SATELLITE POWER SYSTEM CONCEPT DEVELOPMENT AND EVALUATION PROGRAM CRITICAL SUPPORTING INVESTIGATIONS "SUMMARY"

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The Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA) are conducting a broad assessment of the Satellite Power System (SPS) under the Concept Development and Evaluation Program which started in 1977 and will be completed in 1980. This program is intended to assess the SPS concept from a technical, environmental, social and economic viewpoint, to compare it with other advanced energy possibilities, and to make recommendations for future efforts. During this program, NASA has been primarily involved in the system definition area which is aimed at defining a reference system for which the various assessments can be made. In addition, NASA is assessing the impact of emerging technologies on the SPS concept and conducting critical experimental and analytical supporting investigations when required. The NASA has conducted parallel system studies with the Boeing Aerospace Company and Rockwell International to define overall system concepts and operational scenario's. In addition, several independent contracts have been awarded by NASA to investigate specific critical technology areas in more depth than can be accomplished in a system level contract. The majority of these investigations have been accomplished through individual government sponsored contracts of less than $100K in magnitude. The nine (9) specific tasks which fall into this category are listed below:

(1) Design and breadboard evaluation of the SPS reference phase control system concept, Lockheed Engineering and Management Services Company, Inc., (LEMSCO); (2) SPS fiber optics link assessment, Boeing Aerospace Company; (3) Eight element S-band active retrodirective array, Jet Propulsion Laboratory (JPL); (4) SPS antenna element evaluation, Boeing Aerospace Company; (5) SPS solid state antenna power combiner, Boeing Aerospace Company; (6) SPS solid state amplifier development program, Radio Corporation of America (RCA); (7) SPS magnetron tube assessment, Raytheon Company; (8) Microwave ionosphere interaction experiment, Applied Research Laboratory, University of Texas at Austin; and (9) Solid state sandwich concept design consideration and issues, Raytheon Company.

The major objectives established in each of the above tasks and their present status and findings cannot be presented in this short paper. However, two examples will be given to illustrate the type of investigations which are representative of these tasks.

The Boeing Aerospace Corporation was awarded a $30K contract by the Johnson Space Center (JSC) to assess the potential application of fiber optic transmission links for the phase reference signal distribution across the SPS one kilometer antenna. Initially, analytical evaluations of various types of emitters and detectors and various fiber characteristics were made. Four

fibers were selected for testing along with an injection laser diode for the emitter and an avalanche photodiode for the detector[1]. Figure 1.0 shows the laser link configuration which was fabricated and tested prior to delivery to the JSC for future system testing with the Master Slave Returnable Timing System (MSRTS). The MSRTS provides electronic compensation for phase variations in the reference signal that are introduced by transmission path length differences and/or variations.

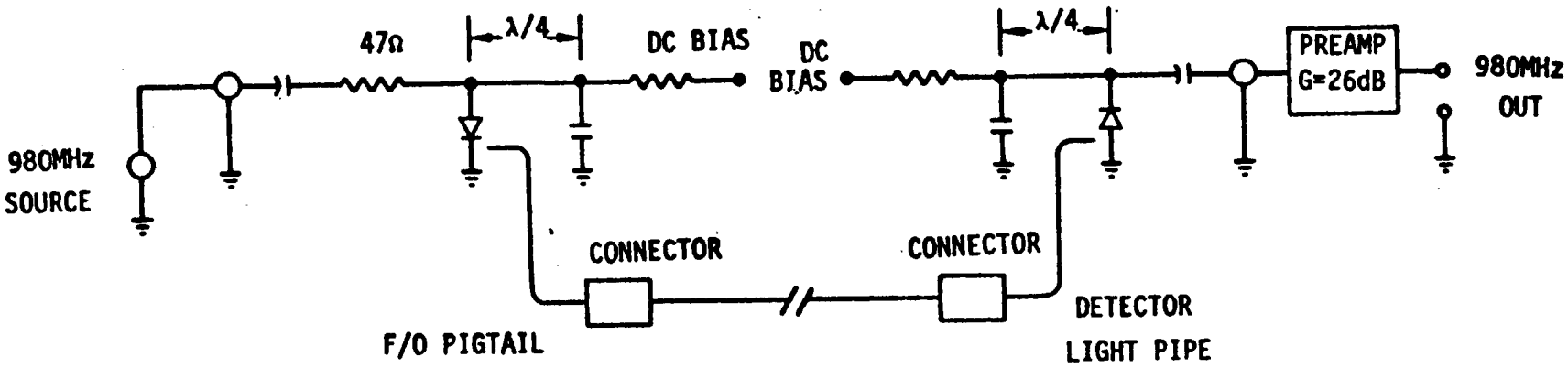
A second example is the $100K contract with the Radio Corporation of America (RCA), awarded by the Marshall Spaceflight Center through Rockwell International. This task effectively continued an earlier investigation which RCA had initiated under contract to JSC for evaluation of potential solid state amplifier design requirements and characteristics. Several commercially available solid state devices were considered and some were experimentally evaluated. The Gallium Arsenide field effect transistors appear to be the most promising at the present time to achieve the high efficiency, high power (5 watts) required for SPS applications[2]. The present task involves further analytical and experimental evaluations of both the solid state device and its associated power amplifier circuitry. Computer modeling and simulation for synthesizing current and voltage waveforms under large signal operating conditions have been developed. These analytical techniques are used to define available tradeoffs for optimizing efficiency and output power for the solid state amplifier. Figure 2.0 shows some typical experimental results using off-the-shelf commercially available FETS. In one instance when optimized for maximum efficiency, a 71% power-added efficiency was achieved. However, tests of similar devices from the same manufacturer but rated for slightly less output power resulted in efficiencies of much less ($\approx$ 60%). The incongruency in these results are under intensive investigation in hopes to shed more light on the underlying causes of efficiency degradation. These experiments along with updated analytical models and computer simulations should provide the basis for device and circuit design parameter specifications to achieve the high power, high efficiency operation necessary.

