Section 8
RF Amplifier Modules

8

8.1 General Information

This section is intended to be used as a guide in isolating faults and troubleshooting Analog and Digital Platinum III TV RF power amplifiers. Understanding the theory of operation is crucial in troubleshooting success. There will be additional information to include the older "Classic" version of the digital modules where appropriate.

8.1.1 Factory Module Repair

When a module failure occurs, the module may be returned to the factory for repair.

Pack carefully to avoid damage, special shipping boxes are available from Harris.

USA customers may send a module in for repair by sending via Federal Express to:

Harris Repair Department

3200 Wismann Lane

Quincy, IL 62301

International customers should contact Harris Repair Department first:

By phone: 217-222-8200
By FAX: 217-224-2840
By mail to the above address

Include the part number and serial number of the module when requesting service. Instructions to ship the module will be processed and communicated to you.

Please provide as detailed information as possible about the nature of the failure and the operating condition of the module at the time of failure. This data will help our Repair Department service your module promptly and efficiently.

If you do not stock a spare module and require another unit for operation, a spare may be obtained as a loaner or rental unit from the Harris Repair Department while your unit is shipped to our factory for repair.

If you are located within the United States, you will be billed for shipping charges, and if your warranty has expired a rental fee will be charged for use of the module.

If you are located outside the United States, the same loaner service will be offered wherever feasible, but in addition to any shipping charges you will be responsible for all import duties, transfer fees or international tariffs.

8.1.2 Local Module Repair

If local repair is necessary, the following troubleshooting guide and repair procedures are recommended. We strongly recommend reading the appropriate parts of the Theory of Operation before proceeding.

The optional PA Module Test Fixture (992-8556-002) is needed for local testing or repair. The fixture will allow testing of a PA or driver module while using the transmitter as the source of DC power and RF drive.

8.1.3 Module Part Numbers

DESCRIPTION	PART NUMBER
Analog Drivers	992-8964-SXX
Analog High Power Drivers	992-8965-SXX
Analog and Digital PAs	992-8969-SXX
Digital Drivers	992-7182-0XX
Digital Drive PAs	992-7191-0XX

The last three digits of the part number designate the module channel information. The character S identifies the system other than system M which is 0. The following two numbers identify the channel.

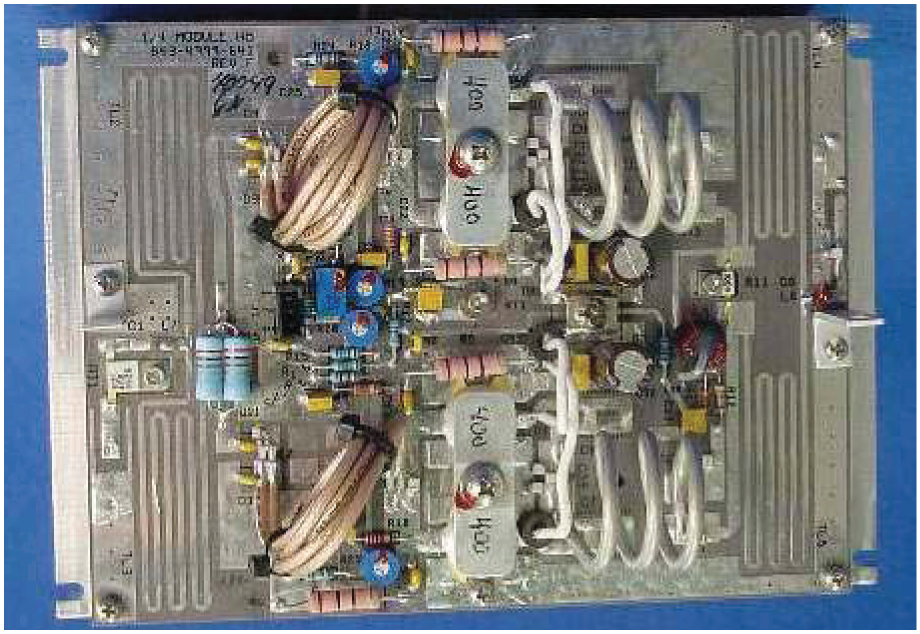

Figure 8-1 High Band Quarter Module

8.2 RF Amplifier Modules Theory of Operation

RF amplifier module assemblies are made from quarter modules, each quarter module has four RF field effect transistors (FETs). Two pairs of push-pull transistors are operated in parallel. The push-pull operation reduces distortion.

Harris builds and tests analog modules, then rebiases analog modules for digital drive service. The PA modules do not have the bias changed. Testing as an analog module makes it easier to evaluate the amplitude and phase distortions.

Quarter modules can be connected in various series and parallel combinations. This and class A or AB bias are utilized to make different types of RF modules:

- Driver modules - multistage gain units used to amplify a low level signal to the drive levels needed by the subsequent amplifier stages.
- 525 Watt drivers for analog service. These are used for as a high power driver.
- 1000 Watt PA modules - single-stage high power amplifiers which use four parallel quarter module stages to achieve output powers of 1050 W peak (280 W average).
- Older Classic Digital transmitters also use RF modules with different bias settings for enhanced linearity. These are identified by part numbers:

992-7182-0XX Digital Drivers, all channels.

992-7191-0XX High band Digital PAs biased for driver stage service.

Different transmitter configurations will utilize one or more of these types of modules. New Platinum-i transmitters will use the same modules as analog transmitters.

A multi-pin connector, J2, on the rear of each module supplies RF drive, 50 Volts DC, and ENABLE commands to the module, and returns a fault status signal back to the transmitter controller. RF output is passed through a separate coaxial connector. The rear panels of drivers and PAs are mechanically keyed differently, so that Driver units cannot be plugged into PA slots. If a driver module could be installed in a PA module location or slot, the higher drive power present would destroy the input stages.

Classic Digital transmitters only. In an emergency, a PA can be substituted for a Driver PA, transmitter output power may have to be reduced to maintain performance and multiple PA cabinet transmitters should have the reject power checked and the Phase and Gain module adjusted if needed.

The modules are "hot-pluggable," meaning that they can be removed or inserted during transmitter operation without turning the transmitter off. A disable switch is located in the front handle of each module for this purpose. As a precaution, squeeze the handle and observe the LEDs. If they remain illuminated, follow procedures for a shorted 50 volt switching transistor (passFET) before removing the module.

The modules protect themselves by automatically disabling themselves if an improper operating condition is detected. A protection, control, and monitor (PCM) system monitors the modules operating conditions. If all of the conditions are acceptable, upon an ENABLE signal from the transmitter controller, the PCM system will enable the module by switching on the 50 Volts. If a fault condition arises or the ENABLE signal is interrupted, the PCM system disables the module by turning off the 50 Volts DC.

Descriptions of the various subsystems of Platinum modules are given below. First, the RF signal paths of the modules are traced; then, the subsystems are described in more detail.

Refer to the cover sheet of the drawing package for your transmitter to locate the necessary drawing numbers for the modules and subassemblies.

For information on Wilkinson dividers and combiners, refer to appendix at the end of this chapter.

8.2.1 Driver Module, Low Band (Band I)

(Refer to the Low Band Driver Amplifier Schematic 839-)

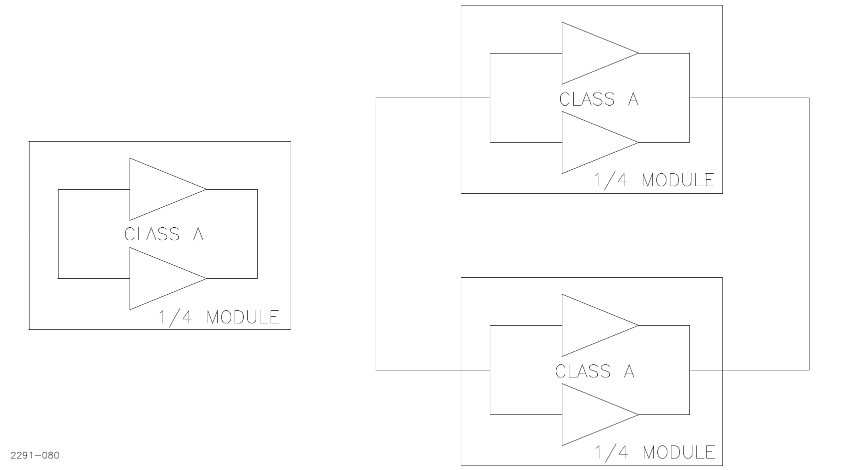

Figure 8-2 Low Band Driver Module, Simplified Block Diagram

The low band driver module consists of a class A stage, driving a second stage consisting of two parallel class A amplifier blocks. The bias current per device will be marked on the hold-down spring clamping bar. This works for analog and digital.

A pi input attenuator (R4, R5, R6 on the Driver RF input assembly) is used to set the overall gain of each low band driver to 35 dB. The input attenuator also serves to improve the modules input return loss.

The attenuator output feeds the first amplifier stage, which produces about 24 dB gain. The output passes to a 2 dB fixed attenuator, used to improve the output match seen by the first stage.

The RF signal then feeds the 2-way Divider assembly. On this divider assembly there is in the signal path a microstrip directional coupler (which provides a forward drive power sample for overdrive protection), a microstrip trombone line section (for phase adjustment), and a foreshortened Wilkinson 2-way microstrip divider. The dividers two outputs drive two parallel Class A amplifiers. The outputs are recombined using a foreshortened Wilkinson microstrip combiner, which passes the signal through a directional coupler to the module output. The directional coupler provides a reflected power sample to the modules protection, control and monitor (PCM) system.

On the input and output Driver RF Interconnection assemblies are provided optional capacitors for response correction. On the input assembly, A5A4, are C1 and C15. On the driver RF interconnect assembly is C4. A capacitor may be added where needed for frequency response correction and or input matching.

The low band driver output is rated at 75 Watts average.

