

**ALPHA 8406 HF Power Amplifier
Test Report for Grant of Certification for
Use in Part 97 Amateur Service under the
Rules of the
Federal Communications Commission**

DGV-PA8406

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**Submitted by:
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**Preliminary
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Table of Contents

1.0 INTRODUCTION.....	3
2.0 DESCRIPTION OF AMPLIFIER	3
2.1 GENERAL FEATURES.....	3
2.2 DESIGN FEATURES.....	3
2.3 DC OPERATING CONDITIONS	4
2.4 SPECIAL DESIGN CONSIDERATIONS	4
2.4.1 Minimal Gain at 27 MHz.....	5
2.4.2 In-band Gain	5
2.4.3 Spurious Emissions.....	5
2.4.4 Anti-tampering Features	5
3.0 TEST RESULTS	6
3.1 IN-BAND GAIN.....	7
3.1.1 Test Procedure	7
3.1.2 Results.....	7
3.1.3 Conclusion	8
3.2 OUT-OF-BAND GAIN	8
3.2.1 Test Procedure	9
4.0 OTHER COMPLIANCE INFORMATION.....	10
4.1 FCC ID.....	10
4.2 FCC Exposure information.....	10
4.3 FCC TIA-603C Case Exposure Test.....	10
5.0 SUMMARY	10
APPENDIX A-1 – PART 97 COMPLIANCE MATRIX.....	11
APPENDIX A-2 – PART 2 COMPLIANCE MATRIX.....	12
APPENDIX B – 4CX1500B TUBE CHARACTERISTICS	13

1.0 Introduction

This report details the results of the tests performed to demonstrate compliance of the design and manufacturing configuration of the ALPHA 8406 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.
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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 8406 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 Amplifier is designed to operate as a “single band amateur VHF amplifier” within band segment from the 50-54 MHz Amateur band. The output stage of the amplifier is designed around a 4CX1500B (8660) (Alpha P/N VTX-X120) tetrode, 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 8406 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 8406 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 50-54 MHz. The 4CX1500B 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 50-54 MHz band.

2.3 DC operating Conditions

The final tube is operated in Class AB1, 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 3.00 kV under no-load conditions, and approximately 2.70 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 than 20 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 300 mA. The approximate control grid voltages are: receive, -65 V; operating idle, -8.0 Vdc; operating active.

2.4 Special Design Considerations

Care has been taken in the design of the ALPHA 8406 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:

2.4.1 Minimal gain at 27 MHz

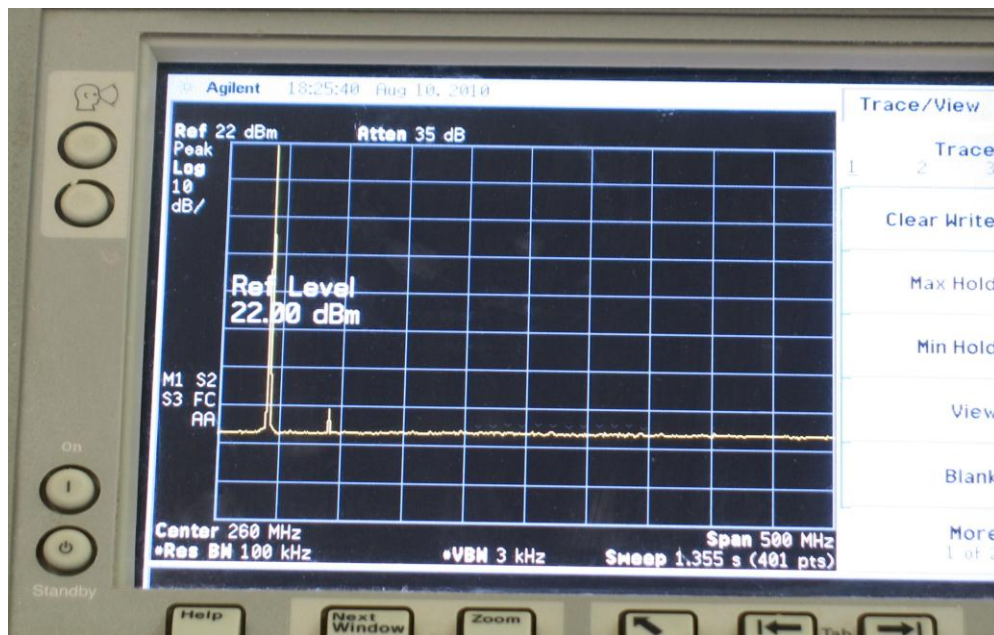
FCC rules severely restrict gain in the 11m (27MHz) band. This is frequency from 26-28 MHz. The ALPHA 8406 has a standard design feature which makes achieving useful gain in this frequency range impossible. The frequency of the driving signal will not pass through the amplifier when enabled due to the tuned input and output circuits being resonate only in the 50-54 MHz band. The first stage of the RF sample circuit is resonate at 50-54 MHz only and will not sample any RF out side the 50-54 MHz spectrum. This is necessary to take the amplifier from Stand-by to Operate. In the design engineering of the amplifier the amplifier gain at 26-28 MHz has gain of -25 dB.

