of drive power from a nominal 50 ohm source, and matches this power to the drive requirements of the tube within the band 1.8-29.6 MHz. The 3CX1500A7 tube amplifies the RF signal, and the output matching network matches this power to a nominal 50 ohm impedance.

The output power is low-pass filtered and returned to the output bypass relay. This power, and any reflected from the load, is monitored by an output power sensor. The power for the operation of the tube and all other circuits is supplied from the AC line by a transformer-coupled power supply of conventional design. A controller module establishes correct operating conditions for the tube and provides operating power for the ancillary circuitry. A front panel display allows the operator to correctly set up the amplifier so that it can be operated in compliance with the FCC requirements. The amplifier does not require any alignment or set-up functionality other than the routine front-panel tuning of the output tank circuit that is required to match the amplifier output to the output load over the 1.8-29.6 MHz segmented bands.

These bands are listed below;

Meters	KHz	KHz
160	1800	2000
80	3500	4000
40	7000	7300
30	10000	10100
20	14000	14350
17	18068	18168
15	21000	21450
12	24890	24990
10	28000	29700

2.3 DC operating Conditions

The final tube is operated in Class AB2, with an electronic bias switch (EBS) to switch the tube to its nominal bias setting only when RF is present at the input. The tube plate voltage is approximately 3.56 kV under no-load conditions, and approximately 3.20 kV when tuned up correctly and delivering full output power. The current drain from the high voltage supply is in the range 0.9 to 1.2 Amps under full load. The grid current is less then 50 mA under normal conditions. The control grid (grid 1) voltage is also regulated, and is set during manufacturing to values that give the correct idle current for the tube which is about 250 mA. The approximate control grid voltages are: receive, +40 V; operating idle, +8.2 V; operating active.

2.4 Special Design Considerations

Care has been taken in the design of the ALPHA 9500 to ensure compliance with the applicable FCC requirements set forth in Part 97 and Part 2 of the Commission's rules. Examples of these features include:

2.4.1Minimal gain at 27 MHz

FCC rules severely restrict gain in the 11m (27MHz) band. This is frequency from 26-28 MHz. The ALPHA 9500 has a unique design feature which makes achieving useful gain in this frequency range impossible. At the input of the amplifier, the driving signal is sampled, and this sample is applied to a frequency counter. The frequency of the driving signal can be determined to within +/- 5kHz. The master microprocessor compares this frequency with a pre-programmed table to determine whether to allow the unit to become fully functional. If it determines that the frequency lies outside the allowable bands, the amplifier remains in Bypass mode, with the input connected directly to the output. Thus the unit has 0 dB gain. There are a few ranges that are blocked for purely technical reasons relating to the design of the product. The range 26-28 MHz is specifically blocked, and the amplifier remains in bypass over this range. The operational parameters are fixed by programming code and are not available to the user. Since the master microprocessor is actually the frequency counter, there is no simple way for this feature to be defeated without severely impacting other functions of the amplifier.

2.4.2 In-band Gain

Gain in the intended amateur ham bands of between 1.8 MHz and 29.6 MHz is limited to no more than 15 dB by means of the way in which the tube is biased and operated. Increasing the gain beyond this is not possible by any simple modifications.

2.4.3 Spurious Emissions

The output filter provided in a Pi L network impedance matching for each amateur band segment. Typical second through fifth order harmonics attenuation is better than 60 dBc due to the Q of the matching networks.

There is no computer, crystal oscillator, switch-mode power supply or other source of spurs non-harmonically related to the driving RF source. The tube circuitry has been designed in accordance with well-established procedures, including the use of an anti-parasitic choke to ensure that the tube will not oscillate by itself at any frequency. Each section of the amplifier design is compartmentalized, and adequate filtering is used for connections between sections.

The cabinet is closed by multiple fasteners, which are spaced close enough to prevent accidental leakage of radiation from the seams. The power cord is bypassed to prevent radiation into and from the AC power supply. RF cable connections are provided with standard SO-239 RF connections.