8.2.2 Driver Module, High Band (Band II)

(Refer to the High Band Driver Amplifier Schematic 843-4999-639)

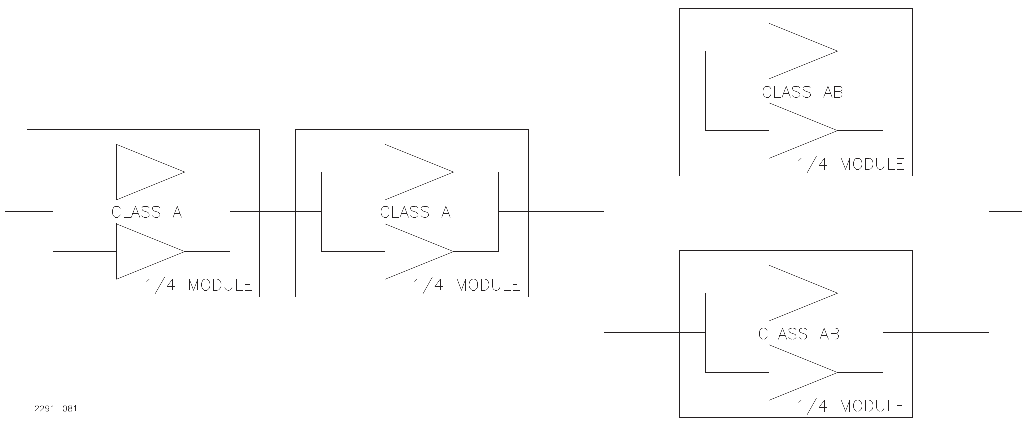

Figure 8-3 High Band Driver Module, Simplified Block Diagram

The high band driver module consists of two cascaded class A stages, driving a third stage consisting of two parallel class AB amplifier blocks. These are class a in the classical version of the driver, 992-7182-0XX.

A pi input attenuator (R4/R5/R6 on the input Driver RF interconnection assembly) is used to set the overall gain of each high band driver to 35 dB. The input attenuator also serves to improve the modules input return loss.

The attenuator feeds the first amplifier stage, which produces about 17 dB gain. Its output passes to a 2 dB fixed attenuator, used to improve the output match seen by the first stage. The signal then passes through a L-section matching network to the second class A stage.

The RF signal then feeds the 2-way Divider assembly. On this divider assembly there is in the signal path a microstrip directional coupler (which provides a forward drive power sample for overdrive protection), a microstrip trombone line section (for phase adjustment), and a Wilkinson 2-way microstrip divider. The dividers two outputs drive two parallel Class A amplifiers. The outputs are recombined using a Wilkinson microstrip combiner, which passes the signal through a directional coupler to the module output. The directional coupler provides a reflected power sample to the modules protection, control and monitor (PCM) system.

On the input and output Driver RF Interconnection assemblies are provisions for response correction. On the A5A6 assembly are C4 and C12. On the A5A4 RF interconnection assembly is C13. On the two way divider RF Interconnection assembly is C14. These capacitors are added as needed for response correction.

High band drivers have a rated output of 65 Watts average.

8.2.3 PA Module

(Refer to the RF PA Module Schematic 843-4999-637)

PA modules consist of four parallel class AB amplifier blocks. Low Band PA modules produce 18.5 dB gain overall, and the gain for a high band PA is 13.7 dB. Quarter module bias can vary depending on application and transistor parameters.

Analog/Digital PA quarter modules were biased at 300 or 400 mA. per FET dependant on the channel and the FET parameters. Special PA modules used in the drive chain of digital transmitters will be biased at 0.8Amps for low band and 0.7 Amps for high band per RF FET.

The module RF input signal feeds the 2-way Divider assembly. On this divider assembly there is in the signal path a microstrip directional coupler (which provides a forward drive power sample for overdrive protection), a microstrip trombone line section (for phase adjustment), and a Wilkinson 2-way microstrip divider.

The Wilkinson combiner in the Low Band module is a foreshortened Wilkinson combiner. Resistors are used in the Wilkinson divider and combiner circuits to provide isolation between ports.

The Wilkinson dividers two outputs feeds the two 2-way Wilkinson microstrip/stripline dividers on the 2X2-Way Divider assembly. The 2X2-Way Divider assemblies four outputs feeds the four class AB amplifiers.

The outputs of the four amplifiers feed into the two 2-way Wilkinson combiners on the 2X2-way Combiner assembly. The output of the two combiners feeds into the two inputs of the 2-way Wilkinson Combiner assembly. The output of this combiner passes through a directional coupler to the RF output jack. The directional coupler sends a voltage sample of the output port reflected power to the PCM system.

The Low Band and High Band PA modules are rated at 285 watts average.

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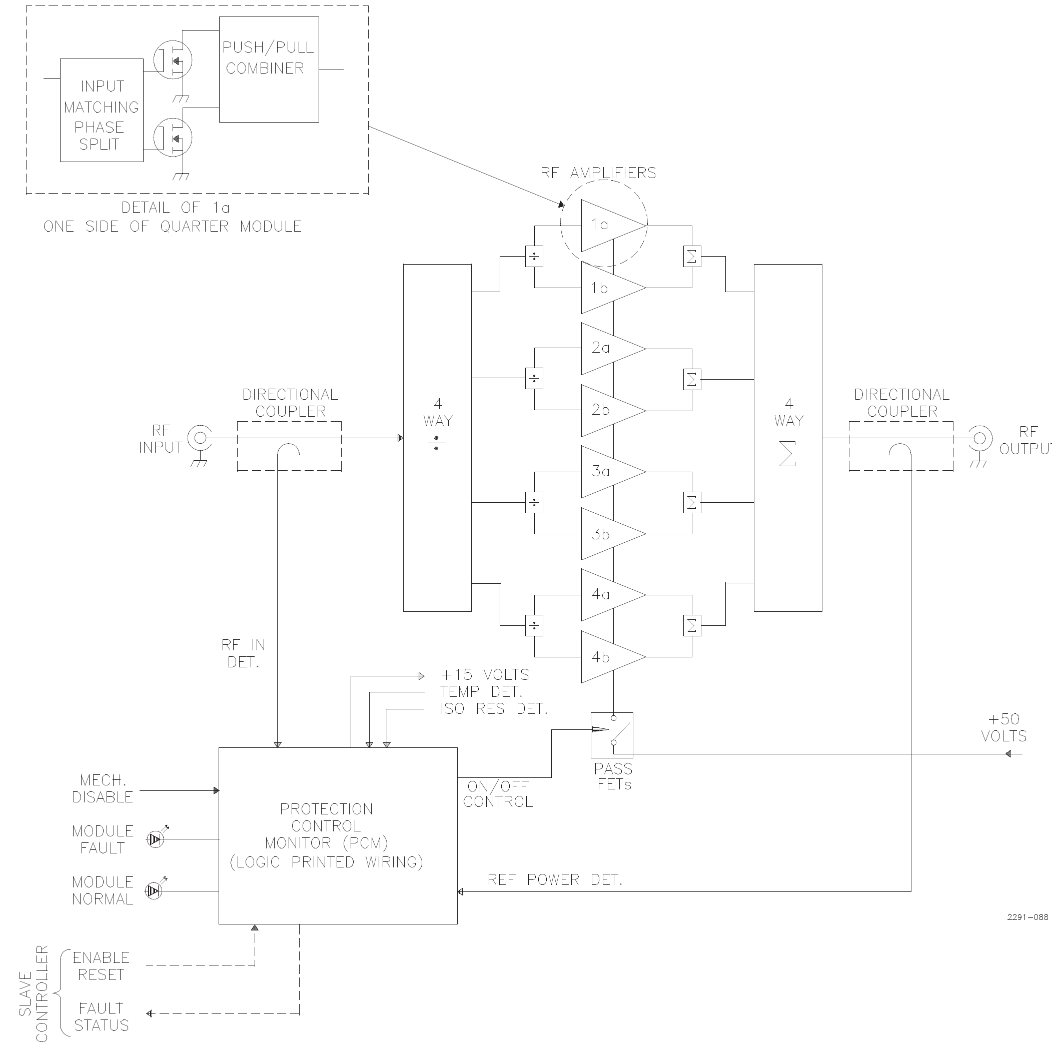

Figure 8-4 PA Module Block Diagram

8.2.4 RF Quarter Modules

The RF amplifier subassemblies within a driver or PA module are called "quarter modules." The quarter modules use n-channel Field Effect Transistors, or FETs, as their active devices. FETs offer several advantages over bipolar junction transistors (BJTs), including improved ruggedness, better linearity, and less susceptibility to thermal runaway.

N-channel FETs operate similarly to NPN Bipolar Junction Transistors. In a common-emitter bipolar amplifier, a small change in base-emitter voltage results in a small change in base current. The base current modulates the collector current, and the output is taken at the collector. Similarly, in a common-source FET amplifier, a small change in gate-source voltage modulates the drain current, and the amplifier output is taken at the drain.

Each quarter module uses four RF FETs. The input contains a gain matching pad, a phase matching coax line and a two-way power divider. Divider outputs each drive a push-pull FET pair. The FET outputs are recombined in a two way combiner, whose output is the output of the quarter module.

Temperature compensated bias voltage for each RF FET is generated from a 15 Volt supply. The supply is part of the module control card (PCM) and switches on with application of 50 Volts to the quarter modules. The quarter module supplies voltages representing temperature and ISO voltage to the module PCM system.

For any given channel, class A and class AB amplifier blocks use the same quarter module circuit. The bias voltage adjustment potentiometer controls the quiescent drain current for each FET, which determines each quarter modules class of operation.

In cases where quarter modules are biased class AB, as in the PA module, each quarter module is capable producing 70 Watts average output into a 50 ohm load. The excess power is necessary to overcome losses in the combining stage.

When the quarter modules are biased class A, as in driver modules, they exhibit improved linearity and about 1-2 dB higher gain. The trade-off, however, is lower power output capability and reduced efficiency. Thus, class A stages are used as pre-amp and driver stages, and class AB stages are used in final power amplifier stages.

Because low band and high band quarter modules utilize slightly different architectures, the circuits are described individually below.

8.2.5 Low Band Quarter Module

(Refer to Low Band Quarter module Schematic 839-7900-701)

The RF input signal first passes through TL1 (Phase setting coax) and then through AT1 Which sets the gain of the quarter module to 19.25 dB. The RF input signal then passes to T1, a two-way coaxial power divider which also performs an impedance transformation. R5 provides isolation between the two divider output ports.

The upper and lower RF amplifier halves are identical. In the upper circuit, C1 blocks DC from the input. Components T2/T3 continue the impedance transformation from the divider to the gates of RF transistors Q1 and Q2. T3 also establishes a 180 phase relationship between the signal voltages sent to the two transistors, which is the basis for push-pull operation.

R2 and R3 "swamp" the transistor gate input impedances, which are highly capacitive. C6/C7/C9/C10 block the DC gate bias from reaching the quarter module input. C8/C5/ C11 complete the input impedance transformation.

An R,L, and C drain-to-gate negative feedback loop exists around each FET. The feedback will ensure stability at low frequencies. C25 and C24 block the 50 Volts present at the drains from reaching the gates through the feedback loops.

L5/L6/C23 form a balanced L-network, which act as both a low-pass filter and an impedance transformer between the FETs and T6. T6 continues the output impedance transformation and combines the transistor outputs in series. C28, C29/R19, and C4 bypass one port of T6 to ground, and C30 and C31 couple the RF to T8.

T8 is a two-way combining transformer which combines the outputs of the upper and lower amplifier halves and completes the output match. R15 provides isolation between T8"s input ports.

