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# Exhibit V Operational description HO82WUALS1306

# ALS-1306 Technical and Operational Overview

The ALS-1306 is an amateur radio multiband radio frequency linear power amplifier. This device requires certification. This device complies with technical standards of CFR Title 47 part 97.317(a) and (b) as of April 2013.

## General Operation

This linear amplifier covers the 160, 80, 40, 30, 20, 17, 15, 12, 10, and 6-meter amateur bands. Up to 100-watts exciter power is applied to relay RLY1 on circuit board RLY. With the main power OFF, the STANDBY/OPERATE switch on STANDBY, with a fault warning LED illuminated, or with the rear panel RELAY jack ungrounded, RLY1 bypasses through RLY2 directly to the antenna port.

When power is ON, the STANDBY/OPERATE switch in the operate position, and the rear panel RELAY control line held low (below 1 volt), exciter power is routed through RLY1 to the PD8 power divider board.

## Power Division

The PD8 power divider board attenuates the exciter input signal, and divides exciter power equally, between two 600-watt power amplifier modules. It is 50-ohms on all three ports, with 8.2 dB nominal attenuation to each output port.

The PD8 circuit board consists of a conventional magic-T power divider, components T2 and R7. This T divides drive power into two equal-power signals. Each signal path has a 5 dB attenuator consisting of high power resistors R1 through R6. The 5 dB attenuators on each output port terminate the T in 50-ohms and provide an additional 10 dB of input port isolation between the two PAM's. With a 50-ohm source, in excess of 30 dB port-to-port isolation occurs between PAM inputs. A minimum of 16 dB isolation occurs regardless of input port termination. The attenuators also work in concert with the magic-T to provide a 50-ohm input termination for each PAM. The 50-ohm termination and input port isolation results in unconditionally stable PAM's.

## PAM-606 (power amplifier modules)

Power amplification comes from two 600-watt power amplifier modules. Each PA module (PAM-606) uses four MFR-150 field effect transistors. Each MRF-150 has 100 mA to 300 mA quiescent current. Transistor conduction angle is slightly over 180-degrees, providing linear class-AB operation. While the precise value of quiescent current has little effect on linearity, it is very important to adjust all eight FET's to the same quiescent current. Target current is typically 150 mA in this design. Normal dc drain operating voltage is approximately 50-volts. Be aware bias control rotation is reversed in CB2 boards, as compared to the previous generation ALS-1300's CB1. When servicing any solid state PA, always verify function of bias and set for minimum bias before applying drain voltage.

Unlike standard Motorola based modules, the PAM-606 modules use two diametrically opposed push-pull pairs of 150-watt MOSFET's. The 300-watt push-pull pairs drive balanced VHF striplines. The balanced striplines combine at a matching transformer. The linear RF power FET's mount on a forced-air-cooled aluminum heatsink.

Two dc fans cool each PAM-606 module. Two thermistors (PAM-606 R2) sense power amplifier transistor temperature. Transistor temperature thermistor R2 regulates bias voltage, reducing bias voltage as transistor temperature increases. This bias feedback system keeps transistor quiescent current stable independent of transistor junction temperatures. PAM-606 thermistors R2 also feed a comparator that removes drive when transistor temperatures approach unsafe levels. Bias voltages for the PAM-606 modules come from the CB-2 control board assembly. Each transistor has an individual bias adjustment, with minimum bias counter-clockwise from the top view. ***This is opposite the control function in older CB1 assemblies.***

A second set of thermistors (PAM-606 R1) monitor heatsink temperatures. Voltages from thermistors R1 regulate fan speed, increasing fan speed and airflow as the heat sink warms.

The PAM-606 modules employ significant negative feedback to reduce gain, improve gain flatness, improve linearity, and ensure stability. The FET's have direct resistive voltage feedback across each individual transistor from drain-to-gate, as well as push-pull transformer (T2) coupled feedback common to the push-pull circuit. Push-pull operation, negative feedback, and linear biasing of FET's provide significant pre-filter harmonic suppression.

The characteristics of linear high-voltage FET's are very much like those of triode vacuum tubes. While this amplifier will run more than 1200-watts PEP output, linearity might suffer. Ameritron recommends running 1200-watts PEP or less for maximum linearity, although most amplifiers will remain clean above 1200-watts PEP. Following these instructions, this amplifier will have IM performance comparable to the best vacuum tube linear amplifiers.

