SMALL EHF/SHF AIRBORNE SATCOM TERMINAL

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ABSTRACT

A fifth generation airborne microwave satellite communication system is currently under development. The terminal which operates in the EHF and SHF bands is designed to provide secure, anti-jam communication for the airborne command post fleet of EC-135 aircraft.

INTRODUCTION

The World Wide Military Command and Control System (WWMCCS) architecture plan recognizes satellite communications as one of the prime command and control communications systems between the National Command Authority and the Nuclear Capable Forces. Satellite communications offer the possibility of secure, jam-resistant communications for the dissemination of Emergency Action Messages and for force direction/reportback communications. To satisfy this requirement the Strategic Satellite System (SSS) has been proposed. One of the first steps in the evolution of this system will be the equipping of the Defense Satellite Communication System, Phase III (DSCS III) with a processing communication package called the Single Channel Transponder (SCT). The Single Channel Transponder on DSCS III will demodulate an SHF uplink signal from a command post and remodulate a UHF downlink to the force element terminals. More advanced stage of the SSS will be the STRATSAT processing satellite with an EHF uplink and SHF/UHF downlinks.

The Avionics Laboratory completed the advanced development of the ASC-18 SHF SATCOM terminal in 1972. That terminal was flight tested in the 1972/1975 period on a C135 aircraft. Following the demonstration of the terminal feasibility, the SHF SATCOM terminal was transitioned into the E-4 Advanced Airbrone Command Post by the Electronics System Division (ESD) E-4 SPO and renomenclatured as an ASC-24. The ASC-24 provides 10 kilowatts of SHF power to a 32 db gain parabolic dish antenna. In 1976 the Avionics Laboratory completed the development of the ASC-22 EHF terminal.

That 1 kilowatt terminal was flight tested using the LES 8 and LES 9 EHF processing satellites. In 1978 the Avionics Laboratory completed the development of the ASC-28 dual frequency SATCOM terminal which provides 10 kilowatts of SHF power or 1 kilowatt of EHF power. The ASC-28 is currently being flight tested.

These large terminals were primarily designed for the E-4 (Boeing 747) type aircraft. Because of the severe space and weight limitation on the smaller EC-135 (Boeing 707) type airborne command post, the ASC-22, ASC-24, and ASC-28 type terminals are not candidates for installation. The small EHF/SHF airborne SATCOM system is being specifically designed to fit the requirements of the space premium EC-135 airborne command post.

EHF/SHF SATCOM SYSTEM DESCRIPTION

To satisfy the EHF/SHF SATCOM requirements for the EC-135 type aircraft, the Avionics Laboratory is procuring the small EHF/SHF SATCOM terminal (Figure 1) from the Raytheon Co. of Sudbury, MA. This terminal will have the following characteristics:

*Air cooled transmitter
*Parabolic dish antenna
*Frequency of operation: SHF Rec 7.25 - 7.75 GHz
SHF Transmit 7.9 - 8.4 GHz
EHF Transmit 43 - 45 GHz
*Intermediate frequency 70 and 700 MHz
*Uncoded parametric amplifier
*Rubidium frequency standard
*Active or computer antenna tracking
*Primary modem - Command Post Modem/Processor (CPM/P)
*Two independent transmit and receive channels
*Digital control/display which interfaces with CPM/P
*Prime power 8 kilowatts at 400 Hz
*Reliability 500 hours MTBF
*Maintainability 30-minute MTTR for 90% of faults
*Weight 1200 pounds
*Volume 18 cubic feet
*Packaging in separate ATR line replaceable units

DETAILED EQUIPMENT DESCRIPTION

The Small EHF/SHF Airborne SATCOM Terminal is designed to interface with the Command Post Modem/Processor (CPM/P) being procured from the Linkabit Corp. of San Diego, CA. With the CPM/P the terminal will be capable of handling 75 bps teletype, 2400 bps vocoded voice or multiplex data streams, Figure 2.

The upconverter will accept a 70 MHz IF signal from the modem and frequency translate it to the EHF band, 43 to 45 GHz, or the SHF band, 7.9 to 8.4 GHz. The upconverter can also accept a 700 MHz IF from other modems. It will provide an output level of approximately 0 dbm to the HPA. The upconverter can be frequency hopped over a wide bandwidth if provided a digital frequency command from a modem such as the Command Post Modem/Processor.

The high power amplifier will accept the 0 dbm input level and amplify the signal. The EHF HPA utilizes a PPM focused travelling wave tube rated at approximately 125 watts air-cooled. The SHF HPA will utilize two 750 watt PPM focused travelling wave tubes connected through a combiner to provide the output power. The output power of both HPA's is controlled from 1 watt to their maximum output.