If any phase or amplitude difference exists between the signal in the upper and lower amplifier halves a voltage will develop across R15.

This RF voltage will be coupled through toroidal transformer T9, to CR1, an RF detector which produces a DC signal proportional to the amount of imbalance. This DC signal is called the ISO voltage sample, and it is sent to the PCM system through J1-2.

8.2.6 High Band Quarter Module

(Refer to High Band Quarter Module Schematic 839-7900-702)

The RF input to the quarter module passes through TL1 (Phase setting coax) and AT1 (Attenuator which sets the gain of the quarter module to 14.25 dB). The RF input then passes through a two-way Wilkinson power divider, consisting of two 75 ohm microstrip sections. R1 provides isolation between the divider outputs.

The upper and lower amplifier halves on the schematic are identical. In the upper amplifier, C9 couples RF into the amplifier while blocking DC. T1 is a coaxial balun transformer, which provides both a step-down impedance transformation and an unbalanced-to-balanced transformation. Its two output signals differ in phase by 180, which establishes push-pull operation in the RF FET pair Q1 and Q2.

R3 and R4 shunt load the highly capacitive gate input impedance of the FETs. C2 completes the input impedance transformation. An adjustable voltage divider feeds bias voltages to the gates of the RF FETs, controlling their quiescent drain currents.

Series inductors feed 50 Volts to the FET drains, and act as RF chokes, blocking the RF from appearing on the power supply lines.

The sliding short sections form small inductances. Together with C4/C5/C37 they form a balanced L-net, which provides both a low-pass response and an impedance step-up transformation between the FET drains and the input of T3.

T3 is a coaxial balun, fabricated from semi-rigid coax. It adds the output voltages of Q1 and Q2 in series, and continues the output impedance transformation. Its outer conductor is grounded by C13, and the RF output is coupled through C15.

The outputs of the two amplifier halves are recombined by a two-way Wilkinson combiner, composed of two 75 ohm microstrip sections.

If any phase or amplitude difference exists between the signal in the upper and lower amplifier halves, an RF voltage develop across R11 and L9. L9 is the primary of a toroidal transformer, whose secondary is L10. Any RF voltage will be coupled through the toroidal transformer to R12/CR1/C33 an RF peak detector which produces a DC signal proportional to the amount of imbalance. This signal is called the ISO voltage sample, and it is sent to the PCM system through J1-2.

8.2.7 Quarter Module Bias

The +15 Volts for the FET bias voltage divider is furnished by a step-down regulator in the Protection, Monitoring and Control Subsystem. This regulated voltage switches with the switched 50 Volts.

Thermistor R1 is mounted to the heat sink between RF FETS Q2 and Q3 and completes a resistive voltage divider between the +15 Volts and ground. As the heatsink temperature increases the resistance of the thermistor decreases.

The change in thermistor resistance changes the voltage reference for the bias adjustment. This change in reference tracks the change in bias current with temperature. This proportional voltage is divided down by the four bias adjust controls R24, R25, R26 and R27 for precise adjustment of the static current of the individual RF FETS.

The reference voltage is also monitored by the module control board, excessive heat sink temperature will result in a temperature fault. R2(HB)or R16(LB) is used for temperature calibration. The voltage is factory adjusted for 5.30 Volts when the heatsink temperature is 25^{o}C. Any adjustment of R2 or R16 will affect the FET static current bias settings.

8.2.8 Protection, Control and Monitor Subsystem

(Refer to Logic Printed Wiring schematic, 839-7900-700.)

Each module is controlled and monitored by a module protection, control, and monitor (PCM) subsystem. Drivers and PA modules utilize essentially the same PCM subsystem. It consists of sensors and control logic within each module, and provides protection against improper operating conditions. The heart of the module PCM subsystem is a printed circuit assembly commonly known as the module control board.

The module control board performs protection from different detrimental operating conditions through an essentially common scheme. It collects voltage samples that provide indications of the operating parameters, and compares these samples to reference voltages. Voltage comparators (U4, U6, U7, and U13) are used to compare the samples to the references, and their outputs are digital signals which indicate either a normal operating condition or a fault.

These digital signals drive PALs (Programmable Array Logic) (U1, U2, U3), which are ICs consisting of hundreds of digital logic gates. The PALs perform two functions. They send signals to the pass FETs, which are used as high-current switches to turn on or off the 50 Volts DC supplied to the quarter modules. They also determine the operating status indications given by the front panel LEDs.

Upon a module ENABLE signal, after the cabinet DC power supply reaches 44 Volts, the control logic turns on the pass FETs. If a fault is detected, the control logic will turn off the pass FETs, disabling the module.

The PCM subsystem performs several functions:

* Monitors input power level and protects the module from being overdriven. A sample from the coupler at the input of the power divider is received at J1-9. If the sample is above the reference established by voltage divider R20-R21, U6 pin 14 will go low, indicating normal drive in a PA module. If the sample goes above the reference set by R101, U6 pin 1 will go low, indicating an overdrive fault.

* Monitors output reflected power, and protects the module from elevated load VSWR. Output reflected samples from the output directional coupler assembly are received at J1-22. The VSWR fault threshold is established by R8. If the voltage at U6 pin 5, determined by the reflected power, is greater than the voltage at pin 4, then pin 2 will go low, indicating a VSWR fault.

* Monitors the DC power supply voltage, and protects the module from high and low voltage extremes. The DC supply is sampled at J1-23, and is scaled down by R48, R47, and R42. A maximum voltage reference is established by the +15 Volt regulated supply,

R43, and R44. If the sample exceeds the reference, U7 pin 1 will go high, indicating an overvoltage fault.

Likewise, a minimum voltage reference is established by R45 and R46. If the reference exceeds the DC supply sample, U7 pin 2 is driven high, indicating an undervoltage fault.

* Monitors ISO voltage samples of the quarter modules, protecting the amplifier from damage due to imbalances between the two halves of a quarter module. The ISO voltage samples are combined by a OR circuit and collected at J1-3, 4, 16 and 17 on the controller board.

A reference is established by R38 and R81. If the ISO voltage sample exceeds the reference, U6 pin 13 is driven low, indicating a fault.

* Monitors the temperature of the quarter modules, turning off the amplifier if excessive temperatures are encountered. A voltage is developed on each module by the thermistor circuitry that is proportional to the heat sink temperature. These voltages are routed to the module controller board, J1-5, 6, 7 and 8. The voltages are compared to a reference by comparator U13. If any quarter module temperature voltage is lower than the reference, the comparator output will go low. This switches the output of the Schmitt trigger high.

*Enables the 50 Volts DC to the quarter modules by controlling a pair of high-power switching FETs (pass FETs) located on the module rear panel. If no faults are present, PAL U1 pin 12 sends a signal to U7 pin 8, which controls a circuit that turns on the pass FETs, a pair of n-channel switching FETs. If a fault condition occurs, the switching FETs are turned off.

The switched 50 Volts dc is reduced to 15 Volts by R39 and U10. This 15 Volts is routed to each quarter module for bias circuitry power.

The incoming 50 Volt DC power is switched on and off by the pass FET assembly, controlling the application of 50 Volts to the Quarter Modules. This switched 50 Volts is reduced to 15 Volts by regulator U10. The +15 is supplied to each module to be used for temperature sensing and FET biasing.

The logic will not allow the module to enable if a fault condition exists, to protect the module from damage.

8.2.9 Module Status LEDs

Each module uses two front panel LEDs to display its current operating status. The LEDs are driven by signals from the PALs and U8 and U9, which are NAND gates configured as buffers. The status can be interpreted from the LEDs as follows:

Steady Red - 50 Volts applied to the module, but the module is not enabled. This will normally occur if a module is removed and then reinserted in the slot. The red LEDs will illuminate then fade out as the supply capacitors discharge each time the transmitter is turned off.

Left 1/2 Green LED Illuminated - Module is enabled but little or no RF drive is supplied to the module.

Driver modules, because of their low input drive level, do not have a drive level indication. Thus, when a driver module is enabled, both halves of the green LED are illuminated regardless of drive level. This is the only difference between the PCM systems on drivers and PAs.

Full Green LED Illuminated - A full green LED illuminated indicates normal module operation. - Module is enabled. Additionally, in PA modules, the presence of RF drive is indicated.

No LEDs Illuminated - The 50 Volt DC power is not reaching the module, or the module has been turned off by pulling on the front handle (mechanical disable).

In some cases this could be the symptom of a module control fault. If you have not disabled the module turn off the transmitter momentarily while removing the module. This will prevent possible arcing of the input connector pins if the module was in fact on but not lighting any LEDs.

8.2.9.1 Red LED Fault Blink Codes

If a module fault occurs, the red light will blink on and off. The number of blinks between pauses is the "blink code," and is used to determine the type of fault. A longer pause identifies the start of the blink code. Blink code help is available through the GUI screen. The blink code is as follows:

1 Blink - High VSWR condition at the module output.

2 Blinks - RF input overdriven

3 Blinks - An elevated ISO voltage resulted from an imbalance between halves of a quarter module.

4 Blinks - The power supply voltage applied to the module is too high or too low.

5 Blinks - The quarter module temperature is too high.

6 Blinks - The pass FET transistors that switch the 50 Volts to the quarter modules have failed.

8.3 Module Troubleshooting

CAUTION:
USE EXTREME CARE WHEN REPAIRING OR TESTING RF AMPLIFIER MODULES. BECAUSE THEY ARE CAPABLE OF PRODUCING OVER 1000 WATTS OF OUTPUT POWER, SERIOUS RF BURNS CAN RESULT FROM COMING IN CONTACT WITH ANY HIGH POWER POINTS INSIDE THE MODULE WHILE IT IS OPERATING.

CAUTION:
THESE MODULES OPERATE WITH 50 VOLT POWER SUPPLIES CAPABLE OF VERY HIGH CURRENTS. ACCIDENTAL SHORT CIRCUITS OCCURRING INSIDE THE MODULES CAN CAUSE SERIOUS DAMAGE DUE TO THE HIGH CURRENTS INVOLVED. CAREFULLY INSPECT THE MODULE FOR ANY DEBRIS THAT COULD CAUSE A SHORT TO OCCUR AFTER ANY REPAIR ACTIVITY.

CAUTION:
FAILURE TO USE PROPER SOLDERING TECHNIQUES OR MATERIALS CAN CAUSE DAMAGE TO THE REPLACEMENT COMPONENTS, OR MAY RESULT IN JOINTS WITH POOR ELECTRICAL OR MECHANICAL INTEGRITY, CAUSING SUBSEQUENT DAMAGE TO THE MODULE. PLEASE READ THE SECTION ENTITLED "SOLDERING PRECAUTIONS" BEFORE ATTEMPTING ANY REPAIR ACTIVITY.