2.4.4 Anti-tampering Features

There are no user-accessible modifications which allow the amplifier to exceed it's design specifications. The tube is operated in a socket specific to that type of

tube, and there are no tubes of greater capability which will fit into that socket.

There are no power supply voltage taps or other DC voltage or current adjustments which increase output power. The power supply has been designed such that the amplifier is reliably capable of sustained operation at full power. In addition, the amplifier power supply will sense the input voltage and automatically select the proper input voltage tap on the transformer so the power supply will always have the proper tube anode voltage.

There is no input attenuation of the RF input signal. The input circuit is constructed on a printed wiring board, and it would be difficult for a user to modify this in any way to exceed the specifications without risking consequential damage to the amplifier. The amplifier is a triode grounded grid design, and the control cathode circuit uses a Pi network design. Almost all of the RF input power is dissipated as heat or loss in the input circuit and drive for the tube. Changing its value or removing it will result in amplifier instability which will likely damage or destroy part of the amplifier. In addition if the drive is increased beyond an acceptable level the amplifier will fault, automatically removing the amplifier from the RF path.

3.0 Test Results

Appendices A-1 and A-2 summarize the applicable certification requirements set forth in 47 CFR Section 2.1060 and 47 CFR 97 of the Commission's rules that the ALPHA 9500 Amplifier meet in order to be certified for Service under Part 97. Appendix A-2 deals with the requirements set for in Part 2, Section 1033 and Appendix A-1 deals with the requirements set forth in Part 97, Sections 307 and 317.

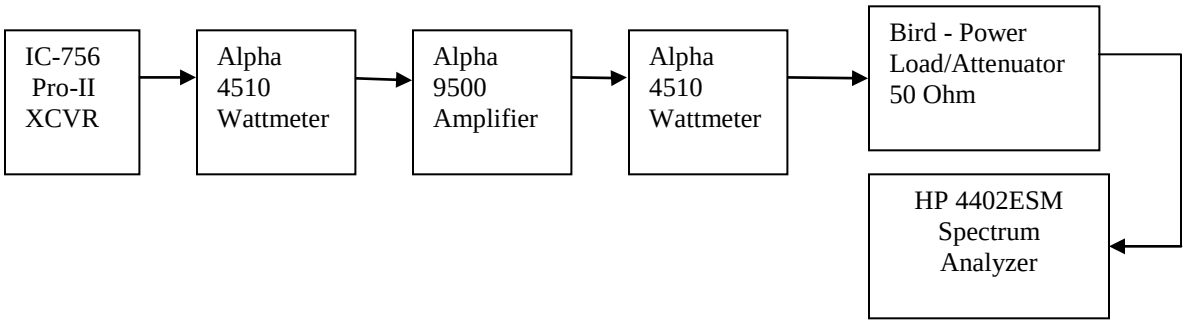
The specific amplifier used in all testing is the Model **ALPHA 9500, serial number ARP00102.** This amplifier was built to the design specifications to which the final (FCC certified) product will be manufactured. Production materials used in the test unit are the same that are anticipated to be used in the production version. No changes to the design of the production version are anticipated.

Test Equipment Used

Equipment Manufacture	Model Number	Serial Number
Kenwood Exciter	IC-756 Pro-II	1887
Alpha Input Wattmeter	4510	ARP00021
Bird Power Attenuator	8325	2454
Alpha Output Wattmeter	4510	ARP00102
Agilent Spectrum Analyzer	ESM4402B	MY45104412
Unity gain reference antenna	Dipole 01	NA

3.1 In-Band Gain

The FCC requirement is to demonstrate that the amplifier will not produce more than 1500 watts output when driven by less than 50 watts input. The test method used was to adjust the amplifier to deliver 1500 watts into an artificial antenna and measure the drive power required to produce this power. The test setup was as shown in Figure 3.1-1 below.



