TELEMETRY TRANSMITTER ACCEPTANCE TESTING AT WHITE SANDS MISSILE RANGE

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ABSTRACT

White Sands Missile Range (WSMR) is the largest overland test range, operated by the Department of Defense, in the United States. It encompasses approximately 4000 square miles of south-central New Mexico. WSMR supports various missile, weapons system, and instrumentation development tests of the Army, Navy, Air Force, NASA, and other agencies, and controls the airspace and electromagnetic (EM) radiation on and around WSMR. Due to the large number of users at WSMR, the EM spectrum has become increasingly crowded and EM radiation control has become extremely important. For this reason, WSMR Regulation 105-10 (Telemetry Radio Frequency (RF) Spectrum Utilization) was adopted and states that all TM transmitters proposed for use at WSMR must be approved. These transmitters are approved upon determination that they meet the requirements set forth in the current Range Commander's Council (RCC) Inter-Range Instrumentation Group (IRIG) Document titled "Telemetry Standards". (NOTE: This document will hereafter be referred to as RCC Document 106). This determination is performed by the White Sands Missile Range Director of Information Management (WSMR-IM) in the form of acceptance testing and analysis. This acceptance testing consists of the verification and analysis of the transmitter's frequency stability, output power, and spurious and harmonic emission levels, in order to prevent EM interference between the many range users. The current test methodology will be explored in sufficient detail so that potential range users will know the procedures used to qualify TM transmitters for use at WSMR. Past methods and future testing considerations will also be briefly examined.

INTRODUCTION

At White Sands Missile Range (WSMR), NM, a requirement exists for formal acceptance of all Telemetry (TM) transmitter model units which are proposed for use at WSMR. This requirement is outlined in WSMR Regulation 105-10, which

prescribes the responsibilities and procedures necessary to assure efficient spectrum utilization and management of these TM bands. This regulation is cited in the WSMR Range Users Handbook, Chapter 17, Paragraph 17-6e. WSMR-IM is responsible for the type acceptance of all TM transmitters proposed for use at WSMR, by manufacturer and model number. Type acceptance must be obtained prior to receiving frequency authorization - the intent being to ensure electromagnetic compatibility (EMC) between the many TM users at WSMR. Due to the large number of range TM users, the possibility of interference is quite high. Some S-Band frequencies have as many as 10 different users and must therefore be time shared. Thus, a premium is be placed on frequency spectrum utilization.

S and L-band TM transmitter testing by WSMR-IM began in 1965. The test objectives then and now remain essentially unchanged. The objectives are to verify the frequency stability, output power, and spurious/harmonic emissions of the transmitter for a given time span at ambient room temperature, and minimum and maximum temperature specifications, and at its minimum, maximum, and mean power supply voltages. Since 1965, WSMR-IM has tested upwards of 120 L and S-Band TM transmitters. Of these approximately 33% have not passed the rigorous tests performed by WSMR-IM to validate the manufacturer's specifications. Many of these were resubmitted after rework by the manufacturer and subsequently accepted for use at WSMR. About 5% of the transmitters have been conditionally type accepted by serial number or for a specific one-time-only test. On these units, WSMR-IM worked closely with project personnel and frequency coordinators to reach an equitable solution in order to facilitate the project.

TELEMETRY USER REQUIREMENTS

Potential users of TM transmitters must submit written requests for transmitter approval to WSMR-IM at least 30 working days prior to their first intended use. These submittals should include the following specifications which reflect the operating conditions anticipated in the test profile.

1. Maximum operating time.
2. Minimum, nominal, and maximum supply voltages.
3. Nominal modulation voltages and frequencies.
4. Minimum, nominal, and maximum baseplate temperatures.
5. Antenna VSWR (optional).

Approval of TM transmitters by WSMR-IM can be accomplished by one of the following four methods:

1. Submission of transmitter to WSMR-IM for test and analysis.
2. Submission of an engineering-evaluation report from an “independent testing organization” to WSMR-IM and its review.
3. The witnessing of in-plant (manufacturer’s plant) testing and evaluation of results by WSMR-IM.
4. The submission of a “certification” from the responsible government contracting agency, ensuring compliance with RCC Document 106.

These four test methods will be discussed in detail in the following pages.