Module faults are most easily verified by swapping the suspected faulty module with a known working module in another slot. If the fault follows the module, then the problem is probably internal to the module. If the fault remains at the same slot after substituting modules, then the search for the problem should probably focus on the rest of the transmitter system.

8.3.1 Platinum™ TV Module Test Fixture (992-8556-002) (Optional Equipment)

Refer to Figures A-4 & A-5

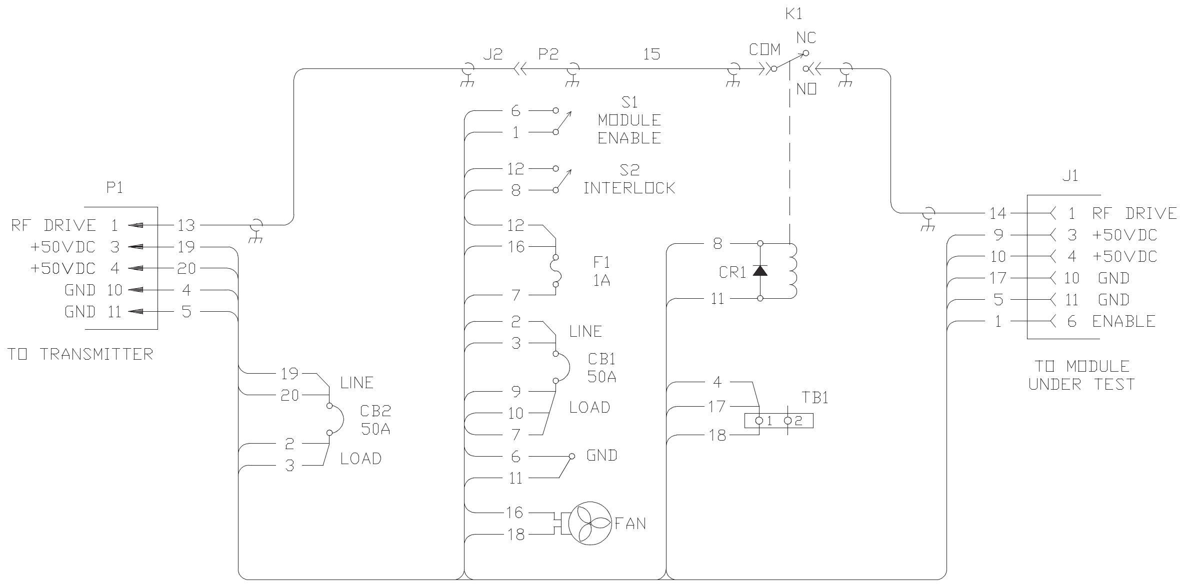

Figure 8-5 Wiring Diagram PA Module Extender (Harris PN 992-8556-002) (Drawing 843 5285 162)

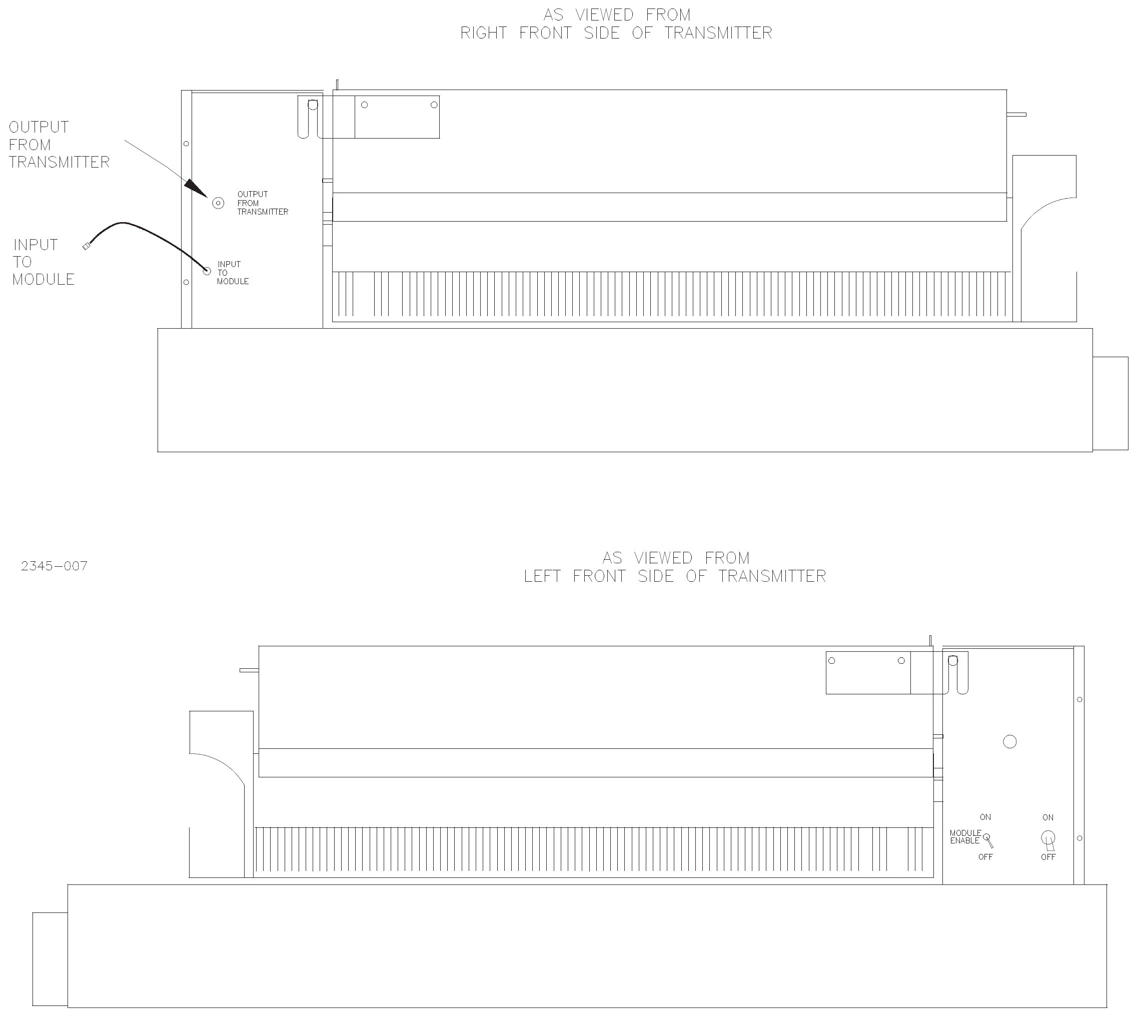

Figure 8-6 Module Test Fixture

The Platinum TV Module Test Fixture consists of a table top assembly with a interconnect cable ending in a plug assembly that is inserted into an empty module slot. The cable to the test load is routed through the end cover opposite the fan and connected inside the test fixture by reaching through the cooling slot.

An interlocked Safety Cover must be in place to activate RF drive to the module under test.

Breaker CB1 limits the current to 50 amps, protecting the cable. Breaker CB2 at the test fixture trips from excess module current and can be used as module power switch. Interlock switch S2 and driver relay K1 prevent application of RF drive until the cover is closed.

Fuse F1 provides protection for the small signal wiring in the extender and the 50 Volt DC fan.

Enable switch S1 allows local control of the module on the extender while the transmitter is on.

CAUTION:
AN EXTERNAL RF LOAD MUST BE CONNECTED TO THE MODULE AT ALL TIMES DURING TEST. BE SURE TO DISABLE AND REMOVE THE MODULE OR TURN OFF THE BREAKER BEFORE REMOVING THE EXTENDER FROM THE CABINET.

8.3.2 Troubleshooting Based on Module Swapping

Many situations exist in which a problem exhibited by a module could be due to a problem either with the module itself, or somewhere else in the transmitter. For example, VSWR faults could be due to either a failure or misadjustment of the VSWR sensing circuitry in the module, or due to a problem with the transmitter cabinet RF connector, combiner cables, reject loads, etc. In fact, most fault indications could be caused by either module or system problems. Thus it is desirable to first isolate the problem to the module or system before continuing the troubleshooting process.

Since the modules are designed for interchangeability with other modules of the same type, one easy test to determine whether a problem lies in the system or in the module is the "swap test," which involves swapping the suspect module with another and observing whether the symptom follows the module.

8.3.3 Troubleshooting Based on Module Blink Codes

The general procedure for troubleshooting based on a module blink code involves several steps.

The first is to check for causes consistent with the blink code (such as checking the DC supply voltage if blink code 4 occurs). Often, this will give an indication of whether the problem lies within the system or the module.

If this does not locate the problem, then the next step is to check for correct threshold voltages on the module logic board. Fault blink codes result from a sample voltage taken within the module exceeding some preset threshold. Thus, if no other module or system problem is found, the problem may be due to an incorrectly set fault threshold (as in the case of thresholds set with potentiometers), or a defective component (such as a resistor) used to establish a threshold. The theory of operation of the module

Protection, Control and Monitor subsystem, gives detailed descriptions of how these thresholds are derived and compared against the corresponding voltage samples.

Finally, if neither of these steps yields success, the problem may lie in a PAL or logic gate on the module control board. This type of problem is generally rare. Measuring voltages at various points in the logic circuitry on the module control board can isolate this type of problem.

A set of troubleshooting procedures, one procedure for each fault code, is given below:

High Output VSWR Fault (1 blink) The cause for this fault is often external to the module. First, check the system VSWR on the display panel, and check for a VSWR foldback or VSWR overload condition on the transmitter. Check the other modules in the same cabinet for VSWR faults as well. If either is found, suspect a problem in the system outside the cabinets.

If not, the problem is either in the suspect module or its cabinet. The swap test is the easiest way to isolate the problem. Swap the VSWR faulting module with a properly working one from another slot. If the problem remains in the same slot, check the RF output cable, connector, and combiner reject load for that module slot.

If the problem follows the module, check the solder connections at the directional coupler and the RF output jack inside the module. If no problem is found, the problem could be an improperly set VSWR fault threshold or a defective module logic board. See paragraphs giving procedure used to check and set the VSWR threshold located on section 8.5.2.5.

Input Overdrive Fault (2 blinks) Normally, this protects the module from damage due to excess RF drive (at least 3 dB above the drive required to drive the module to full power). To isolate the cause of fault, reduce the visual exciter RF output to zero, then enable the module with a transmitter ON command. If the fault remains, the problem is likely to be with the module control board.

If the fault clears when RF drive is removed, check to see that the module is not being overdriven. If not, then the overdrive threshold on the control board may be misadjusted. See procedure located in section 8.5.2.4 to check the Overdrive Threshold.

