Bendix

Aerospace
Systems Division

NO.	REV. NO.
EATM-44	

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DATE 24 Feb. 1969

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PSEP Power Management

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INTRODUCTION

The purpose of this EATM is to update the description of the functional aspects of the PSEP Power Subsystem, incorporating the effects of recent changes. The functional description is presented in a series of plots of various aspects of power distribution versus the system input power. These plots can be used as input parameters for studies of thermal control and for determining operational plans.

POWER SUBSYSTEM DESCRIPTION

Following is a partial list of power memoranda discussed at the EASEP Critical Design Review on 14 January 1969:

EATM-32, PSEP Power Requirements, 10 January 1969
EATM-33, PSEP Power Balance, 11 January 1969
EATM-38, Preliminary Operations Plan, 13 January 1969

As a result of the CDR and subsequent studies, several changes were made to the PSEP which effect the information presented in these memoranda:

1. The following heaters internal to the central station will be disconnected:

DSS HTR1 (CD-25)	9.9 watts
DSS HTR2 (CD-26)	4.9 watts
DSS HTR3 (CD-9)	9.9 watts

2. PDR 1 (CD-5) will be reduced from 6.9 watts to 5.0 watts

3. PDR 2 (CD-7) will be reduced from 13.8 watts to 10.0 watts.

Changes from ALSEP which were approved at the CDR include:

1. The regulators were changed from a range of 55 watts to 36 watts.

2. The transmitter heater was disconnected.

Figure 1 shows the PSEP power functional block diagram with the lunar noon nominal input of 42 watts and nominal operating conditions with no dump loads connected to the converter output bus.

Figure 2 shows the output expected from the solar panels as a function of sun angle. The center curve is based on data obtained from the acceptance tests of the flight panels. It is slightly higher than the nominal curve presented in EATM-33. The upper and lower curves show the ±5% limits on the output power which is approximately the variation expected from seasonal solar radiation variations.

POWER MANAGEMENT

Calculations were made of reserve power, central station dissipation and power in the power dissipation module, external to the station, as functions of system input power. These calculations are shown in Figures 3 through 5. Each of these figures has six curves which correspond to six load conditions for the PSEP. The minimum and maximum output power limits from Figure 2 are shown as vertical lines at 34 and 48 watts. The nominal output at lunar noon of 42 watts is also shown.

The nominal load curve is for the station operating with no external dump loads on. The effects of the addition of external loads PDR 1, PDR 2, or PDR 1 and 2 are shown as separate load lines on each figure. The effects of the reduction of load from the nominal, by turning the transmitter or transmitter and PSE off, are also shown on each figure. It is not expected that the various commandable load adjustments will be required for normal daytime operation.

There are nine other combinations of loads which can be achieved by turning on dump loads; three each when the transmitter is off, the PSE is off, and when the transmitter and PSE are off. These combinations are not shown because of their relative unimportance and for clarity of presentation. (The PSE off condition is not shown either). The general effect of adding external load can be estimated on Figure 4 by considering a family of three curves to the right of each of the "off" curves.

The reason for having external power dumps is to provide the capability of adjusting the central station internal load (and operating temperature) for a wide range of input power. The PSEP primary power source provides a power level which varies with sun angle and in addition there is some uncertainty about the panel temperatures which effects the output power. This uncertainty arises because the lunar surface temperatures are not uniform and because of the difficulty of exactly simulating the deployed thermal conditions.