## 2KWF6 Lowpass Filter Assembly

Each PAM-606 module connects directly to the 2KWF6 circuit board assembly through 50-ohm cables. Both PAM's feed into a 50-ohm high power combiner. The combiner is integrated into the 2KWF6. This combiner isolates the two PAM-606 inputs while maintaining 50-ohm impedance. Two 25-watt 200-ohm power resistors, R7 and R8, dissipate power level or phase errors between the PAM inputs. Voltage step-down transformer T1 senses voltage across combiner dump resistors, R7 and R8. ***T1 is located on the 2KWF6 lowpass filter board.*** This voltage, representing PA combiner unbalance, appears on the front panel multimeter as a "PAB" (power amplifier balance) indication. PA unbalance reference voltage also feeds a comparator on the CB2 control board. This comparator disables the PA in the event the power amplifiers become significantly unbalanced, and illuminates the PA front panel light.

The output of the high-power combiner enters the filter section through a directional coupler consisting of current transformer T2, capacitors C36-38, C40-42, and resistors R4, 5 and 6. This directional coupler detects power amplifier termination errors. These errors include filter band errors. A comparator on the CB2 control board monitors directional coupler termination errors. Any significant filter or antenna reflected power error disables the amplifier. Such errors normally come from selecting the wrong filter for the exciter's operating band, or having a poor load SWR on the amplifier.

The output of the filter board directional coupler routes through one of seven 5-pole lowpass filter groups. Relays, controlled by CB2 control board logic, select the appropriate lowpass filter components.

## Control Functions and Protection Logic

The CB2 control board contains all fan speed, biasing, transmit relay control, band relay control, band data processing, overload protection, and control logic lockouts. In the event of an operational fault, including out-of-band operation, the CB2 locks out the amplifier and illuminates the proper front panel warning light sequence.

## Band Decoding

The CB2 board contains band-decoding systems. It also has a sensitive embedded frequency counter system. The frequency counter system in all ALS-1306 amplifiers, regardless of band selection mode, automatically disables operation between 25 and 28 MHz. This embedded logic function cannot be disabled or changed.

## Temperature

Temperature sensors on each PAM-606 (power amplifier module) monitor heat. Bias and fan speed track FET temperature. The ALS-1306 protection circuitry reduces power as transistors approach conservative thermal limits, and disables the amplifier before transistor exceed safe operating temperature limits.

## Bias

The CB2 senses voltage from a thermistor-controlled voltage divider system. Bias is normally set for 150 mA at room temperature. As FET temperature increases, divider voltage decreases. This reduces bias voltage.

Each PA module jack, J7A and J7B, has individual bias supply lines and temperature sensing circuitry. Bias is adjusted with eight potentiometers near the two PA module connectors.

Bias voltage is sequenced with T/R RELAY switching. Bias is applied after the input relay closes, and is removed when the input relay reverts to receive mode.

## Band

Band data comes from external rear panel connectors, or an internal bandswitch board BS-2. External data is compatible with most modern amateur transceivers, such as Elecraft, ICOM, Ten-Tec, and Yaesu. Band data from the appropriate source is decoded. The proper band relays are selected using decoded band information.

## Protection

The CB2 contains protection logic for predetermined levels of antenna reflected power, filter reflected power, PA module balance, and PA transistor temperature. In the event of a safety fault, the transmit-receive relay is disengaged in a normal receive transfer and a proper warning indicator is given. The normal sequence is remove bias, remove exciter relay, remove antenna relay, and illuminate warning LED.

Reset requires removal of the fault condition and placing the STANDBY-OPERATE switch in the STANDBY position. If faults are cleared, operation will resume upon placing the STANDBY-OPERATE switch in the OPERATE position.

## Harmonics

This amplifier greatly exceeds FCC harmonic requirements. HF harmonic suppression typically 10-15 times better than FCC mandated suppression levels. Harmonics are practically immeasurable on all television channels. There is no reason to use an external low-pass filter with this amplifier.

Harmonic suppression comes from push-pull operation of linear devices, followed by high-quality 5-pole low-pass filters. Many amplifiers use inexpensive ceramic disc or mica capacitors. Lead inductance of mica or disc capacitors reduces high-order harmonic suppression. This amplifier uses quality multi-layer high voltage chip capacitors.

## SWR

The SWR board is a standard 50-ohm directional coupler. The SWR board samples output connector current and voltage, vector summing voltage and current samples to a dc output voltage. The resultant voltages represent forward and reflected power, or SWR mismatch, to an ideal 50-ohm resistive load.

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