FINAL POWER AMPLIFIER OVERVIEW

FUNCTIONAL DESCRIPTION

The High Level Transmitter (HLT) Final Power Amplifier (FPA) consists of two identical Final Amplifiers: FPA#1 & FPA#2. They provide the third and final stage of RF amplification in the MSR Transmitter. Although the two final amplifiers are identical, they are not redundant since both amplifiers are used during tactical operation. If one amplifier is in a fault condition, however, it is possible for the Transmitter Group to operate with the remaining FPA at a reduced power output (3 db down).

Medium level RF from the on-line Driver is split equally by a power divider in the Driver and applied to the two final amplifiers. After amplification, the two pulsed outputs are sent to the Microwave and Interconnections (High Power Microwave) where they are added together in an RF power combiner and routed to the selected Antenna Face.

The following paragraphs describe the interrelationship of the major Final Amplifier functions: RF Signal Amplification, Modulation, High Voltage Power Generation, Beam Collapse Detection, Control and Monitoring, Status Control, Crowbar Generation, HVPS Fault Monitoring, and Power Distribution.

RF Signal Amplification:
The RF Signal Amplification circuit amplifies the medium level Final Amplifier Input Signal received from the on-line. Driver and converts this signal to a high level RF Output which is radiated from the antenna. RF Signal Amplification is accomplished by a hybrid klystron consisting of a klystron and a TWT in the same envelope. The klystron is turned on and off by cyclical application of a Modulating Anode Pulse (On and Off signals) from the Modulation circuit. An X-Ray Radiation signal is sent to the Beam Collapse Detection circuit which monitors the beam in the klystron. Another fault signal sent to the HLT Control and Monitoring Klystron RF Arc Alpha/Gamma 1 output, indicates when there is arcing within the klystron.

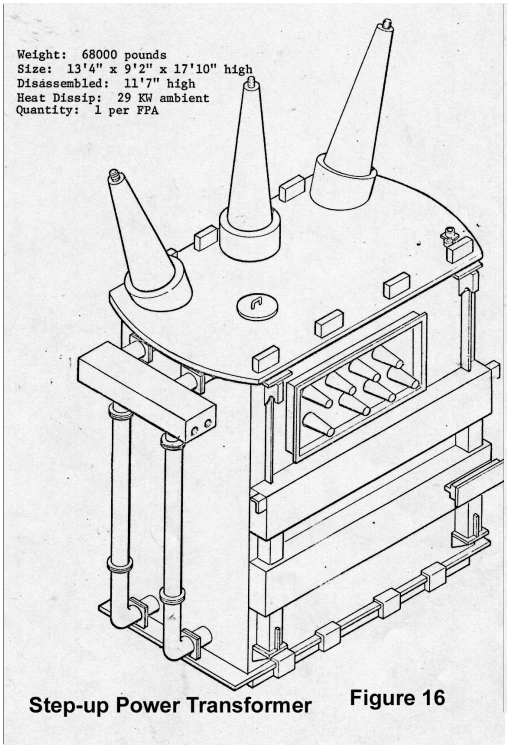
When any of the printed circuit cards in the RF Signal Amplification circuit is removed, the Printed Circuit Card Interlock signal received from the 'HLT Control and Monitoring is inhibited from being sent back to the HLT Control and Monitoring:

Modulation:
The Modulation circuit switches the modulating anode of the Final Amplifier Klystron between two dc potentials which activate the Klystron to the on and off states. This modulation is controlled by on and off triggers. These triggers initiate on and off pulses in the On/Off Pulse Generation circuit. The pulses are amplified in the On/Off Pulse Amplification circuit and are forwarded through the Pulse Coupling circuit to the