The drive source for this test is a currently available Amateur Radio transceiver manufactured by Icom, the Model IC-756 Pro II. It has adjustable output power up to about 100 watts across the 1.8-29.7 MHz band. For RF power measurement, the Alpha 4510 model directional wattmeter was chosen for both input and output power measurements. Typical Accuracy is +/- 4%

3.1.1Test Procedure

The amplifier was tuned up for 1500 watts output power in band from 1.8 to 29.7 MHz as indicated on the output 4510 wattmeter. The input RF drive power required to obtain this condition was read from the input Bird wattmeter. A spectrum analyzer was connected to the output of the Bird power attenuator via power attenuation pad to ensure that the spectrum was clean, and that the amplifier was not being tuned to an oscillation or other spurious output. This was repeated in the upper and lower band edges for each band. Spurious outputs directly related the output frequency were examined up to the 10^{th} harmonic. Results were recorded in dB below full carrier output, or dBc. Other spurious signals were recorded if they exceeded the noise floor of the test setup- which was below –80 dBc.

3.1.2 Results

Across the HF amateur band, power was set to 1500 watts out and the input drive was recorded. The data taken is presented in Table 3.1.2.1, page 8. This power level was used for all frequencies except 10 MHz amateur band where the power output was set for 200 watts maximum.

Band Meters	Frequency	Power In	Power Out	2nd	3rd	4th	5th	6th	7th-10th	Gain dB
160	1810	60	1500	-59	-63	-80	-80	-80	-80.00	13.98
160	1990	56	1500	-60	-70	-80	-80	-80	-80.00	14.28
75	3510	54	1500	-60	-71	-80	-80	-80	-80.00	14.44
80	3990	50	1500	-62	-68	-80	-80	-80	-80.00	14.77
40	7010	70	1500	-66	-69	-77	-80	-80	-80.00	13.31
40	7290	69	1500	-69	-73	-80	-80	-80	-80.00	13.37
30	10.01	60	1500	-63	-68	-80	-80	-50	-80.00	13.98
30	10.01	7.4	200	-80	-80	-80	-71	-80	-80.00	14.32
20	14010	57	1500	-65	-80	-80	-70	-80	-80.00	14.20
20	14340	50	1500	-67	-80	-80	-67	-80	-80.00	14.77
17	18010	53	1500	-65	-80	-80	-80	-80	-80.00	14.52
17	18158	56	1500	-67	-80	-80	-80	-80	-80.00	14.28
15	21010	60	1500	-73	-80	-80	-80	-80	-80.00	13.98
15	21440	63	1500	-70	-80	-80	-80	-80	-80.00	13.77
12	24940	57	1500	-71	-64	-80	-80	-66	-80.00	14.20
11	26000-28000	1-100	1-100	-80.00	-80.00	-80.00	-80.00	-80.00	-80.00	Unity
10	28100	53	1500	-71	-71	-80	-80	-80	-80.00	14.52
10	29600	51	1500	-69	-67	-80	-61	-80	-80.00	14.69

Table 3.1.2.1. Spurious emission levels referred to carrier power (dBc)

There were no other detectable spurious emissions from the product above the test equipment threshold, approximately 80 dB below full power output. The test was repeated with the amplifier in Standby mode, and no emissions exceeding those in the above table were found. The amplifier was placed in the Off condition, and no spurious emissions exceeding those in the above table were found.

3.1.3 Conclusion

The results show that the amplifier satisfies the requirement of 97.307 (d) that the mean power of any spurious emission from a station transmitter or external RF amplifier transmitting on a frequency below 30 MHz must be at least 43 dB below the mean power of the fundamental emission, in Operate, Standby or Off condition.

The ALPHA 9500 complies with the FCC requirement 97.317 (a)(1) because it is not capable of amplifying the input RF power (driving signal) by more than 15 dB gain on all frequencies at which it is intended to operate since (1) the amplifier requires at least 50 Watts of drive to produce the designed output power (2) the amplifier gain does not exceed 15 dB, and (3) since the amplifier is linear, it will proportionally produce lessmthan 1500 watts at lower input levels.