2.4.2 In-band Gain

Gain in the intended amateur ham bands of between 50-54 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 C network impedance matching for each amateur band segment. Typical second through tenth order harmonics attenuation is better than 72 dBc due to the Q of the matching networks and the addition of a high Q low pass filter in the output network.



Primary spectral picture of the 8406 with a 500 MHz span. Primary signal is shown on the far left and is set to the top of the screen. The next harmonic is seen just to the right. All other harmonics are below the noise floor. Actual harmonic readings were taken at a much narrower bandwidth for accuracy.

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 cathode resistance to stabilize gain and bias. 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 and has RF beads installed on the AC leads into and from the AC power supply. RF cable connections are provided with standard “N” Female connections. Key line interface is also filter with RF beads and by-pass capacitors.

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 tetrode

swamp grid driven design with a resistor terminating the input RF. 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 8406 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.

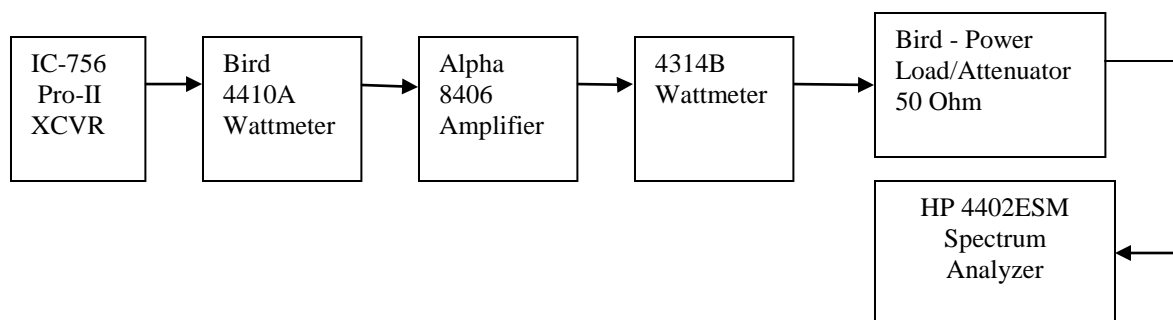
The specific amplifier used in all testing is the Model **ALPHA 8406, serial number 840610330001**. This amplifier was built to the design specifications to which the final (FCC certified) product will be manufactured. Production materials used in the test unit are the same that are anticipated to be 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
Icom Exciter	IC-756 Pro-II	1887
Alpha Input Wattmeter	Bird 4410A	5563
Bird Power Attenuator	8325	2454
Alpha Output Wattmeter	Bird 4314B	4560
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 (load) and measure the drive power required to produce this power. The test setup was as shown in Figure 3.1-1 below.