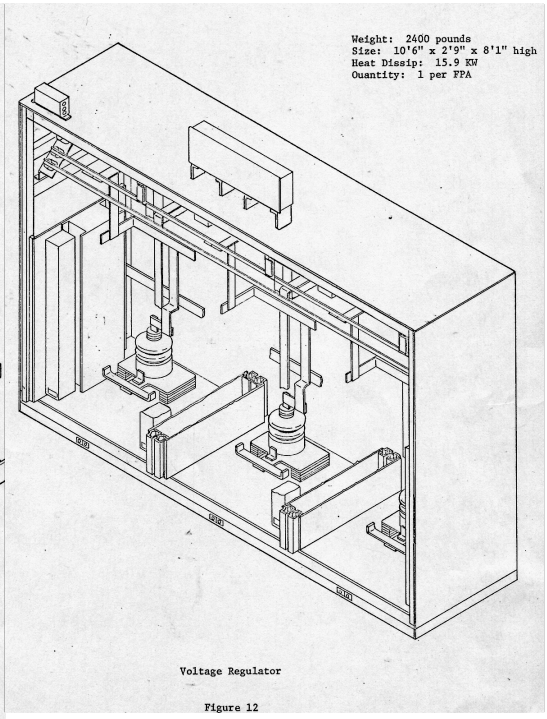
Amplification Control circuit. In the Amplification Control circuit, on and off beam switching tubes (BST) control the application of on/off Mod Anode pulses to the modulating anode of the Final Amplifier Klystron. An on pulse causes the Klystron to conduct and an off pulse terminates the conduction. On and off triggers initiate and terminate the generation of a ramp pulse in the Ramp Pulse Generation circuit. This ramp pulse is amplified in the Ramp Pulse Amplification circuit and forwarded through the Pulse Coupling circuit to the Amplification Control circuit where it is used to hold the on BST on and the off BST off for the specified interval between the on and off pulses. On BST, off BST and Klystron bias signals are developed in the Bias Generation circuit.

High Voltage Power Generation

The High Voltage Power Generation circuit develops the regulated -150 KV used in the RF Signal Amplification circuit, Modulation circuit, and the Crowbar Generation circuit. The High Voltage Power Generation circuit converts 4160 VAC, Ph A, B, C power to 150 KV and also provides for regulation of the -150 KV output. During normal operation, these circuits are controlled from the HLT Control and Monitoring. During maintenance test, the High Voltage Power Generation circuits can be exercised locally from the HVPS Fault Monitoring circuit or remotely from the HLT Control and Monitoring.



Step-up Power Transformer Figure 16



Voltage Regulator

Figure 12

Beam Collapse Detection

The Beam Collapse Detection circuit monitors the RF Signal Amplification circuit for

occurrence of a beam collapse in the klystron contained in that circuit. This monitoring function is performed continuously and when a beam collapse condition is detected, destruction of the klystron is prevented by fault logic in the Beam Collapse Detection circuit. This circuit then initiates protective action in the Control and Monitoring circuit and subsequently by the Crowbar Generation circuit. The Beam Collapse Detection circuit consists of six circuits, four of which are directly involved in beam collapse monitoring. These circuits are X-Ray Detection, Pulse Counting, Output Pulse Generation, and Clock Pulse Generation. The two other circuits. Test Control and X-Ray Detection Fault Monitoring perform testing and fault monitoring respectively, of the Beam Collapse Detection circuit.

Control and Monitoring

The Control and Monitoring circuit comprises the major control interface between the Final Amplifier and the HLT Control and Monitoring. The Control and Monitoring circuit also provides control between the various circuits of the Final Amplifier. The control functions include the initiation of various operating command signals and the monitoring of different operating parameters in the Final Amplifier. The Control and Monitoring circuit receives fault signals from within the Final Amplifier and Ancillary Control, Major or Minor Fault Indications from the Gas Pressurization System. Certain of these signals are forwarded to the HLT Control and Monitoring as the Final Amplifier Major Fault Sum. It also receives an Ancillary Control signal from the High Purity Water-Transmitter Cooling System. The operating command signals involve both the automatic initiating of commands based on Final Amplifier operating status and the manual initiating of commands based on desired operating conditions or modes. This functional area includes the circuit breakers, switch-indicators, meters and built-in test equipment located on the control and indicator panels associated with the Final Amplifier. The Control and Monitoring circuit also sends Status signals to Gas Pressurization System and the High Purity Water- Transmitter Cooling System.

The Final Amplifier Timing Indication signal sent to the HLT Control and Monitoring indicates when the klystron filament 20-minute time delay warm-up cycle has been completed.