APPROVAL METHODS

SUBMISSION OF TRANSMITTER TO WSMR-IM FOR TEST AND ANALYSIS

Approximately 80 % of all transmitters type accepted by WSMR-IM have been directly submitted for test and analysis. WSMR-IM performs rigorous tests on the transmitters in order to validate the manufacturer’s specifications and to verify that the unit will meet the project’s requirements. Despite the rigorous tests WSMR-IM makes all efforts to support missions in a timely manner, and in this spirit often makes engineering evaluations and compromises on units that may be slightly out of tolerance. This involves analysis of mission profile, and analysis of interference potential. These acceptance tests do not serve to analyze the integrity of the TM data upon transmission and reception, but rather to ensure the TM transmitters’ frequency stability and to determine the levels of any spurious/harmonic emissions.

Test History

The test scenario has changed very little in the past 20 years. A unit that is submitted for testing is monitored for frequency stability, power output, and spurious/harmonic emissions as a function of operating time, supply voltage, and baseplate temperature. If the unit fails, it can be sent back to the manufacturer for rework. If this is not desired, THREE different units can be submitted to WSMR-IM for testing. If these three units pass, the unit is unconditionally type accepted. However, if one of these units fails, then SIX units can be resubmitted. This procedure can be continued in the same geometric progression.

Testing Procedure

There is a typical acceptance testing format used by WSMR-IM for TM transmitters. However, due to the growing complexity of TM transmitters and their modulation schemes, testing procedures may differ slightly for different transmitters, and the testing group (WSMR-IM) reserves the right to customize the testing procedure to optimize the data analysis. The following procedure is the foundation for most TM transmitter tests performed by WSMR-IM.

1. Mount transmitter (device) under test (DUT) on heatsink (baseplate) of appropriate mass, and apply nominal supply voltage (typically +28 Vdc). Heat or cool unit to nominal temperature (+ 25 degree C) and allow for thermal stabilization. Ensure that the DUT is impedance matched and correctly terminated to optimize the VSWR.

2. Upon stabilization at + 25 degree C, remove supply voltage for a few seconds and reapply power. Monitor the output frequency, output power, and supply voltage for the specified test time (typically one hour). Upon completion of this time test, check for spurious/harmonic emissions IAW MIL-STD 461 and 462.

3. Upon completion of the one hour “soak,” remove power and increase the power supply voltage to the maximum specified operating supply voltage. Reapply power and monitor output frequency and output power for five minutes.

4. Slowly decrease the supply voltage to the minimum specified operating supply voltage. Monitor frequency and output power throughout.

5. Turn off power for a few seconds, then reapply power and monitor frequency and output power, at the minimum specified operating supply voltage, for five minutes.

6. Remove power and reset supply voltage to the nominal value. Reduce the temperature to the minimum specified operating temperature.

7. Repeat steps one through five at this low temperature.

8. Slowly increase the temperature to the maximum specified operating temperature and monitor the frequency and output power.

9. Repeat steps one through five at this high temperature.

10. Return temperature to + 25 degrees C, remove supply voltage, and allow the unit to thermally stabilize.

During steps two through nine of the procedure above, the carrier frequency of the DUT and level of spurious/harmonic emissions are monitored. The DUT's frequency stability cannot exceed the amount stated in RCC Document 106 (typically 0.003% for L-Band systems and 0.002% for S-Band systems) and the spurious/harmonic emission level must not exceed -25 dBm. The output power is also monitored in order to ensure that it does not deviate greatly from that specified by the manufacturer. After this procedure is completed, the frequency characteristics of the unit as it is being powered up are examined to verify its compliance with RCC Document 106. At this time, the test procedure does not call for modulation of the DUT. However, at such time as modulation requirements arise, WSMR-IM will have the necessary equipment and software to support this requirement.

Acceptance Test System and Instrumentation

The Radio Systems Branch has recently designed, engineered, and procured a fully automated test system. The present test system is shown in figure 1. and a brief description of the major equipment is detailed below.

1. Microwave Counter - A portion of the RF energy is sampled by a microwave counter. The counter has a time base stability of 5×10^{-10} per day. For a 180 day calibration cycle, and a 0.1 second gate time, the worst case uncertainty is only about 2 kHz (for a 2.3 GHz signal). This amount is quite small compared to the tolerances outlined in RCC Document 106. Similar small uncertainties are found for L-Band signals as well.