Test Set up Figure 3.1-1

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 50-54 MHz band. For RF power measurement, the Bird 4314B model or similar type directional wattmeter was chosen for both input and output power measurements. Typical Accuracy is +/- 5%

3.1.1 Test Procedure

The amplifier was tuned up for 1500 watts output power in band from 50-54 MHz as indicated on the output 4314B 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 spectral output 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 the 50-54MHz band. Spurious outputs directly related the output frequency were examined up to the 10th 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 50-54 MHz VHF amateur band, power was set to 1500 watts out and the input drive was recorded. The data taken is presented in below.

Band Meters	Frequency	Power In	Power Out	2nd	3rd	4th	5th	6th	7th-10th	Gain dB
6	50.1	60	1500	-73	-77	-80	-80	-80	-80.00	13.97
6	51.0	55	1500	-73	-78	-80	-80	-80	-80.00	14.35
6	52	54	1500	-74	-77	-80	-80	-80	-80.00	14.43
6	53	58	1500	-73	-79	-80	-80	-80	-80.00	14.12
6	53.9	61	1500	-74	-78	-80	-80	-80	-80.00	13.90

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 above 25 MHz must be at least 43 dB + 10 dB log of the power below the mean power of the fundamental emission (1500 watts Out), in Operate, Standby or Off condition. This level must be more than 73 dBc.

The ALPHA 8406 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 less than 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 test 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.