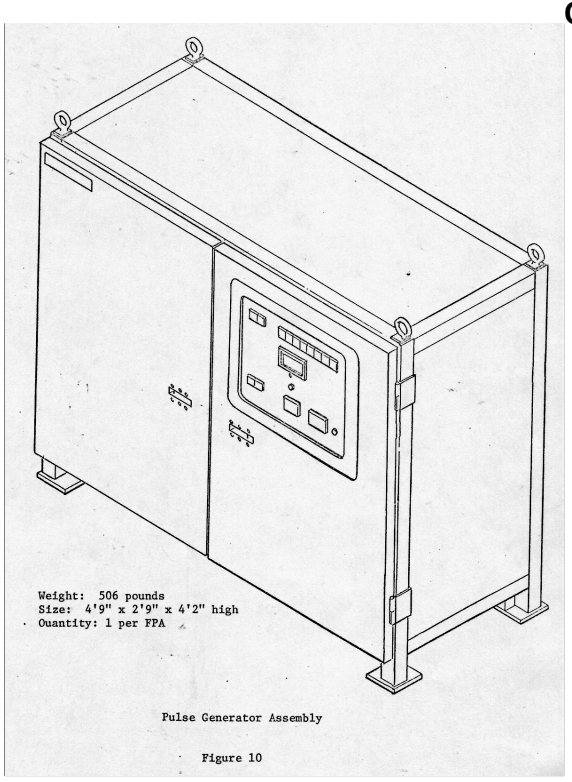
When fault Resets are generated in Final Amplifier, they are also sent to the HLT Control and Monitoring. The operating command signals involve both the automatic initiating of commands based on Final Amplifier operating status and the manual initiating of commands based on desired operating conditions or modes. This functional area includes the circuit breakers, switch-indicators, meters and built-in test equipment located on the control and indicator panels associated with the Final Amplifier.

STATUS CONTROL

GENERAL

Electrical interlocks are maintained throughout the Final Amplifier (comprising continuations of interlocks running throughout the Transmitter Group) to provide automatic and manual control of equipment status. The interlocks comprise series/parallel electrical paths; the continuity of each path is dependent upon the current status of whatever equipment is associated with the given interlock (qualifying inputs). Each interlock is classified according to the impact its operation has upon system operation. Thus, should a qualifying input cause non-continuity in the Standby Interlock (any segment). Transmitter Group operational level would revert to (or fail to go above) Standby level. Failure of any segment of the Off Interlock causes nearly-complete equipment shutdown.

CROWBAR GENERATION



Pulse Generator Assembly

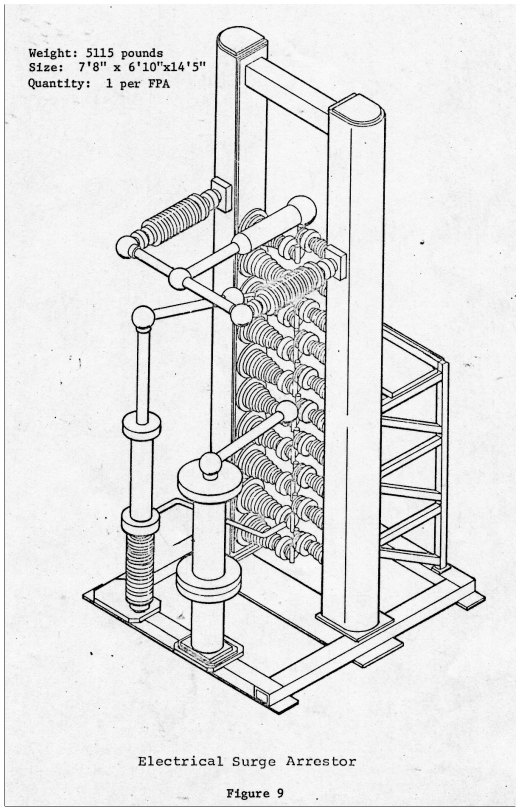
Figure 10

The Crowbar Generation circuit protects the Final Amplifier Klystron from damage when any one of four final amplifier faults occur. Crowbarring is the rapid discharge of the HVPS energy storage capacitors through a triggered multiple spark gap to the high voltage return. The time from a fault signal to initial crowbar firing is 2.5 microseconds. It takes the crowbar approximately 1 millisecond to discharge the HVPS energy storage capacitors. The faults which cause crowbarring are:

1. Klystron overcurrent.
2. HVPS overvoltage.
3. Undercurrent in any one of the seven klystron solenoids.

4. Low input ac power to the power supplies which provide power to the Crowbar Generation circuits.

Except for the fault sensors, some controls and indicators, and the Electrical Surge Arrestor (spark gaps), the Crowbar Generation circuits are in Pulse Generator Assembly.