The antenna acquisition of the satellite may be accomplished by manually pointing the antenna and initiating a spiral scan which allows the acquisition and track receiver to lock to the satellite downlink energy. An alternate method is to use a computer pointing system provided by the Command Post Modem/Processor which automatically points the antenna towards the satellite. After initial acquisition, tracking may be via the active tracking system utilizing the downlink energy from the satellite or the passive pointing system utilizing the Command Post Modem/Processor computer pointing. In the active tracking mode the beacon receiver locks to the downlink beacon from the satellite. The system is designed to acquire the beacon with a C/N_o of 34 db or less within 60 seconds. Doppler errors of up to 100 KHz can be corrected using the beacon autotrack receiver.

The moderate gain antenna system being procured consists of a mechanically steered parabolic antenna with Cassegrain feed. A rate gyro system on the antenna will provide the inertial stabilization necessary to maintain pointing during aircraft maneuvers. Tracking update will occur from the beacon autotrack system or the computer pointing system. The antenna is designed to have low side lobes and at least 20 db isolation between the transmit and receive ports for full duplex operation. The system can be operated in an SHF transmit/SHF receive mode or in EHF transmit/SHF receiver mode. The antenna will handle up to 3 kilowatts of CW power at SHF and up to 500 watts CW power at EHF. It is designed to operate from -15° elevation relative to the aircraft platform, up to the zenith. It is designed to continue to track during aircraft accelerations of up to 2 G's. The antenna will be mounted on top of the aircraft and covered by a fiberglass radome. The radome is approximately 31 inches high, 150 inches long, and 30 inches wide. The radome is expected to increase the drag of the aircraft no more than 1% during normal operating configurations. The antenna pedestal will protrude inside the aircraft approximately 12 inches below the ceiling.

The uncooled SHF Low Noise Amplifier has a bandwidth of 500 MHz and gain of approximately 40 db. The LNA will be located on the roof of the aircraft near the antenna pedestal to minimize the loss.

The SHF downconverter will frequency translate the SHF signal from the LNA down to a 70 or 700 MHz IF signal. The downconverter is designed to handle a signal in the 500 MHz band. The downconverter can be frequency hopped utilizing a digital control word from the modem. Various gains are available through the downconverter, depending upon the modem to be utilized.

The terminal contains a rubidium frequency standard with a long term stability of 2×10^{-11} per month. The frequency standard will output various frequency references including 5 MHz, 1 MHz, 100 KHz, 1 pulse per second and IRIG B time-of-day code.

The frequency control unit consists of a microprocessor which controls the transmit frequency, receive frequency, frequency offset, doppler correction, and frequency hopping/dehopping information.

Through the remote control unit various doppler modes, such as active doppler, computer doppler and atomic standard, may be selected. Likewise frequency hopping commands where the modem provides the bandspread or the terminal provides the bandspreading may be selected. Frequency correction for the satellite clock error can be inserted as an offset for system operation.

The remote control panel will provide the controls and indicator for controlling the small EHF/SHF airborne SATCOM terminal. It will also provide for the built-in-test/fault monitoring capability. The panel is being designed to minimize the number of switches and thumb wheel controls. A processor will be utilized in the remote control unit to ease operator procedures in such functions as terminal turn on, antenna pointing, and systems start up. The control is being designed as an exception type panel. Rather than displaying the status of all possible systems, the control panel will provide either a go status indication or an indication of what fault or actions may be required to get to the go status. All controls in the control panel utilize the digital interface so the entire operation of the remote control panel can be accomplished through the Command Post Modem/Processor.

In that configuration the small EHF/SHF remote control panel is strictly a backup in case of failure to the Command Post Modem/Processor plasma display/control.

SCHEDULE

The Small EHF/SHF Airborne SATCOM Terminal contract was awarded to Raytheon Corporation, Sudbury, MA in December 1978. Delivery of the flight hardware is scheduled for early 1981. It will be installed in a 4950th flight test C135 aircraft along with the Command Post Modem/Processor in early 1981. Flight testing will be accomplished during 1981 and 1982.

CONCLUSION

The Small EHF/SHF Airborne Satcom Terminal is designed to provide world wide anti-jam communication for space premium command post aircraft. The ATR type packaging will allow the terminal to be distributed in available rack space rather than requiring one large integrated rack installation as required in previous microwave systems. The processor controlled terminal is being designed to minimize the complexity of turning on and locking up the SATCOM system. A prestored set of frequency, power level, antenna pointing and doppler mode will allow the terminal to be brought up automatically in a preprogrammed mode without operator intervention.