3.2 Out-of-Band Gain

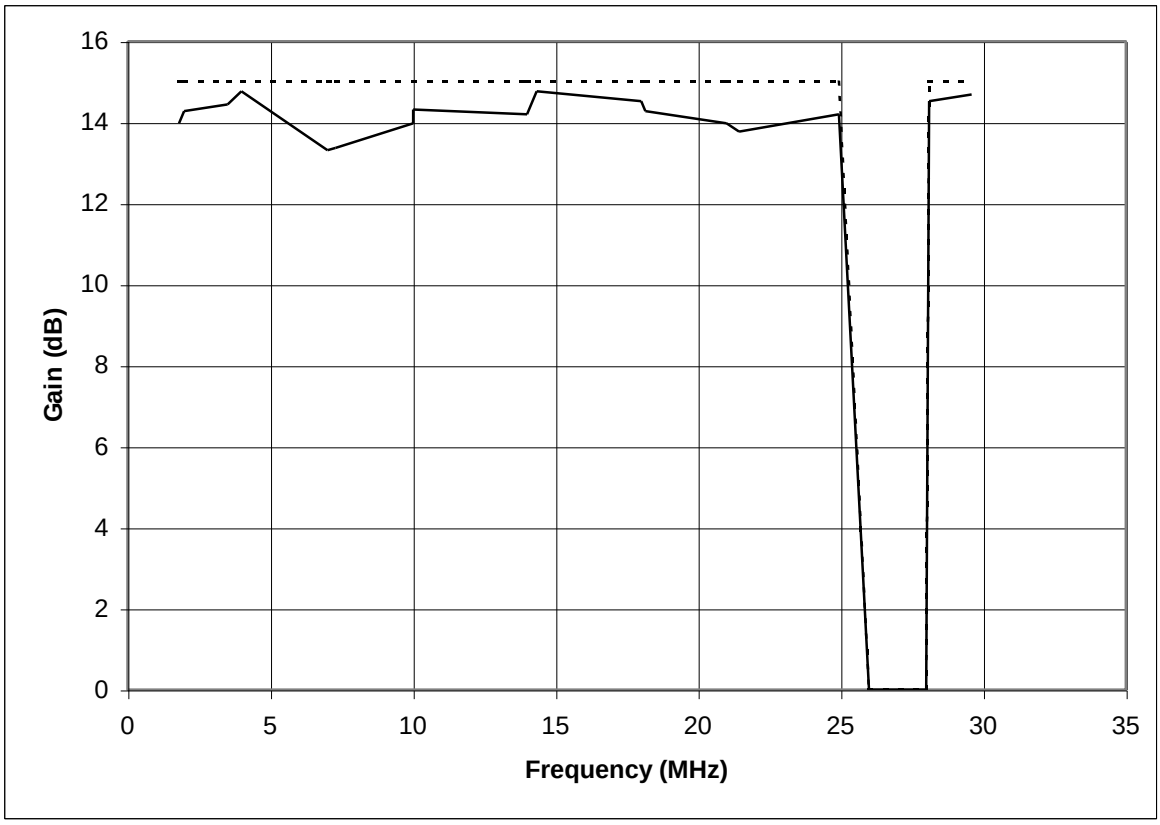
97.317 (a)(3) requires that a power amplifier shall exhibit no more than 0 dB gain from 26-28 MHz; less than 0 dB of gain from 26-28 MHz. The test method used to determine this was to place the amplifier in its operational mode, and adjust it for maximum gain at these frequencies (26-28 MHz) , and then measure the "insertion gain", that is, the gain measured by inserting the amplifier into circuit while controlling the drive power to a constant level. The test setup was identical to that used for in-band gain measurement, and is shown in Figure 3.1-1.