Electrical Surge Arrestor

Figure 9

The Crowbar Test Control circuit makes it possible to fire the crowbar manually for testing. This is accomplished by means of indicator switches which forward a signal that the Fault Logic recognizes as a fault indication. The Fault Logic circuit monitors high voltage, klystron overcurrent, solenoid current, and 208VAC primary voltage to crowbar power supplies. A fault in one of the monitored parameters causes the Fault Logic circuit to generate a signal which causes the Pulse Generation circuit to develop a 96 KV pulse train which triggers the spark gaps in the Electrical Surge Arresting circuit. When these spark gaps flash over, the energy stored in the HVPS energy storage capacitors is rapidly shunted to the high voltage return. The Crowbar Generation Monitoring circuit transmits two signals: one that indicates the crowbar has been triggered and a signal that indicates that the crowbar has actually fired. The Crowbar +12 KV Generation and Crowbar +12V/+350 Generation circuits provide power for the Crowbar Generation circuits. When the crowbar is triggered, the Crowbar HVPS Control 'develops a signal which opens interlock circuits and presents a

fault indication. The Crowbar Power Supply Monitoring circuit monitors various parameters and control functions associated with the crowbar power supplies.

HVPS Fault Monitoring

The HVPS Fault Monitoring circuit contains the HVPS Maintenance Control circuit and all of the circuits required to monitor the high voltage. Fault indications are received from the STET and from other Final Amplifier circuits. By means of diode logic or circuits, and relay logic, the HVPS Fault Monitoring circuit develops a HVPS Fault Sum Ind Bus signal which is sent to the HLT Control and Monitoring HLT Fault and Status Reporting circuit. Fault signals are also sent to the Status Control circuit to interrupt the Standby and Final Amplifier HVPS Off Interlock signals and to the Control and Monitoring circuit to inhibit the enable command that turns on the 4l60 VAC PH A, B, and C primary power. During tactical operation, the High Voltage Power Generation circuit is controlled by commands sent from the HLT Control and Monitoring to the HVPS Maintenance Control circuit. During maintenance, control is exercised from either the HLT Control and Monitoring or internally at one of two locations within the HVPS Maintenance Control circuit. When control originates within the HVPS Maintenance Control circuit, maintenance control and status indications are sent to the HLT Control and Monitoring; maintenance control commands are sent to the error correction circuit in the High Voltage Power Generation circuit and status indications are sent to enable one of two indicator light-switches in the Status Control circuit.

Power Distribution

The Power Distribution circuit generates operating voltages for the Final Amplifier. It sends 4l60 Vac Ph A, B, C power to the High Voltage Power Generation circuit and distribution of the primary power is controlled by a Primary Power Control signal received from the Control and Monitoring circuit. Status of all circuit breakers in the Power Distribution circuit is forwarded to the Control and Monitoring circuit by the Circuit Breaker Status signal.

PHYSICAL DESCRIPTION

The Final Power Amplifier (FPA) consists of two separate channels; Final Amplifier No. 1 and Final Amplifier No. 2.

Each channel contains final modulators, a klystron, focusing solenoid, power supplies, and local control and monitoring circuits.

The modulators (ON and OFF Decks), klystrons, and focusing solenoids are mounted in oil-filled amplifier-modulator tanks in the Klystron room. High voltage power supply sets are contained in their own rooms. The remaining equipment is contained in cabinets located in the Klystron room, the Transmitter Control room, and the High Voltage Power Supply Control room.

The FPA Group consist of the following assemblies:

- Solenoid & Beam Collapse Detector
- Power Supplies-two double-bay racks
- Power Supply-Modulator
- Amplifier-Power Supply
- Control Monitor
- Amplifier Modulator Tank
- Damping Resistor Assembly
- Resistor Assembly
- Reactor
- Capacitor-Resistor Assembly
- Damping Network
- Rectifier Assembly
- Electrical Surge Arrestor
- Pulse Generator Assembly
- Capacitor Shorting Gate
- Power Supply Control
- Voltage Regulator
- Circuit Breaker Assembly