Theory of Operation

5.1 Theory of Operation - Overview

The Alpha 8406 uses tetrode vacuum power grid tube (4CX1500B) as the amplifying devices. The main power supply is an unregulated transformer/rectifier/capacitor power supply for the high voltage (HV) and heater circuits. All other power supplies are regulated. The control circuit uses a microprocessor "in the loop" to monitor and control amplifier operation. There are 7 circuit cards in the amplifier. In addition to these, the tubes, tank circuit assembly, and transformer complete the main sections of the amplifier. These major blocks are described below. The 8406 amplifier includes a 5 V power supply that is mounted behind the front panel. Any time the amplifier is plugged into the mains power, this 5 V supply is active and there is power to the micro-controller on the main control board. This feature allows the amplifier to be turned on or off remotely as well as remote monitoring and debugging though a USB cable connected to a computer.

5.2 Tubes

The amplifier is designed to use the 4CX1500B tetrode tube. The amplifier design uses these tubes well within their ratings. The tube is operated in Class AB1, with a plate voltage of 2,800V (nominal, full output, key down), a grid 1 voltage of -50 to -60 volts, and a grid 2 voltage of +230 volts. The tube has an inductance resistor in series with the cathode. This resistor stabilizes the tube bias and provides negative feedback, which improves linearity (and hence IMD performance). Electronic bias switching (EBS) increases the negative grid 1 voltage in pauses in speech or between Morse code elements. This reduces the standing bias on the tube, resulting in less waste heat, longer tube life and higher overall amplifier efficiency. The artifacts of EBS are not noticeable under normal communications conditions.

5.3 Output Tank Circuit

The output tank circuit of the Alpha 8406 is designed to provide reliable high efficiency, low distortion performance in a very compact volume. The basic topology is "pi-C", which provides harmonic attenuation adequate to meet the requirements of all countries globally that permits power outputs of 1,500 watts. The amplifier is designed to operate with only a single tube in order to reduce tube capacitance.

5.4 Tube Deck

The tube deck is a mechanical assembly built around the tube deck PCB. The tube deck PCB has the tube socket mounted on it, as well as those critical circuit elements that need to be in close proximity to the tubes. The tube socket contains integral screen grid (grid 2) RF bypass capacitors. Also on this PCB is the input bypass relay. This relay is under microprocessor control and in one position switches the input RF to the tube and in the other it switches the input RF to the tube matching circuit. The tube is operated as a "swamped grid" tetrode design. The tube grid is tied at RF to a 50-ohm swamping resistor, which absorbs most of the input drive power. The RF voltage across this resistor is added to the grid 1 DC bias to provide the net low-impedance tube grid 1 bias. The RF impedance represented by grid 1 and its capacitance is compensated for by a series inductance to provide less than 2:1 SWR on each band at the amplifier's input.

5.5 Mains Board

The power supply functions are split between the mains board and the high voltage (HV) board. The mains board mostly deals with the primary side of the transformer. The various taps for the transformer primary are routed through this board and so is the AC line input. Relays on the mains board connect the AC line to the appropriate taps on the primary. One of 5 tap options is selected by using a 5-way jumper field. See section 4.3 for more details on how to set the jumper. Also on the mains board is a step-start circuit. This circuit consists of a relay and a resistor, which are time-sequenced to limit the inrush current into the amplifier when it is first turned on. When initially turned on, the tap relays operate from a voltage derived from resistors from the AC line. They hold via contacts on the trip relay on the HV board. The regulated minus 12 volt and minus 124 volt supplies are also located on this board. Many of the important voltages for the amplifier are brought to test points on this board.

5.5 High Voltage Board

The main high voltage for the amplifier is created on this board using a full-wave bridge rectifier and a bank of capacitors. This power supply has two 10-ohm resistors, one in the positive (B+) lead, and the other in the negative return, which goes to ground. The combination of these two resistors limits the surge current in the case of a B+ arc. The voltage across the resistor in the negative return is used to monitor tube plate current in the control board. This voltage is also used to generate the "hard fault" condition. When the power supply current exceeds about 2 to 2.5 Amps, a relay operates to open the coil circuit of the mains tap relays on the mains board. When these relays release, the amplifier goes to the power-off state. This hard fault circuit operates independently of microprocessor control. The regulated screen supply is also located on this board. All power supply filter capacitors on this board have bleeder resistors which will discharge the capacitors in less than 60 seconds. If it is necessary to work on this board, it is nevertheless recommended that the discharged condition be confirmed with a voltmeter, due to the remote possibility of bleeder resistor failure.

5.7 Control Board

The control board is the heart of the amplifier. It is based around a PIC microcontroller. This microcontroller has a built-in multi-channel analog-to-digital converter, which is used to monitor all the critical voltages and currents in the amplifier, as well as the input power and output forward and reflected power. It uses these converted values to control the amplifier's operation and to drive the display board on the front panel. A USB port is provided for remote monitoring and is found on the back of the Alpha 8406. The USB driver for the amplifier is provided on the CD shipped with the unit or can be found on the Alpha website at www.rfconcepts.com

5.8 Display Board

The display board uses a MAX7219 LED driver chip. It receives data from the controller via an SPI interface. It contains a regulator to drop the +12 V to +5 V for the display.

5.9 T/R Board

The T/R board contains the input and output relays, as well as the input power detection and output directional wattmeter. The voltages from the detector are connected to the control board. There is a trimmer capacitor on this board that is adjusted with the amplifier operating into a good 50-ohm dummy load. The capacitor is rotated to minimize the reflected power voltage. The board also has a static protection inductor on the RF output for 50 -54 MHz operation. This is located between the PCB and the flange of the output connector.

5.10 Center Partition Board

This contains the RF decoupling circuit on the B+ line as well as the "crowbar" safety circuit. This safety device consists of a piece of spring metal, which shorts out the B+ line when the top cover of the amplifier is removed.