3.2.1 Test Procedure

The amplifier was set to its operational mode, and the gain adjusted for the maximum gain at the frequency band listed above. The Microprocessor controller will read the input frequency of each band. If the input frequency falls out of the programmed band limits, the amplifier will not engage, and the RF is passed through to the RF output connector without any amplification.

In fact, the amplifier will not amplify in the 26-28 MHz range. This is due to the microprocessor reading the input drive frequency. If the input frequency falls outside of the allowed amateur band, microprocessor programming tells the amplifier to switch the unit to the bypass mode and the amplifier circuitry is removed from the input and output through path. No amount of adjustment of any user controls allows any gain other than 0 dB in the rage 26-28 MHz. This measurement circuitry is tightly coupled to the main microcontroller and interlocked with the amplifiers power measurement circuitry. There are no simple means for a user to overcome this lockout.

The amplifier gain as a function of frequency is shown in the following graph. The FCC gain mask is shown as a dotted line. The measured amplifier gain is shown as a solid line. The amplifier gain is below the FCC limit at all frequencies.



4.0 Other Compliance Information

Other compliance information is specified below.

4.1 FCC ID

The FCC ID number will be located on the outside rear panel of the Amplifier.
The Proposed FCC ID is **DGVPA-77DF**. The FCC ID will be printed in black block lettering on the gold-anodized chassis finish in a font size of eight-point (or greater). Graphical depictions of the FCC Information are included in Appendix E.

4.2 FCC Exposure Information

The FCC requires users to check their installations for compliance with published values for allowable exposure to RF fields. This information is in the ARRL publications FCC printed rules and on the web. Maximum levels of power that may be run with out calculation of exposure are shown in the table below:

You must perform an RF environmental evaluation if the peak-envelope-power (PEP) input *to the antenna* exceeds these limits.

Band	*Power (W)*
160 meters	500
80	500
40	500
30	425
20	225
17	125
15	100
12	75
10	50

For more information go to the web at: http://www.arrl.org/news/rfsafety/eval/

4.3 ERP Conducted Case Radiation

Conducted case radiation tests were taken at a field lab at Criterion Technology at Rowlinsville, CO 80474. The test was taken in an indoor range lab using the substitution method TIA-603C. Power radiated level is for this amplifier with operation above 25 MHz must be 43-(10log of the power) or -11.23 dBm. A signal generator was placed and connected to an unity gain dipole next to the Device Under Test and the reference level was set to -11.23 dBm radiated on the 10 meter frequencies of 28.100 MHz, 28.900 MHz and 29.600 MHz. The amplifier was operated at 1500 watts CW into a resistive dummy load and the amplifier was rotated 360 degrees on a non conductive table on all three frequencies. All radiation levels were below –11.23 dBm using the substitution method. A separate report is submitted with the application with a full synopsis for

the test procedure and findings. All readings were below the minimum level required. The reading for the 28 MHz test are listed below:
Conducted Emissions Test Readings (readings must be below -11.23 dBm)

28.100 MHz	-14.23	dBm
28.900 MHz	-14.03	dBm
29.600 MHz	-12.73	dBm

5.0 Summary

All Applicable certification requirements are met or exceeded by the ALPHA 9500.

Appendix A-1 – Part 97 Compliance Matrix

Controlling Parameter	Standby/Off W/50 Watts Drive	At Max Gain With less than 50 watts drive	At Full Output With 50 watts drive	Part 97 reference	Test Report
Limits on spurious emissions (radiated and conducted)	-60 dB	n/a	n/a	97.317 (a) (2), 97.307 (e)	Section 3.3 and 3.4
Limits on spurious emissions (radiated and conducted)	n/a	n/a	-60 dB	97.317 (a) (2), 97.307 (e)	Section 3.3 and 3.4
Must be no user-accessible methods to mod amp to exceed specs	Yes	Yes	Yes	97.317(c)	Section 2.4.4
Must not exceed 1500 watts out with 50 watts drive	n/a	n/a	Yes	97.317(c)(6)(iii)	Section 3.1
Must be capable of sustained operation at max power level	n/a	n/a	Yes	97.317(c)(6)(iv)	Section 2.1
Must not have attenuation at the input level that if removed or modified would permit the amplifier to reach max gain at less than 50 watts drive		Yes	n/a	97.317(c)(7)	Section 2.4.4
Must not possess any features that would permit operation in other than amateur service	n/a	Yes	Yes	97.317(c)(8)	Section 2.4.4