ISO Voltage Fault (3 blinks) The RF input to the quarter module passes through a two-way divider on the quarter module, and is then fed to two parallel amplifiers on the quarter module. The outputs of these two amplifiers are recombined in a two way combiner on the same board. The combiner contains a 10 Watt reject load resistor, called an ISO resistor because it is used to provide isolation between the combiner input ports.

If outputs of the two parallel amplifiers are equal in amplitude and phase, the voltage across the ISO resistor will be very small. Should some component fail on one of the amplifiers, its output would decrease to a level much lower than the other parallel amplifier, which would cause the voltage across the ISO resistor to increase significantly. If the ISO voltage of any quarter module exceeds about 1.9 Volts, the control board shuts the power amplifier module down and indicates an ISO fault.

An ISO fault will almost always be caused by a component failure in a quarter module (RF FET, chip cap, ISO resistor, or open solder connection). The common cause is a damaged RF FET.

Damaged FETs are sometimes caused by problems in the module output combiner, examine this area first before trying to re-enable the module to avoid further damage. With DC power and RF drive removed, visually inspect the connections between the quarter module outputs and combiner inputs, between the combiner sections, between the combiner output and the directional coupler, and between the coupler and the output connector. An inspection mirror aids the examination greatly. Next, use an ohmmeter to confirm an open between the output connector center pin and chassis, and continuity between the center pin and each quarter module output. Also examine each quarter module, especially the area near its output.

If no problems are found with the output circuitry, try to confirm the ISO fault with the module on the test fixture. Put the safety cover down (applying RF drive), switch on the DC power and attempt to enable the module. If the ISO fault does not occur again, there may be a problem in the system rather than with the module (for example, an open cabinet combiner dump load or a damaged module RF power input connector).

If the ISO fault is confirmed, check the bias current of each quarter module, one at a time with no drive applied (lift the safety cover to remove RF drive). A quarter module with bad FET(s) will have lower bias current than the others. Check the section on bias current setting to confirm the correct bias current for each quarter module. If a quarter module with low bias current is found, first record its total bias current, then observe the current while turning off bias to each FET one at a time with the bias adjustment pots. Record the current after turning each pot off and look for one or more FETs whose bias current is zero or lower than the others.

If no quarter modules or FETs indicate low bias current, there are two possibilities: either a shorted, open or damaged component on a quarter module, or a problem with the PCM (logic) board. Try to rule out a problem with the PCM board first. If a storage oscilloscope or peak-holding DMM (e.g. Fluke 87) is available, try to confirm an ISO voltage greater than about 1.9 Volts. Remove DC power, clip a probe onto the ISO voltage line close the safety cover, connect the probe to the scope or DMM, apply DC and enable the module. If the ISO voltage does not appear, look for problems on the module PCM board (check for 0.9-1.0 Volts on U6 pin 10). If no storage scope or peak-holding DMM is available, proceed to looking for problems on the quarter modules after checking for 0.9-1.0 Volts on U6 pin 10 of the PCM board.

To find a problem on a quarter module, first try to locate one quarter module that is the source of the ISO fault. With DC power off and RF drive removed, connect a scope or meter to the ISO voltage line, and disconnect the 50 Volt wires from all but quarter module #1 (nearest the back of the module). Cover the exposed ends of the loose 50 Volt lines with electrical tape to prevent them from shorting within the module. Close the safety cover (applying RF drive), turn on the DC power and try to enable the module, observing whether or not an ISO fault occurs. Shut off the DC, remove the 50 Volt connection from quarter module #1, reconnect the 50 Volt line for quarter module #2, and again try to enable the module. Repeat with each of the remaining quarter modules. The module should ISO fault during one of these trials (the quarter module with the problem is the one with its 50 Volts connected when the fault occurs), and the ISO voltage should read a low value (several tenths of a Volt or less) during the other trials.

Once a quarter module with a problem is located, perform a careful visual inspection, looking for burned or broken components, bad solder joints, solder splashes, loose hardware, open circuit board traces, etc. Check the output ISO resistor (low band R15; high band R11) by lifting one lead and measuring with an ohmmeter (should measure 190 to 210 ohms for low band, or 95 to 105 ohms for high band).

See the procedure located in section 8.5.2.3 to check for the correct ISO Fault Threshold.

Power Supply Voltage Fault (4 blinks) The RF FET transistors operate on a nominal 50 Volt DC supply. If the power supply voltage is too high or too low, the devices could be damaged. The control board monitors the voltage, and reports a power supply voltage fault if it is not between approximately 44 and 54 Volts.

If several modules exhibit the same fault, check the voltage of the power supply and look for faulty connections. Remember that heavy current draw could cause the supply voltage to drop significantly lower than that measured with only a voltmeter loading the line. If only one module exhibits the fault, check the DC supply voltage and connections, plus the module power supply pins and the wiring to its slot. If no problem is found in the power supply or connections, then the problem could be on the control board, either in the control logic or the comparator thresholds. See the procedure for checking for correct Over/Under Voltage Fault Threshold located in 8.5.1.3 in this section.

Over Temperature Fault (5 blinks) The module can be damaged if it is not cooled properly while operating. To protect the amplifier, each quarter module has a temperature sensing circuit that signals the control board to disable the power amplifier if the temperature of any quarter module temperature exceeds 80^{o}C. When this occurs, the logic disables the module, and commands the red LED to blink five times.

First, check the cabinet air filters and module heatsink for accumulated dust. Verify that the cabinet air plenum is providing proper air flow to the module slot. Measure the air inlet temperature, it should be below the maximum temperature rating of 50^{o}C. If the temperature is more than a few degrees above outside temperature, the air supply system may not be adequate.

If an improper module fault is suspected, allow the module to cool to room ambient. Re-enable the module, a real temperature fault will not cause an immediate fault, the thermal mass of the heat sink requires at least ten minuets to generate a temperature fault.

Check quarter module temperature calibration as follows: Supply +50 Volts to the module and, without enabling it, check the voltages at test point TP-1 on each quarter module center board. This voltage represents the temperature of the heatsink at the location of the temperature sensor. The voltage is calibrated to be **5.30** Volts at a temperature of 25^{o}C. The calibration control is R2 on each quarter module board. The voltage at TP1 is compared against a reference voltage of 5.82 Volts generated by a voltage divider.

Measure the quarter module temperature reporting inputs at U13 pins 5,7,9, and 11. If any quarter module input is lower than the reference check for an overheated quarter module, an incomplete temperature reporting circuit, or failure of a quarter module bias and temperature reporting circuit. If the reference voltage is lower than all the temperature reporting lines, the outputs of U13 should be high, and the output of U5 should be low, and the module should not be reporting a temperature fault. If a temperature fault is reported check for proper operation of comparator U13, Schmitt trigger U5, or possible PAL failure.

Pass FET Failure Fault (6 blinks) Should one of the pass FET DC switch transistors fail to a shorted condition, the control board will sense it and blink the red LED six times. The pass FETs are 60 amp 100 Volt MOSFETs used as DC switches to enable and disable the module as necessary by applying or removing DC from the quarter modules.

CAUTION:
IF A PASS-FET FAILURE IS INDICATED, THE MODULE CANNOT BE TURNED OFF EXCEPT BY TURNING OFF THE PA CABINET OR BY DISABLING THE POWER SUPPLY WHICH POWERS THE PA. A MODULE INDICATING PASS-FET FAILURE SHOULD NOT BE REMOVED FOR SERVICE WITH POWER APPLIED, AS COMPONENT DAMAGE COULD RESULT.

A shorted pass FET (drain-source short) is normally confirmed by measuring the resistance from the red 50 Volt wire of any quarter module to the +50 Volt pins of the input connector with an ohmmeter.

If open pass FETs are suspected check the voltage at collector (case) of Q1 of the Module Control Board as the module is enabled and disabled. This voltage is fed through resistance to the gate of the pass FETs. When Q1 collector is high (enabled), +50 Volts should appear at the quarter modules. When Q1 collector is low (disabled), no voltage should be present at the quarter modules.

If a fault is suspected in the gate voltage circuit, trace signals back through CR4, R58, and C9 to the oscillator U4. Pin 7 should show a triangle wave with peaks at 0 and +15 Volts. Buffer U7 pin 14 should be low if enabled. PAL U1 pin 12 should be low if enabled, and +5 Volts if disabled.

8.3.4 Isolating Other Failures

This section includes troubleshooting procedures for situations where a problem is not indicated as a fault by the module logic and control circuit, and no blink code is given.

Amplifier Module Will Not Enable, Has 50 Volts Applied To It But No LEDs Will Light The cause could be a loss of the 15 Volt DC supply in the module. Check the following:

If fuse F1 on the module control board is open, check for a short circuit on the 15 Volt line after the 15 Volt regulator.

If resistor R80 on the module control board is open, look at the 15 Volt regulator U11 itself. The regulators tab is internally connected to its output, and thus must be isolated from the chassis. Use an ohmmeter to check whether the regulator tab has shorted to the chassis.

Amplifier Module Will Not Enable, Has a Steady Red LED Illuminated and Will Not Change to the Green LED Illuminated A possible cause could be that the module control board is not receiving the enable command from the slave controller. Try enabling the module on the bench or on extender, or try the swap test after reading the precautions in section A.3.2. If the module now enables, use a multimeter to check the enable wiring in the transmitter cabinet.

If the module still does not enable while in a different cabinet slot, check the continuity of the yellow enable wire inside the module. This wire runs from the black plastic power connector on the module rear panel to a feedthrough capacitor, then to J1-12 on the module control board. If this wire is intact, then the module control board is probably defective. The module is normally enabled by grounding this control line.

Module Has Only 1/2 Green LED Illuminated and Low or No RF Output The module has been enabled but little or no RF drive has been applied to the quarter modules. This indication is given only in PA modules; drivers have both green LEDs on during an enable condition, regardless of drive level. This indication is sometimes a normal condition in PA modules used in the drive chain of a transmitter whose output power is significantly below 30kW.

If this is not the case, then the cause for loss of drive could be either in the module or in the transmitter cabinet. First, check for normal exciter and transmitter output levels.

If the exciter drive level seems normal, try the module in a different cabinet slot that is known to have proper RF drive. If the problem doesn't follow the module, then inspect the cables leading to the module RF input for that transmitter slot. If the problem does follow the module, check the RF input cable inside the module, connected between the black power connector on the module inside rear panel and the 4-way power divider.

Module Has Full Green LED Illuminated But No RF Output

PA modules: Since an insufficient drive level causes one of the green LEDs to go out, that cause is ruled out. This condition would most likely be caused by a failure of the pass FET driving circuitry on the module control board. The control board logic has illuminated the green enable LED, but it is not turning on the pass FETs. This will not allow the quarter modules to receive the 50 Volts DC that they need in order to operate. See the paragraphs on Pass FET Failure Fault (6 blinks) located on page A-22 in this section.