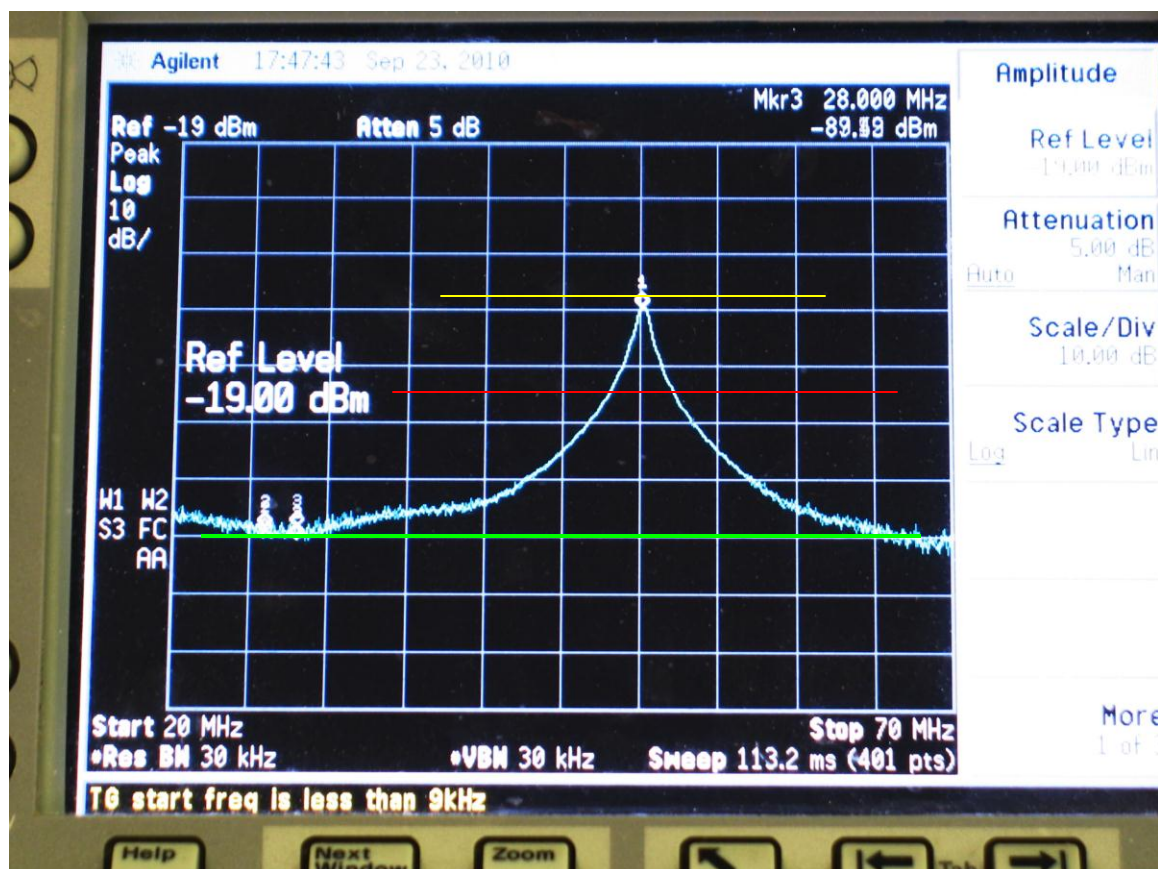
3.2.1 Test Procedure

The amplifier was set to its operational mode, and the gain adjusted for the maximum gain at the frequency band 50-54 MHz. An input signal was provided in the 26-28 MHz band

In fact, the amplifier will not amplify in the 26-28 MHz range. This is due to the single band construction of the amplifier. No amount of adjustment of any user controls allows any gain other than -40 dB in the range 26-28 MHz.

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 gain is shown as a solid line. The amplifier gain is below the FCC limit (0 dB of gain) at all frequencies.

Out of Band Gain Graph



With the amplifier tuned to 50 MHz and the input keyed RF is fed from a tracking generator on the spectrum analyzer to the amplifier input. The output amplifier RF is shown on the blue trace. The above plot is tracking from 20-70 MHz.

Marker #1 is at 50 MHz. Marker number 2 is at 26 MHz and marker number 3 is at 28 MHz. The vertical scale is 10 dB per division. The yellow line represents normal 15 dB of amplifier gain. The red line represents 0 dB of gain. The green line is -25dB of gain. In the 26-28 MHz band the amplifier has negative gain of at least -25 dB.

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 DGVPA8406. 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.

For more information go to the web at: <http://www.arrl.org/news/rfsafety/eval/>
Insert levels for 50 MHz

4.3 ERP Conducted Case Radiation

Conducted case radiation tests were taken at a field lab at Criterion Technology at Rowlinville, 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-(10 log of the power) or -13.00 dBm. A signal generator was placed and connected to an unity gain dipole next to the Device Under Test (amplifier) and the reference level was set to -13.00 dBm radiated on the 6 meter frequencies of 50.1 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 the frequency of 50.1 MHz. All radiation levels were below -13.00 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 50 MHz

Conducted Emissions Test Readings (readings must be below 13dBm) are listed below. A full submittal of the field test is contained in the Criterion Labs report. This is a separate document.

Harmonic	Freq. MHz	TIA 603-C limit -- 13dBm	Reading Level dBm	dBm Difference
Fund.	50.1	-13	-25.7	-12.7
2	100.2	-13	-32.5	-19.5
3	150.3	-13	-57	-44
4	200.4	-13	-44.5	-31.5
5	250.5	-13	-55.2	-42.2
6	300.6	-13	-55.9	-42.9
7	350.7	-13	-36.8	-23.8
8	400.8	-13	-49.5	-36.5
9	450.9	-13	-49.5	-36.5
10	501.0	-13	-49.6	-36.6

Synopsis readings from conducted case emissions test.

5.0 Summary

All Applicable certification requirements are met or exceeded by the ALPHA 8406.

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)	-73 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	-73 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.

4CX1500B/8660

For information on this and other CPI products, visit our website at: www.cpi.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
Screen Dissipation	12 Watts
Grid Dissipation	(Max.) 1 Watts
Frequency for Max. rating (CW)	110 MHz
Amplification Factor	200
Plate Voltage	3000 VDC
Screen Voltage	200-400 VDC
Plate Current	.9 amps
Filament/Cathode Voltage	Oxide Coated 6.0 Volts
Current	9-11 Amps
Capacitance	Grounded Cathode
Input	75 pf
Output	12 pf
Feed through	.05 pf
Cooling	Forced Air
Base	Special breach-lock 4 pin
Air Socket	Alpha special
Air Chimney	SK-2216
Length	4.6 in;
Diameter	3.37 in;
Weight	27 oz.