2. Spectrum Analyzer - A portion of the RF power from the DUT is coupled to a spectrum analyzer. The analyzer is used to obtain general spectral characteristics of the DUT and is used to find spurious/harmonic emissions provided the bandwidth of the directional coupler corresponds to the frequency range of the desired spurious/harmonic emission search.

3. Time Interval Analyzer - This unit is a device which essentially analyzes frequency versus time characteristics of sources below 500 MHZ by continuously measuring the time interval between gating events such as 0-Volt crossings of the sinusoidal source. These gating events can be spaced by as little as 600 nanoseconds. By mixing a sample of the L or S-Band signal with an appropriate Local Oscillator (LO) source, the frequency stability of the DUT during power-up can be determined.

4. Voltmeter - The voltmeter is used to determine the actual supply voltage and to determine the temperature at the thermocouple sensors by monitoring the DC voltage from the thermocouples.

5. Controller/Printer/Plotter - The system controller is used to control the test instrumentation over the IEEE-488 Interface Bus. Various testing scenarios can be implemented for different supply voltages, temperature profiles, test times, and modulation. These tests are fully automated such that the various test parameters can be entered by the test controller. The test data can be printed out in a tabular manner or plotted to show the relationship between center frequency and/or output power and any of the parameters of time, temperature, and supply voltage.

SUBMISSION OF AN ENGINEERING-EVALUATION REPORT FROM AN "INDEPENDENT TESTINGORGANIZATION" TO WSMR-IM AND ITS REVIEW

About a dozen telemetry transmitters have been approved using this method of report evaluation. These reports must include the pertinent data that would be obtained from acceptance tests run by WSMR-IM. This data includes center frequency, output power, and spurious emission levels at the nominal, maximum, and minimum temperatures and supply voltages. In addition, any test procedures must be provided to WSMR-IM for evaluation.

THE WITNESSING OF IN-PLANT (MANUFACTURER'S PLANT) TESTING AND EVALUATION OFRESULTS BY WSMR-IM

This procedure has been used several times when the logistical problems of providing WSMR-IM with an actual telemetry transmitter for test cannot be resolved. If this method of test acceptance is desired, then the project must provide WSMR-IM with the testing procedure to be used by the manufacturer, for evaluation and concurrence. In the past, this method has proved valuable in the identification of test procedures errors by the manufacturer. These include use of band-limiting attenuators, and couplers for spurious emission checks, and improper power supply input and modulation input grounding techniques.

THE SUBMISSION OF A "CERTIFICATION" FROM THE RESPONSIBLE GOVERNMENT CONTRACTINGAGENCY, ENSURING COMPLIANCE WITH RCC DOCUMENT 106

WSMR-IM has accepted a few transmitter units based on this certification process. This acceptance is based upon an analysis of test data and test procedures, and is often done in conjunction with WSMR-IM personnel to ensure adequate testing procedures to comply with RCC Document 106.