Driver modules: The pass FET driving circuitry could also be the culprit, as in PA modules. In driver modules, however, a more likely cause is insufficient or no drive.

Try swapping driver modules, if the problem follows the module, check the module RF path, starting with the RF input cable inside the module, then moving to the input attenuator (R4, R5, R6) on the interconnect board, then to the first stage. Also, check the connections between each stage and the next.

If this doesn't isolate the problem, check the DC voltage and current supplied to each quarter module, through the red wire connected to screw terminal TB1. Measure the applied voltages and normal idle currents for each quarter module.

If a quarter module indicates 50 Volts present but no current, check the 15 Volts supplied through J1-1.

If the problem stays in the same transmitter slot, the problem is within the transmitter (AGC module, phase and gain module if present, preamp if present, power divider if parallel drivers are used, or RF cables).

8.3.5 Locating Failed RF FETs

8.3.5.1 DC Resistance Test

The most common symptom of a bad FET is an ISO fault (3 blinks). Using a analog or digital multimeter (or equal), measure the DC resistance from the gate to ground of each FET. This is done with the module on the bench with neither RF or DC power applied. Compare the resistance measured from one FET to the next. The resistance indicated will vary with the voltage of the multimeter used. A resistance on one FET significantly lower than the others indicates a bad FET or leakage in a gate chip capacitor.

If no FET indicates a low gate to ground resistance proceed to idle current testing.

8.3.5.2 Idle Current Test

First, it is necessary to determine the original bias current per FET, and to determine on which quarter module the failed FET lies. For this procedure, no RF drive will be applied; however, a RF load resistor should still be placed at the module output to prevent oscillation.

Starting with the first quarter module (nearest the logic board) and working toward the front handle, measure the total idle current of each quarter module in turn. Either insert a current meter in line with the 50 Volt wire at TB1, or use a clamp-on DC current meter if available. With no RF drive applied, apply 50 Volts and enable the module. Note the quarter module current, disable the module, remove the 50 Volts and move the current meter to the next quarter module.

If no current meter of sufficient range is available, a small resistance can be placed in series with the 50 V line, and the voltage drop used to calculate current from Ohms Law (I=V/R). Values from 0.1 to 0.2 ohms should be satisfactory. A sensitive digital meter with a millivolts range is needed to use this technique.

After taking the current measurements on each quarter module, determine the correct bias current setting per FET. A bias current value marked on the hold down spring should be used instead of this chart.

- Analog and Platinum-i Modules:

Driver: Low Band1.0 Amp, High Band,Quarters # 1&2 = 400mA, 3&4=1.0 Amp.

HB&LB PAs:all FETs bias at 300 or 400ma, check hold down spring bar.

- Classic series digital drivers:

The nominal bias current per FET is:

Low and high band driver	1.0 Amp.
Driver PA Low Band	0.8 Amp
Driver PA High Band	0.7 Amp
PA Module	0.3 or 0.4 Amps as marked on hold down clamp

Now that the correct bias current is known and the quarter module with failed FET(s) has been located, one can locate the failed FET. Move the current meter to the quarter module showing abnormally low current. Again, apply DC power only and enable the module. While observing idle current, slowly rotate the bias control for each transistor **counterclockwise**, one at a time; this should reduce the current for the corresponding FET.

If the idle current does not drop when the pot is turned fully counterclockwise, then the RF FET is probably bad. To determine which pot affects the idle current of each FET, refer to Figure A-6. Note the location difference between high band and low band quarter modules.

Procedure for setting bias current on a quarter module:

First, determine the correct bias current per FET. Connect a current meter in series with the 50 Volts to the quarter module. Next, set the bias pots fully counterclockwise, apply 50 Volts, and enable the module. The current meter connected to the quarter module being adjusted should read almost zero current (less than 20 mA). **Slowly** turn each bias pot clockwise to set the current for the corresponding FET, then adjust the next bias pot until a total of twice the current per FET is reached, and so on, until the last FET is adjusted such that the total current is four times the current per FET.

Example: On a low band class AB stage, after determining that the correct bias for a given quarter module is 400 mA per FET, start with all bias pots fully counterclockwise. **Slowly** turn R25 clockwise until 400 mA is reached, then turn R26 clockwise until 800 mA is reached, then R27 until 1.2 A is reached, and finally turn R28, stopping at 1.6 A total.

CAUTION:
*ADJUSTING THE BIAS POTS TOO FAR CLOCKWISE OR TOO QUICKLY CAN DESTROY AN RF FET DUE TO EXCESSIVE CURRENT. GO **SLOWLY**.*

8.4 Parts Replacement Procedures

8.4.1 Soldering Precautions

Please read the following precautions before attempting any repair activity:

a. Be sure to use the correct type of solder depending on the repair being made. For soldering coaxial cables, use a SN 96, AG 4 alloy for lowest loss and best mechanical strength. For all other joints, use SN 63, PB 37 for its low melting point.

b. Always use electrical solder with a rosin flux. Never use plumbing solder or acid fluxes, which can cause copper to corrode. Start with clean, tinned leads, which will minimize the need for flux. If it is necessary to use additional flux, use as little as possible.

c. Choose the correct soldering equipment for the job. Use tips that are the appropriate size for the components involved. Use a grounded iron when installing static-sensitive components (most semiconductors).

d. Choose a soldering temperature just hot enough to melt the solder quickly, while as low as possible to prevent damage to the new components. An iron with a temperature adjustment is best. Typical settings are:

   650°F for small chip caps
   750°F for RF FET tabs
   800°F for coax cables and wiring on large pads.

e. Make the new joint as mechanically sound as possible before making the electrical solder connection. Provide mechanical strain relief for leads on components which are flange-mounted.

f. Clean all flux residue away from the area when finished. When working around devices where thermal compound is used, be sure not to allow solvents to flow between the device and the heat sink, which can cause the heat thermal compound to dissolve.

g. Be sure to search for and remove solder splashes, solder bridges, loose solder wire or wire lead clippings, and screws before replacing the cover. Loose metal inside the module can lead to short circuits, which can cause serious damage to the module and possible injury.

8.4.2 Quarter Module Replacement

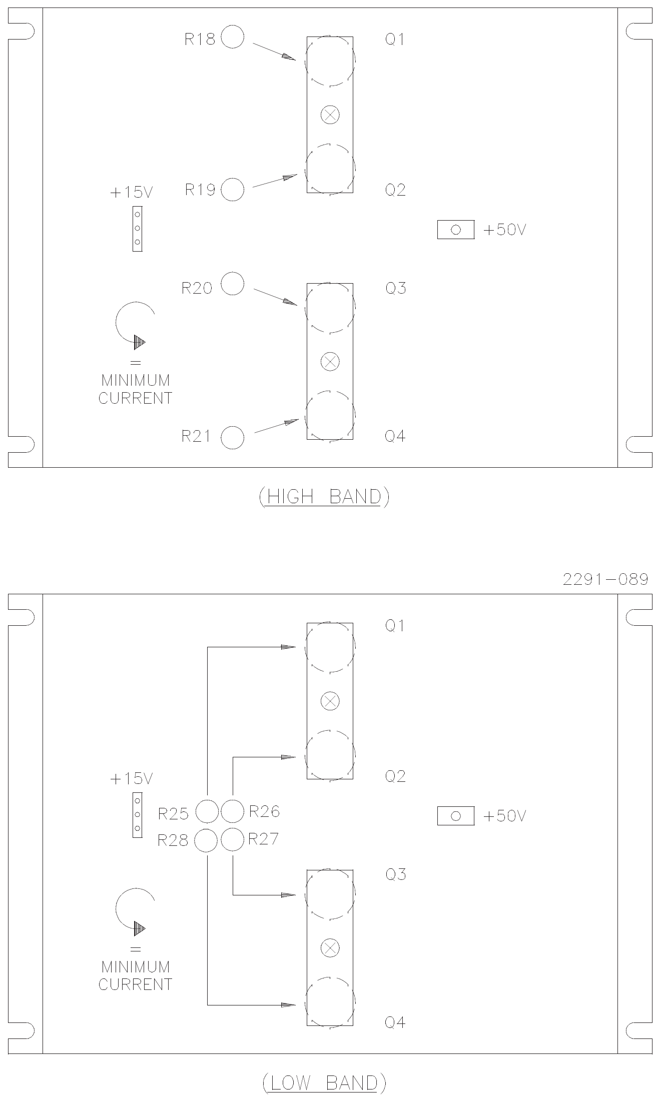

Figure 8-7 Quarter Module RF FED Bias Pots

Platinum quarter modules can be field replaced with another quarter module FACTORY TUNED to the same channel. The gain of each quarter module is adjusted by the value of the quarter module input pad. The input to output phase relationship is set by TL1, the phase setting coax. This coax must remain with the quarter module, use the replacement cable already attached to the REPLACEMENT quarter module for proper phasing. Replacement quarter modules are furnished with the bias for PA usage, for DRIVER or driver PA usage the bias must be reset.

8.4.3 RF FET Replacement

CAUTION:
THE RF AMPLIFIER FETS ARE SENSITIVE TO DAMAGE FROM STATIC ELECTRICAL DISCHARGE, AND SHOULD BE HANDLED IN AN ANTI-STATIC ENVIRONMENT. A GROUNDED WORKING SURFACE, GROUNDED IRON, AND ELECTROSTATIC DISCHARGE BRACELET SHOULD BE USED.

CAUTION:
IN ORDER TO PROTECT THE NEW FETS FROM ACCIDENTAL DAMAGE TO OVERCURRENT, BE SURE TO TURN OFF THE BIAS (FULLY COUNTER-CLOCKWISE) TO ALL FOUR FET POSITIONS ON THE QUARTER MODULE BEFORE INSTALLING THE NEW FETS.

CAUTION:
WHEN CLEANING THE OLD THERMAL COMPOUND FROM UNDERNEATH THE FET AFTER REMOVAL, USE A SWAB WITH JUST ENOUGH SOLVENT TO CLEAN THE SURFACE. DO NOT USE TOO MUCH SOLVENT, AND DO NOT USE AN AEROSOL SPRAY CLEANER, AS EITHER MAY SEEP UNDERNEATH NEARBY FETS AND DISSOLVE THE THERMAL COMPOUND FROM UNDER THEM, CAUSING PREMATURE FAILURE.

WARNING:
RF TRANSISTORS, ISOLATION RESISTORS, AND INPUT ATTENUATORS CONTAIN BERYLLIUM OXIDE (BEO) CERAMIC, A HAZARDOUS MATERIAL. THE LIDS ARE MADE FROM AL2O3 AND ARE HARMLESS. THE BEO IS HARMLESS WHILE INTACT, BUT THE DUST IS TOXIC. AVOID CRUSHING OR BREAKING THE BEO CERAMIC, AND DISPOSE OF FAILED DEVICES PROPERLY.