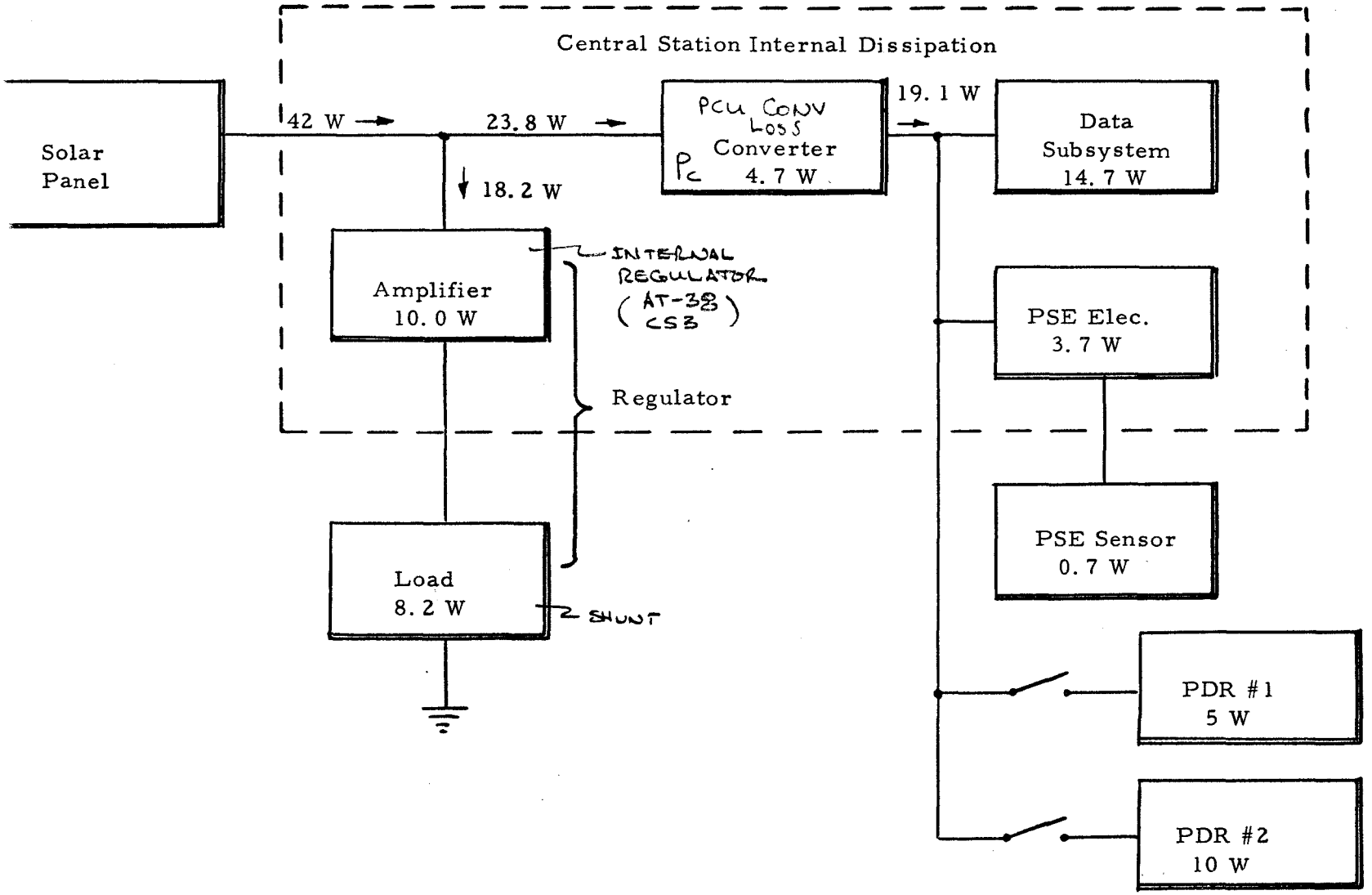

Figure 1. PSEP Power Balance, Lunar Noon, Nominal Input