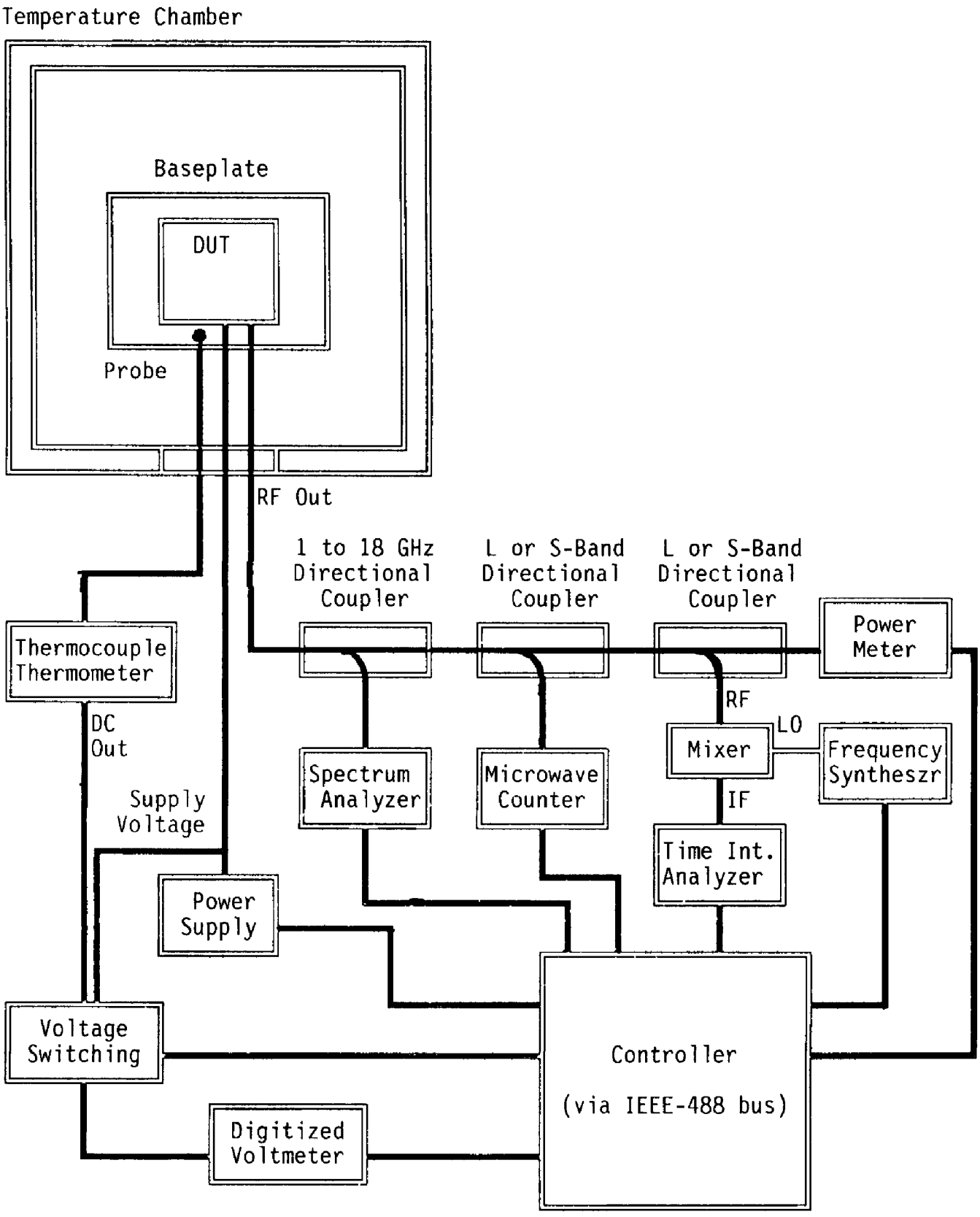

Figure 1. Block Diagram of Telemetry Transmitter Acceptance Test System.

CONCLUSION

Due to the crowded electromagnetic (EM) environment at WSMR, the practice of type approval of TM transmitters for spectrum utilization monitoring is extremely important. WSMR-IM has had the responsibility of performing acceptance tests to determine type acceptance. These tests do not check TM transmitters or TM systems for items such as error rates or general TM information quality; but rather strive to prevent interference between all range users by monitoring the TM transmitter's frequency stability and RF emissions. The general procedures used for these acceptance tests and the test instrumentation systems were outlined in the preceding paragraphs. In a continuing effort to improve the testing procedures and to keep up with the expanding technology in the TM field, WSMR-IM has engineered and procured a state-of-the-art TM transmitter acceptance test system. By designing a test system which uses a central controller to control and to obtain data from the test instrumentation, data collection and analysis can be performed more efficiently and accurately. The new test system is fully automated and TM transmitter tests can be easily reconfigured as the need may arise. Also, the new test system can easily be upgraded to expand along with expanding TM technology and changing RCC Documents. With this new TM transmitter test system, WSMR-IM will be better equipped to help ensure an electromagnetically controlled environment at WSMR for the many missile systems to be tested at White Sands Missile Range.

REFERENCES

[1]. Range Commander's Council Document 106-86, "Telemetry Standards", Revised April 1991

[2]. White Sands Missile Regulation 105-10, "Telemetry Radio Frequency (RF) Spectrum Utilization", April 6, 1988

[3]. MIL-STD 461-C, "Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility", August 4, 1986

[4]. MIL-STD 462, "Measurement of Electromagnetic Interference Characteristics", July 31, 1967

[5]. 1991 White Sands Missile Range Users Handbook.