Appendix A-2 – Part 2 Compliance Matrix

Required Report Information	FCC Part 2 Application Reference	Test Report
Name and Address of Manufacture	2.1033 (C) (1)	Section 1.0
Proposed FCC Identifier	2.1033 (C) (2)	Section 4.1, Appendix E
Copy of Installation and Operation Instructions	2.1033 (C) (3)	Appendix C
Type(s) of emissions	2.1033 (C) (4)	Section 2.1
Frequency Range	2.1033 (C) (5)	Section 2.1
Range of operating power values and description of means of varying output levels	2.1033 (C) (6)	Section 2.1 Section 3.1
Maximum power rating	2.1033 (C) (7)	Section 2.1
Measured DC voltages and Currents at various stages of circuit	2.1033 (C) (8)	Appendix C
Tune Up Procedures	2.1033 (C) (9)	Appendix D User Manual Section XXX
Complete set of Schematics and detailed circuit description	2.1033 (C) (10)	Appendix F
Photo or drawing of equipment ID plate showing the information to be placed thereon	2.1033 (C) (11)	Appendix E, Section 4.1
8X10 photos of the equipment showing construction detail	2.1033 (C) (12)	Appendix G
FCC Identifier Markings must be clear and legible on Product	2.295	Appendix E, Section 4.1

Appendix B – 3CX1500A7 Tube Characteristics

The 3CX1500A7/8877 power triode is designed for use as a cathode driven Class AB2 or Class B amplifier, in audio or RF applications including the HF or VHF band or as a cathode driven plate modulator Class C RF amplifier. As a linear amplifier, high power gain may be obtained without sacrifice of low intermodulation distortion and high amplification factor combine to make drive requirements exceptionally low for a tube of this power capacity.