The Phillips FET (ON4402H) is used for both low band and high band modules. Each FET is marked with a gain code and a threshold code. For replacement the gain code is the most important. The quarter module has been assembled in the factory with FETs that have the same gain code. When the quarter module is aligned the gain is set with an attenuator on the input. Therefore the FET being replaced must have the same gain code as the other FETs on the quarter module for proper performance. The gain code is a number (3 through 7) located above and to the left of the ON4402H marking on the cap.

Each gain code has a part number assigned to it. These are shown in the following table:

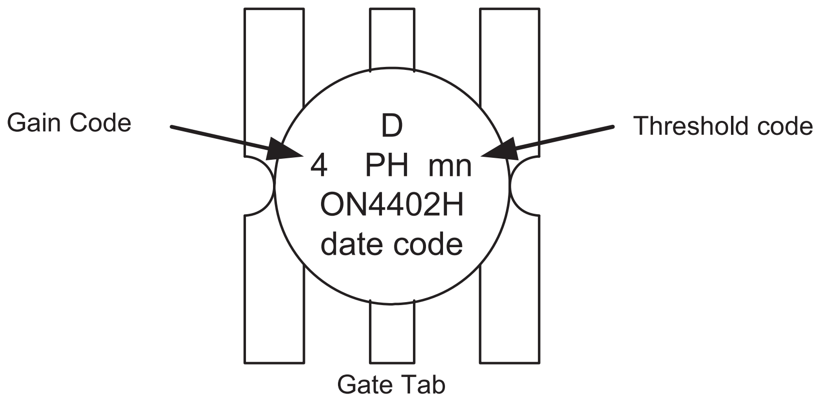

Figure 8-8 FET Marking Code

Gain Code	Harris Part Number
3	380-0737-003
4	380-0737-004
5	380-0737-005
6	380-0737-006
7	380-0737-007

Once a failed FET is isolated, remove it from the board using the following procedure:

a. Turn off the bias to all four FETs by rotating the bias control pots counter-clockwise.

b. Remove the clamp holding down the transistors.

c. Using a 45 Watt soldering iron with a wide blunt tip, desolder the leads lifting them with a small knife. It is important to use enough heat to quickly flow the solder and work quickly so as not to damage the foil.

d. Remove the old heat sink compound. Use a small amount of solvent, such as Isopropyl Alcohol, on a swab, being careful not to allow it to run. Do not use sprays of any kind, as they may dissolve the heat sink compound from underneath nearby FETs.

e. Re-flow the solder left on the foil where the tabs will seat. Be sure the surface is smooth and that no solder bridges remain.

To install the new FET:

a. Tin the bottom of the FET leads lightly with solder.
b. Use the following procedure for filling a syringe with thermal compound.
    1. Required Equipment:
        a. A 5mL syringe
        b. Zinc oxide (Wakefield) thermal compound
        c. A stirrer (clean, no lint)
        d. A clean cloth
    2. Procedure:
        a. On a clean, dry surface open the heat sink compound jar and stir the compound thoroughly with a clean stirrer. Make sure there is no settling in the compound before proceeding.
        b. Assemble the syringe if necessary.
        c. Put syringe tip in the compound up to the beginning of the barrel of the syringe.
        d. Push and pull plunger several times while the tip is in the compound (2 to 4 times) to make sure there are no air gaps when filling the syringe.
        e. With the tip of the syringe still in the compound, begin swirling the tip around in the compound while drawing back the plunger to fill the syringe to 5mL.
        f. Remove syringe from compound and clean off carefully with the clean cloth.
c. Apply heat sink compound on the RF FET.
    1. Required Equipment:
        a. Xacto knife (blade #11). Use only a fresh blade for this procedure (no nicks or mars, has not been used for anything else. When in doubt, change the blade)
        b. Cleaning solvent
        c. Q-tip
        d. Wakefield compound in new 5mL syringe
        e. A clean cloth
        f. ESD (electro static discharge) equipment

2. Procedure:

   a. Make sure you are ESD safe through the entire procedure.

   b. Take the FET to be installed and make sure the back side is clean. Make sure that the heat sink mounting surface is clean as well. If the surfaces are not clean, clean them with a Q-tip dipped in cleaning solvent. Make sure solvent is dry before proceeding.

   c. Use the Xacto knife (blade #11). Only use a clean, fresh blade (this blade should only be used for this procedure). Measure out a small amount (1-2mm from the tip of the syringe) of compound from the dispensing syringe onto the Xacto blade.

   d. Apply the compound evenly on the FET by moving the flat side of the blade in a circular motion on the back side of the FET. Clean excess compound off the blade.

   e. Holding the Xacto blade at a 45 degree angle or less from the FETs surface, gently press down with the blade edge.

   f. Continuing to hold the blade at 45 degrees or less, and starting at one end of the FET, sweep slowly across the FET. Made sure the blade does not lift up. There should be a thin opaque film left on the surface after sweeping. The gold flashed back of the FET is slightly concave, the heat sink compound should be thickest in the center. There should be excess heat sink compound on the blade. Carefully wipe the excess compound off on a clean cloth (do NOT try to re-use this compound).

   g. Place FET firmly into the holes of the PC board. Try to pull the FET up, applying moderate force. If the FET resists being pulled up, it is well seated. If it is easily pulled up, clean both surfaces, inspect for surface irregularities, and try again.

   h. Install spacer, levelers and leaf spring. Insure that leaf spring and levelers are centered over the FET packages and that the spacer is resting flush with the heatsink. Tighten the screw securely. The leaf spring should bottom out on the spacer and the split washer should be fully compressed.

   i. Solder the leads using low-temperature solder. Inspect for solder bridges. Scrape away any flux using a small knife. Do not use any sprays or liquids that may run under the transistor and dissolve the heatsink compound. Inspect for proper flow of solder between the FET leads and the board foil.

   j. Check to see that all bias pots of the quarter module have been turned fully counter-clockwise before applying any power.

Refer to the section on Idle Current Testing to set bias controls

WARNING:
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8.4.4 Testing and Replacing Isolation Resistors

In order to test ISO resistors, it is necessary to desolder one of the leads before testing the resistor with an ohmmeter.

When replacing a flange-mounted ISO resistor, bend the resistor leads curving upward slightly to provide mechanical strain relief to allow for differing expansion between the circuit board and the heat sink. Be sure to clean away the old thermal compound from the heat sink surface, and apply just enough compound to the flange of the new device in order to assure a good thermal interface. After applying reasonable torque to the flange screws, solder the leads quickly using a hot iron.

8.4.5 Pass FET Replacement

If pass FET replacement is necessary, replace both FETs with the matching parts. If this is not done there may be a tendency for one FET to carry more of the current and lead to a repeated failure.

When pass FETs are replaced, change Q1 and R72 on the Module Control Board, and change the 5.6 ohm resistors and the zener diode on the pass FET bus bar assembly. These parts are typically stressed in the event of pass FET failure and replacing them will promote long term reliability.

Use the same ESD procedures outlined in the section on RF FET replacement. The FET drains are insulated from the chassis with SIL-PADS, silicon insulating pads that need no heat sink compound.

Before enabling the module, check to see that the drains are not shorted to the chassis using an ohmmeter.

8.4.6 Chip Cap Replacement

It is a common technique to use two irons with small tips (one on each side) when removing or installing chip caps. Both sides of the chip cap should be heated simultaneously to avoid residual stresses which might later cause a failure.

Note that the capacitor values listed in the Parts List are typical values. Check the value of the capacitor to be replaced before ordering a replacement part.

8.5 Test Procedure Solid State TV Modules

Install transmitter section of module test fixture into transmitter.

Attach RF output cable to module test fixture through access slot in the fixture, and connect to wattmeter and 50 ohm load (1kW).

Install input wattmeter. Use RF input access cable on side of test fixture.

Attach extension section and install module onto fixture. (Do not install module protective cover at this time.)

Perform a complete visual inspection of the module to be repaired.

Remove red wire from TB1 and install a current meter in line. The current meter needs to be capable of measuring 400 mA steps accurately, and up to 10 Amps total. A clamp-on probe, if available, makes the task easier. Use an ammeter that is resistant to RFI.

8.5.1 Pre-operational Checks

8.5.1.1 Initial Power Up

Close CB2, this breaker is only to protect the wiring between transmitter and test fixture.

Apply 50 Volts DC only to module by turning on circuit breaker CB1. (Red LED on module front panel will be on.)

The +5 and +15 Volt PCM supplies can be checked when 50 Volts is applied.

8.5.1.2 Idle Current Check

The module cover section of the extender assembly should be removed so that no RF drive can be applied.

Enable module with MODULE ENABLE switch on test fixture.

Red LED will extinguish. On PA modules one half of green LED will illuminate. On driver modules both halves of green LED will be on.

Note the current reading of the quarter module, the current should be four times the nominal value or the four times the value marked on the FET hold down clamping bar. The test procedure allows other idle currents if the values are marked on the clamp spring.

If quarter module currents are all OK, the module is ready for RF testing. If the current is incorrect, refer to Idle Current Test procedures.

8.5.1.3 Over/Under Voltage Check

Since there are no adjustments this is an operational check only. Measure the voltages at U7:

Pin 4 = 10.3V +/- 0.2V	50 Volt supply sample approximately 1/5th ratio
Pin 5 = 11.1V +/- 0.2V	Over threshold
Pin 6 = 8.9V +/- 0.2V	Under threshold

To simulate over voltage fault, connect an isolated supply at the junction of R47 and R48. Monitor U7 pin 7 voltage to note trip point.

Inject increasing DC voltage until the circuit trips.

To simulate under voltage fault connect a 100k ohm variable resistor across R47.

Monitor U7 pin 7 and decrease the value of resistance until the circuit trips.

If an external 50 Volt source is available to operate the entire module you may check the trip points for operation at 44 Volts and 53.5 Volts.

8.5.2 RF Testing

CAUTION:
IF THE UNIT BEING TESTED IS A DRIVER BE SURE THE FIXTURE IS CONNECTED TO A DRIVER POSITION IN THE TRANSMITTER. EXCESSIVE DRIVE WILL DESTROY THE INPUT ATTENUATOR IF A DRIVER IS DRIVEN FORM THE HIGH RF LEVELL OF A PA SLOT.

Complete RF testing is not usually required after module repair. If the gain measures OK and the module combiner reject loads are cool, a module power drop test will confirm the module is putting out normal power in a normal phase relationship.