The other tasks noted previously each represent an advance in the technology base of one form or another and as a whole have added significantly to understanding the future satellite power system technological advances required.

References:

1. Lindsay, Thomas A., "SPS Fiber Optic Link Assessment", Boeing Aerospace Company, January 31, 1980.

2. Belohoubek, E. F., et. al., "Analysis of S-Band Solid State Transmitters for the Solar Power Satellite", Final Report, RCA Laboratories, June 1, 1979.



EMITTER

- NEC INJECTION LASER DIODE
- BIAS COUPLED THROUGH QUARTER-WAVE MICROSTRIP
- I_{BIAS} = 88ma DC
- OPTICAL POWER = 437 µwatt @ EMITTER DIGTAIL
- V_{980MHz} = 0.7 VOLTS RMS

FIBER

- CORNING IVPO, GRADED INDEX
- LENGTH = 303 METERS
- ATTEN. = 3.9dB/km
- BW = 870MHz-km
- N.A. = 0.218

DETECTOR

- RCA AVALANCHE PHOTODIODE
- BIAS COUPLED THROUGH QUARTER-WAVE MICROSTRIP
- V_{BIAS} = 180 VOLTS DC
- OPTICAL POWER = 228 µwatt @ DETECTOR LIGHT PIPE
- V_{980MHz} = 135 mv RMS OUT OF PREAMP

FIGURE 1 INITIAL SPS 980MHz FIBER OPTIC LINK CONFIGURATION

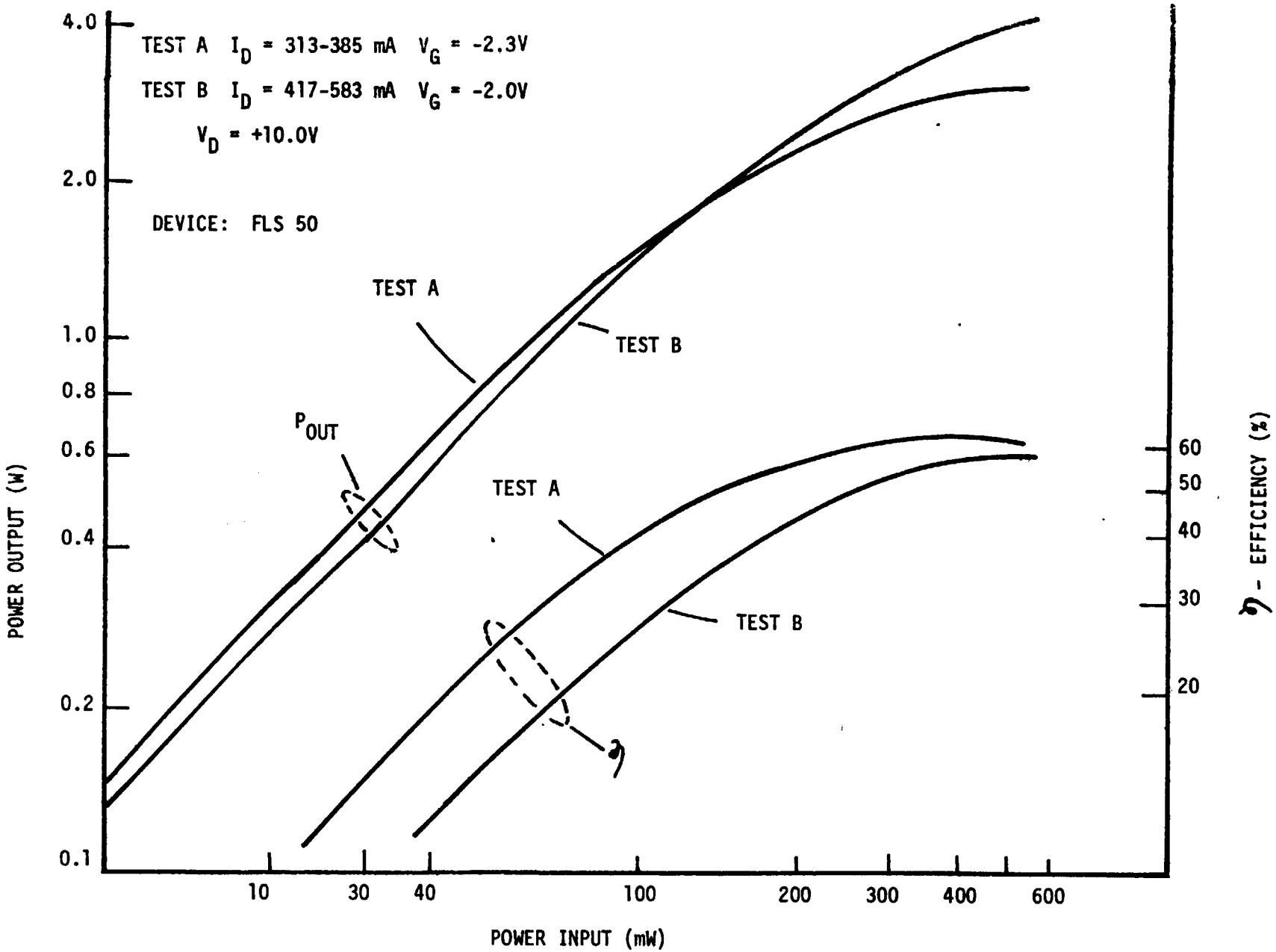


FIGURE 2.0 TEST RESULTS - MAX. POWER AND MAX. EFFICIENCY TUNING