3CX 1500A7/8877

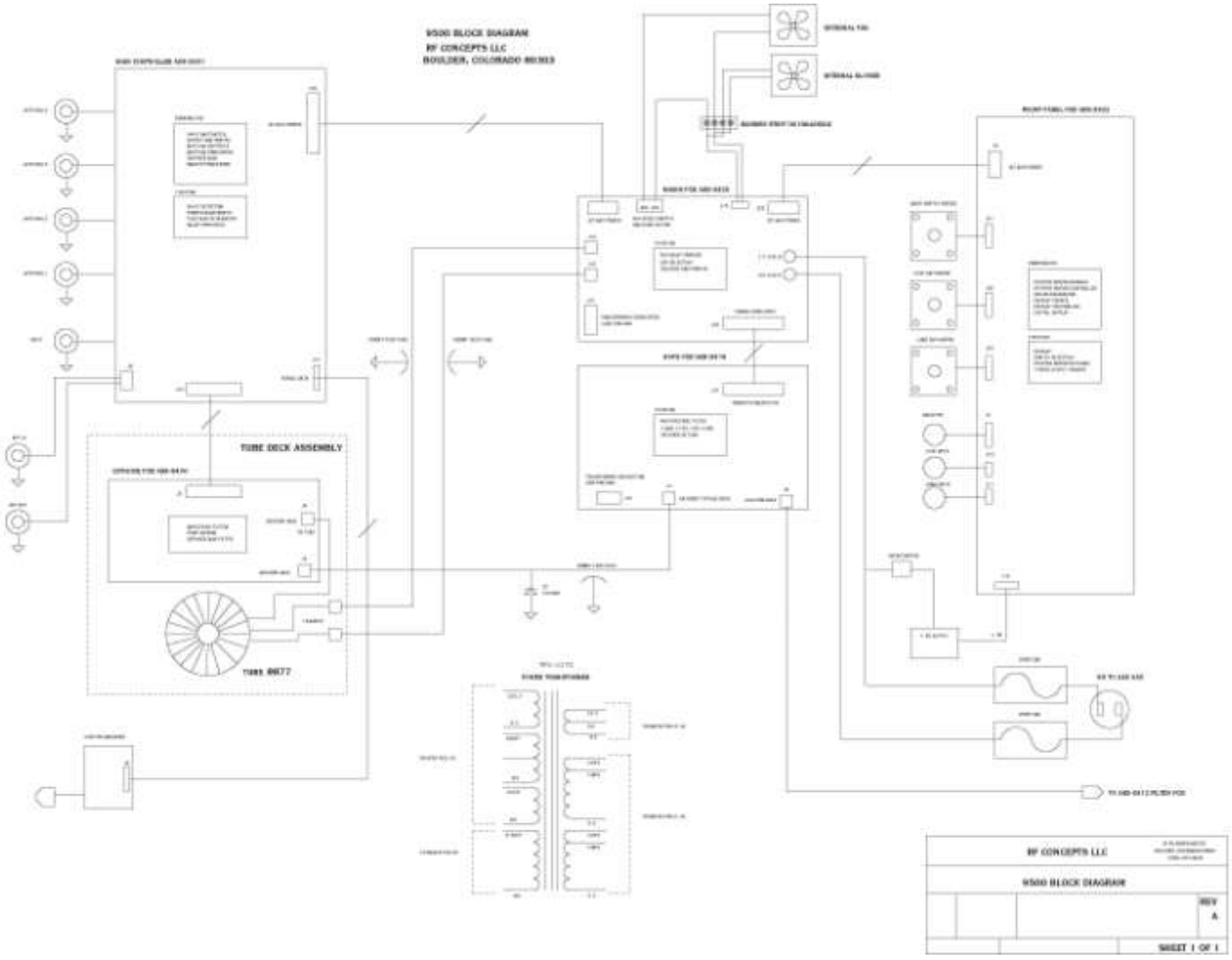
For information on this and other CPI products, visit our website at: **www.cpii.com**,
or contact: CPI MPP Division, Eimac Operations, 607 Hansen Way, Palo Alto, CA 94303
telephone: 1(800) 414-8823. **fax:** (650) 592-9988 | **email:** powergrid@cpii.com

The values listed above represent specified limits for the product and are subject to change. The data should be used for basic information only. Formal, controlled specifications may be obtained from CPI for use in equipment design.