Testing of drivers may be done in a PA slot if the drive cable access loop on the extender is removed and a external source of RF is applied (i.e. the standby exciter in dual configurations).

NOTE:
IF YOU ATTEMPT TO OPERATE A PA IN A DRIVER SLOT, THE DRIVE LEVEL WILL BE INSUFFICIENT TO COMPLETE THE TESTS.

8.5.2.1 Application of Drive

To test a driver module it is recommended to adjust exciter power to minimum before applying RF in the configurations with only one driver in the path.

Install protective cover on the module and note the power output on the wattmeter. PA module output should be in proportion to the others in the system. Check the repaired module output power against other good modules.

8.5.2.2 Gain Check

Modules are tested for analog service and the Classic drivers and PA drivers have the bias changed.

Analog PA gain is measured in factory test at visual frequency with carrier only operating at 625 Watts.

Digital PA Gain is measured 600 watts average power.

Low band driver gain is measured at 30 Watts average power.

High band driver gain is measured at 150 Watts average power.

Turn off module and move the wattmeter to meter the input power. Turn on module and using an element of appropriate range measure the input power. Turn off the module and if needed move metering to the output, turn on module and measure output power. Bird type wattmeters may have problems with digital power accuracy but the ratio may be OK.

Calculate gain in dB using 10 log(P out/P in).

Since the driver input power is in mW, it will be necessary to use a power meter with an appropriate range to measure input power.

All driver modules should have a gain of 35 dB +/-0.5 dB.

Low band PA modules should measure 18 dB minimum.

High Band PA modules should measure 13 dB minimum

INPUT/POWER DIVIDER PWA.

In Driver modules the pad is constructed using three resistors. The resistors are selected using Table A-2, (817-2100-639) Input Attenuator/Driver.

8.5.2.3 ISO Volts Check

Adjust PA power to 250 Watts. For a high band driver use 150 Watts aural and for a low band driver use 65 Watts.

If necessary, manually disable some of the other modules to bring the drive level up as required.

Measure the voltage at P1-2 on any one of the four quarter modules. (They are wired in parallel.)

Verify the value to be 0.3 Volts DC or less.

To test the fault threshold, remove the RF Drive.

Using an isolated DC supply (possibly a 9 Volt battery and a variable resistance), inject voltage at P1-2 of any quarter module and slowly increase voltage until the module faults.

The module should trip off between 1.7 and 2.1 Volts.

8.5.2.4 Overdrive Check

Perform this check only after verifying that the module gain adjustment is correct. See paragraph on Gain Check located elsewhere in this section.

Pre-set the Overdrive Pot R101 fully clockwise

MODULE TYPE	DRIVE LEVEL	TRIP TOLERANCE
High Band PA	120 WattsCW	2 Watts
Low Band PA	35 Watts CW	1 Watt
Low Band Drivers	140 milliwattsCW	10 milliwatts
High Band Drivers	350 milliwattsCW	10 milliwatts

To set the trip point adjust R101 CCW until the module faults and gives a blink code 2 on the red LED.

The red LED display has a few seconds time delay before indicating. It may be helpful to observe the power meter or quarter module current which will react instantaneously, while setting the overdrive trip point.

Check the setting by reducing the power, enable the module, and increase power. The drive power level must trip within the allowed tolerance. If not readjust R101 as required.

8.5.2.5 VSWR Protection Check

- Precise Method:

STEP 1 Connect a 50 ohm termination to the module RF input. Connect a signal generator, test amplifier, and power meter to the module output per Figure A-7.

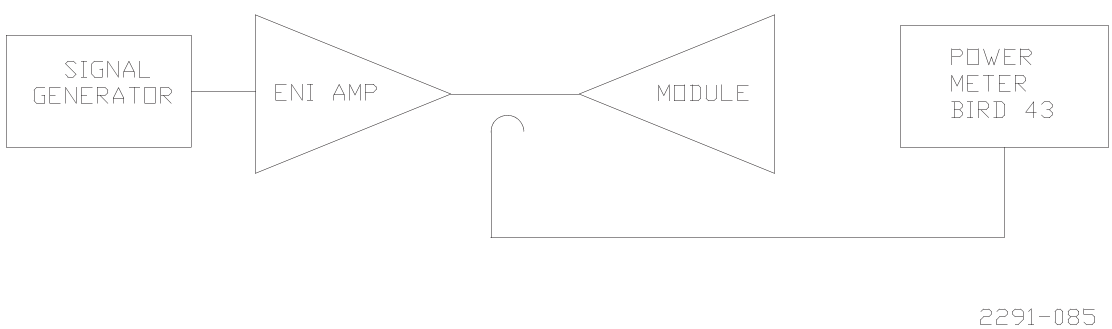


Figure 8-9 VSWR Protection Test Setup

STEP 2 Apply 50 V DC and enable the module.

STEP 3 Set the signal generator to the Aural carrier frequency and apply 94.5 Watts CW into the PA module RF output.

STEP 4 Slowly adjust R8 CCW until the module disables and gives a blink code of one on the red LED.

STEP 5 Reduce the signal generator level and enable the module. Slowly raise the signal generator level while monitoring the power applied to the module. The module should disable between 90 and 100 Watts. If not, readjust R8 as required.

STEP 6 Turn off the 50 V DC.

- Field Calibration

STEP 1 If the control card has functioning power supplies, measure the voltage at U6 pin 4 and adjust R8 for the same voltage on the new board.

OR

STEP 1 Measure the resistance from wiper of R8 to ground and adjust R8 for the same resistance value.

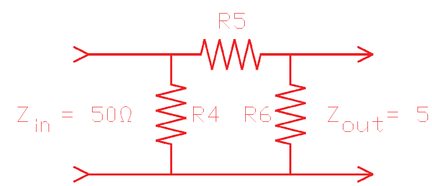
Table 8-1 Input Attenuator/Driver

CURRENT REVISION 0 DWG. NO. 817-2100-639

ZONE	LTR	DATE	REVISION	DFTM	ENG	ECN

Atten.	R4 and R6	R5
0.5	1740 Ω 548-1390-000	2.87Ω 548-2268-000
1.0	866Ω 548-2280-000	5.76Ω 548-2269-000
1.5	576Ω 548-2279-000	8.66Ω 548-2270-000
2.0	432Ω 548-0856-000	11.5 Ω 548-2193-000
2.5	348Ω 548-2267-000	14.7 Ω 548-2254-000
3.0	294Ω 548-1991-000	17.8 Ω 548-2194-000
3.5	249Ω 548-0712-000	20.5Ω 548-2256-000
4.0	221 Ω 548-0839-000	23.7Ω 548-2195-000
4.5	196 Ω 548-2266-000	26.7Ω 548-2271-000
5.0	178 Ω 548-2053-000	30.1 Ω 548-2196-000
5.5	162 Ω 548-0828-000	34.0 Ω 548-2258-000
6.0	150 Ω 548-2207-000	37.4Ω 548-2197-000
6.5	140 Ω 548-1047-000	41.2 Ω 548-2272-000
7.0	130 Ω 548-0227-000	45.3Ω 548-2198-000
7.5	124 Ω 548-0332-000	48.7Ω 548-2260-000
8.0	115 Ω 548-0581-000	52.3Ω 548-2199-000
8.5	110 Ω 548-0276-000	57.6Ω 548-2273-000
9.0	105 Ω 548-2203-000	61.9 Ω 548-0665-000
9.5	100 Ω 548-0363-000	66.5Ω 548-2261-000
10.0	95.3Ω 548-2202-000	71.5 Ω 548-2200-000
10.5	93.1 Ω 548-0814-000	76.8Ω 548-2263-000
11.0	88.7Ω 548-0754-000	82.5Ω 548-0703-000
11.5	86.6Ω 548-0813-000	86.6Ω 548-0813-000
12.0	82.5Ω 548-0703-000	93.1 Ω 548-0814-000
12.5	80.6 Ω 548-0372-000	100 Ω 548-0363-000
13.0	78.7Ω 548-2201-000	107 Ω 548-2204-000
13.5	76.8Ω 548-2263-000	113 Ω 548-2264-000
14.0	75.0Ω 548-0576-000	121 Ω 548-2205-000
14.5	73.2Ω 548-2262-000	127 Ω 548-2265-000
15.0	71.5 Ω 548-2200-000	137 Ω 548-2206-000

Atten.	R4 and R6	R5
15.5	69.8Ω 548-0811-000	143 Ω 548-2276-000
16.0	68.1 Ω 548-0753-000	154 Ω 548-2074-000
16.5	68.1 Ω 548-0753-000	162 Ω 548-0828-000
17.0	66.5Ω 548-2261-000	174 Ω 548-2277-000
17.5	64.9Ω 548-2275-000	182 Ω 548-0756-000
18.0	64.9Ω 548-2275-000	196 Ω 548-2266-000
18.5	63.4Ω 548-2274-000	205Ω 548-2278-000
19.0	61.9 Ω 548-0665-000	221 Ω 548-0839-000
19.5	61.9 Ω 548-0665-000	232Ω 548-2054-000
20.0	61.9 Ω 548-0665-000	249Ω 548-0712-000



NOTE: Not all applications will use the same Resistor Reference Designators as shown above.

QTY.	HOLE	DESCRIPTION

UNLESS NOTED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
.X ± .030
.XX ± .015
.XXX ± .005
ANGLES ± 1 DEG.

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MFG. ENG. R.J. Crockett
MAT'L.

TITLE
Assembly Instruction
Input Attenuator

SHEET 1 OF 1
DWG. NO. 817-2100-639

Table 8-2 30 Watt Attenuators

Attenuation - dB	Harris Part No.	KDI Part No.
0.75	556-0126-075	A3RH54-075
1.00	-100	-100
1.25	-125	-125
1.50	-150	-150
1.75	-175	-175
2.00	-200	-200
2.25	-225	-225
2.50	-250	-250
2.75	-275	-275
3.00	-300	-300
3.25	-325	-325
3.50	-350	-350
3.75	-375	-375
4.00	-400	-400
4.25	-425	-425
4.50	-450	-450
4.75	-475	-475
5.00	-500	-500

2.2 MECHANICAL SPECIFICATION

2.2.1 Substrate:	Beryllium Oxide Ceramic
2.2.2 Resistive Element:	Thin Film
2.2.3 Flange:	Copper, Nickel Plated per QQ-N-290
2.2.4 Tabs:	Beryllium copper, Gold Plated per MIL-G-45204
2.2.5 Cover:	Alumina Ceramic
2.2.6 Outline Drawing:	See Figure 1
2.2.7 Marking:	Parts to be marked with Attenuation value and date code.

Title: SPEC, 30 WATT ATTENUATOR	Sh 2 of 3	Rev	Dwg: 817-2100-611