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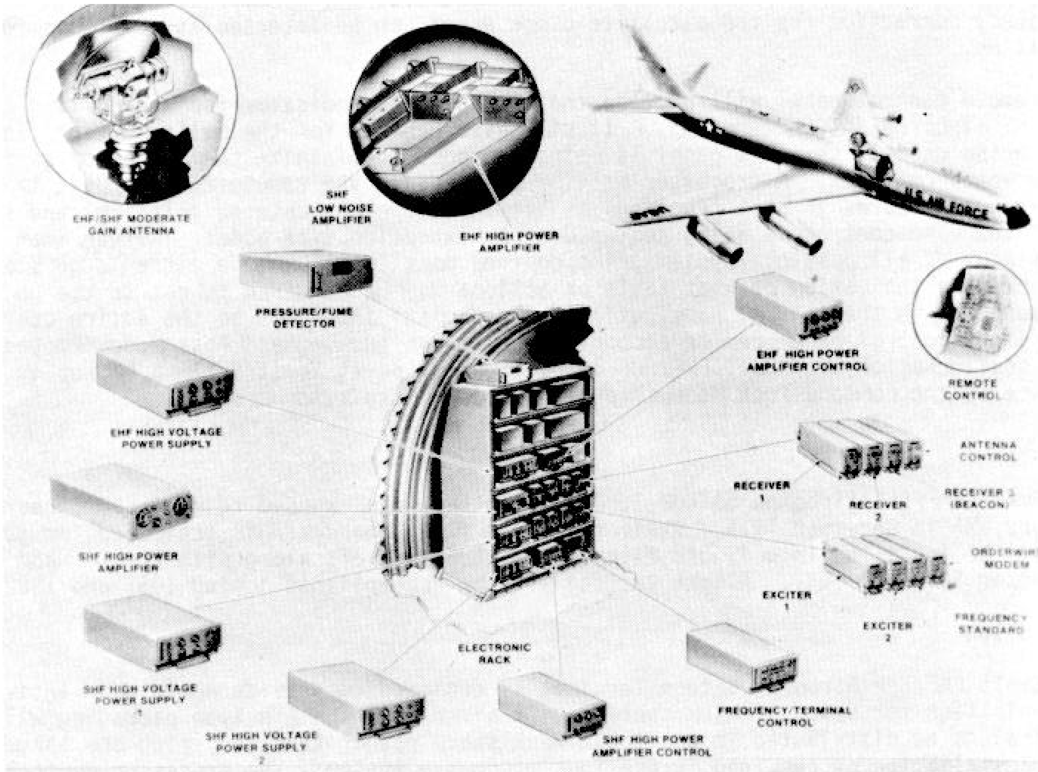

FIGURE 1 SMALL EHF/SHF AIRBORNE SATCOM TERMINAL

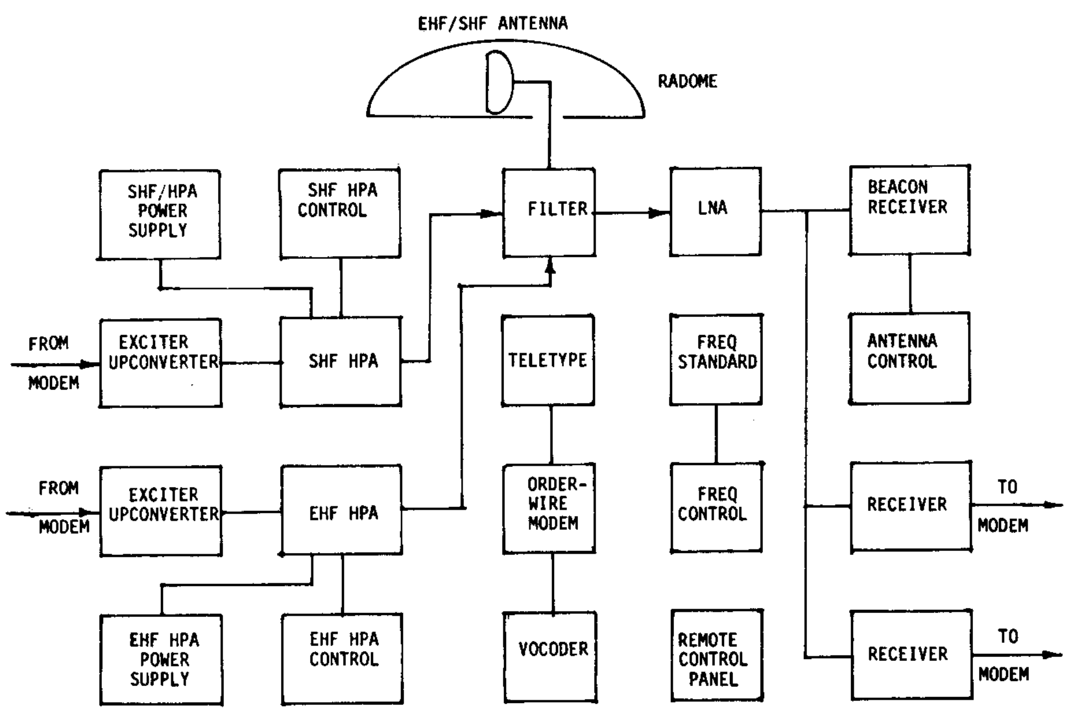

FIGURE 2 SMALL EHF/SHF AIRBORNE SATCOM TERMINAL BLOCK DIAGRAM