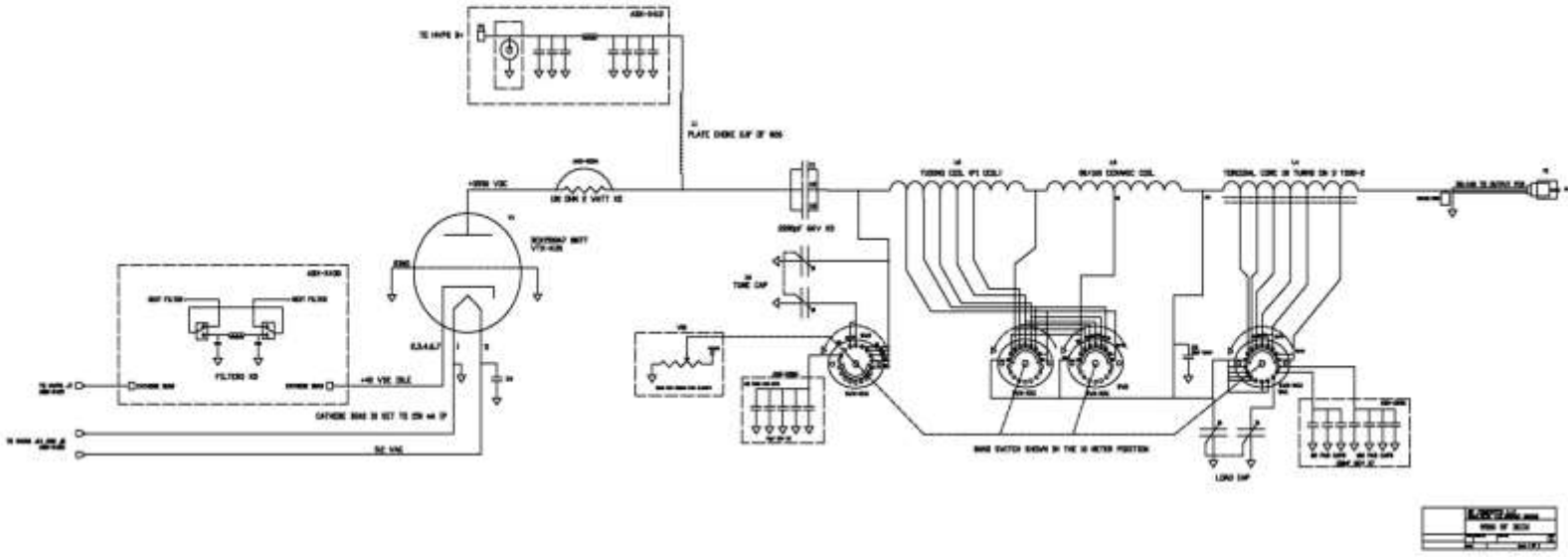
Characteristics

Plate Dissipation	(Max.)	1,500 Watts
Grid Dissipation	(Max.)	25 Watts
Frequency for Max. rating	(CW)	250 MHz
Amplification Factor		200
Filament/Cathode		Oxide Coated
Voltage		5.0 Volts
Current		10.5 Amps
Capacitance		Grounded Cathode
Input		38.5 pf
Output		0.1 pf
Feedthrough		10.0 pf
Capacitance		Grounded Grid
Input		38.5 pf
Output		10.2 pf
Feedthrough		0.1 pf
Cooling		Forced Air
Base		Special 7-Pin
Air Socket		SK-2210
Air Chimney		SK-2216
Length		4.02 in; 102.20 mm
Diameter		3.38 in; 85.80 mm
Weight		1.6 lb; 0.7 kg

Appendix C – Amplifier Block Diagram and RF Section Voltage and Current Levels

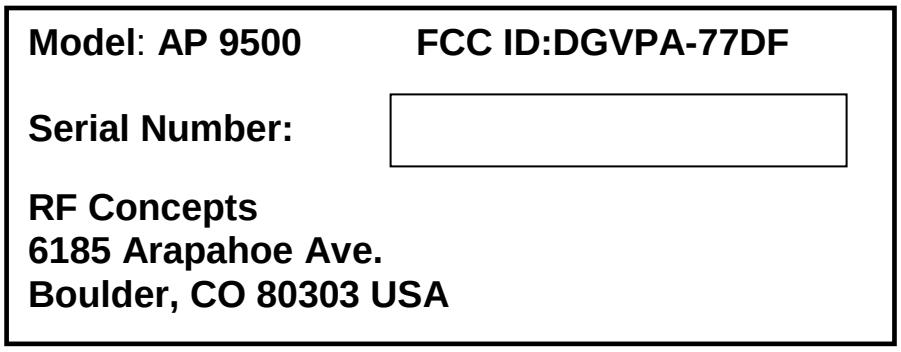


Block diagram of amplifier voltage and current levels



Appendix D – Copy of Installation and Operating Instructions

Appendix E – Drawing of Equipment ID Plate



Note: The above drawing is not to scale. It is shown in expanded view for clarification purposes only. The FCC ID number will be in located on the outside rear panel of the Amplifier. The Proposed FCC ID is **DGVPA77DF**. The FCC ID will be printed in black block lettering on the gold-anodized chassis finish in a font size of eight-point (or greater).

Appendix F – Complete Set of Schematics