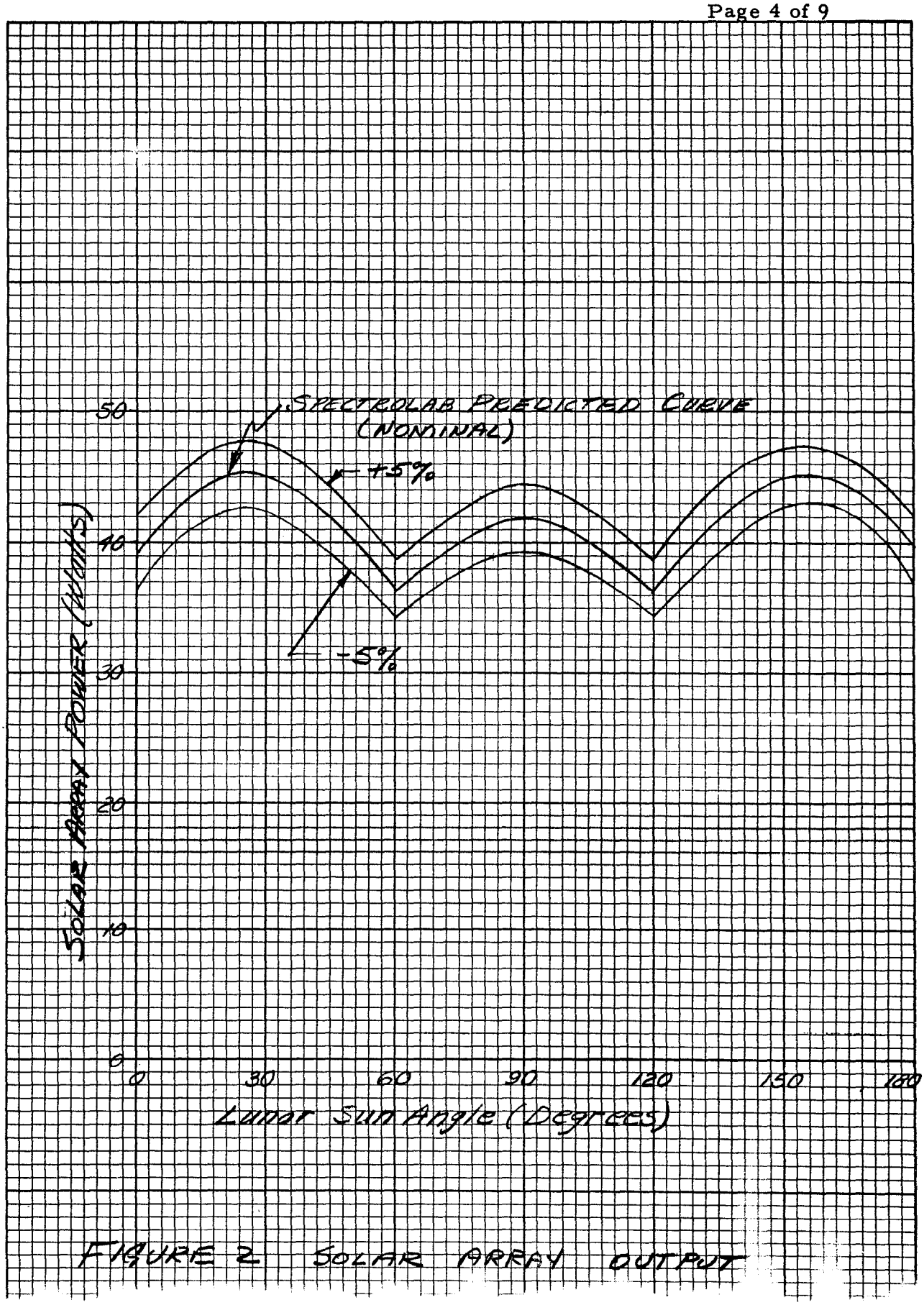

FIGURE 2 SOLAR ARRAY OUTPUT

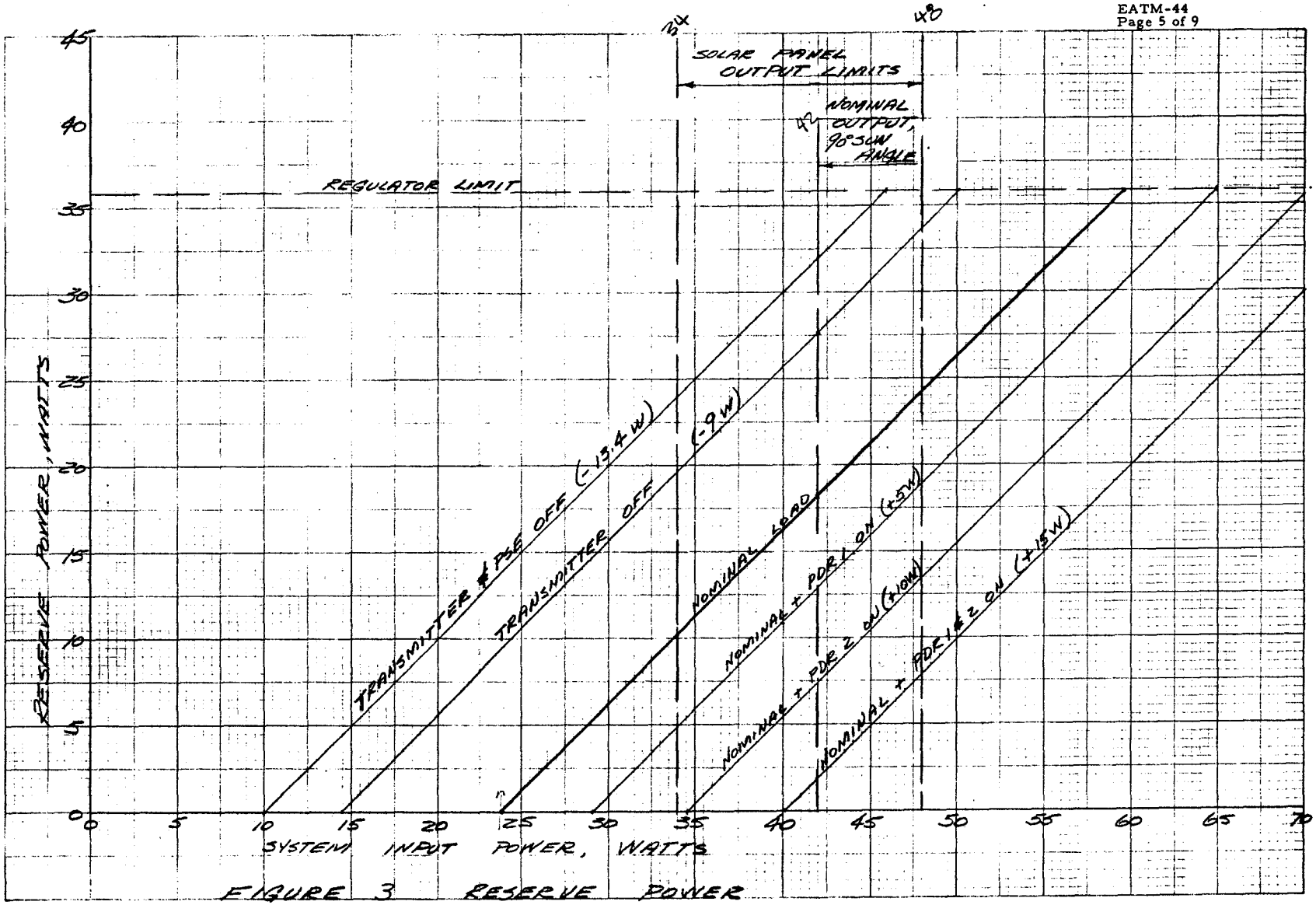

FIGURE 3 RESERVE POWER

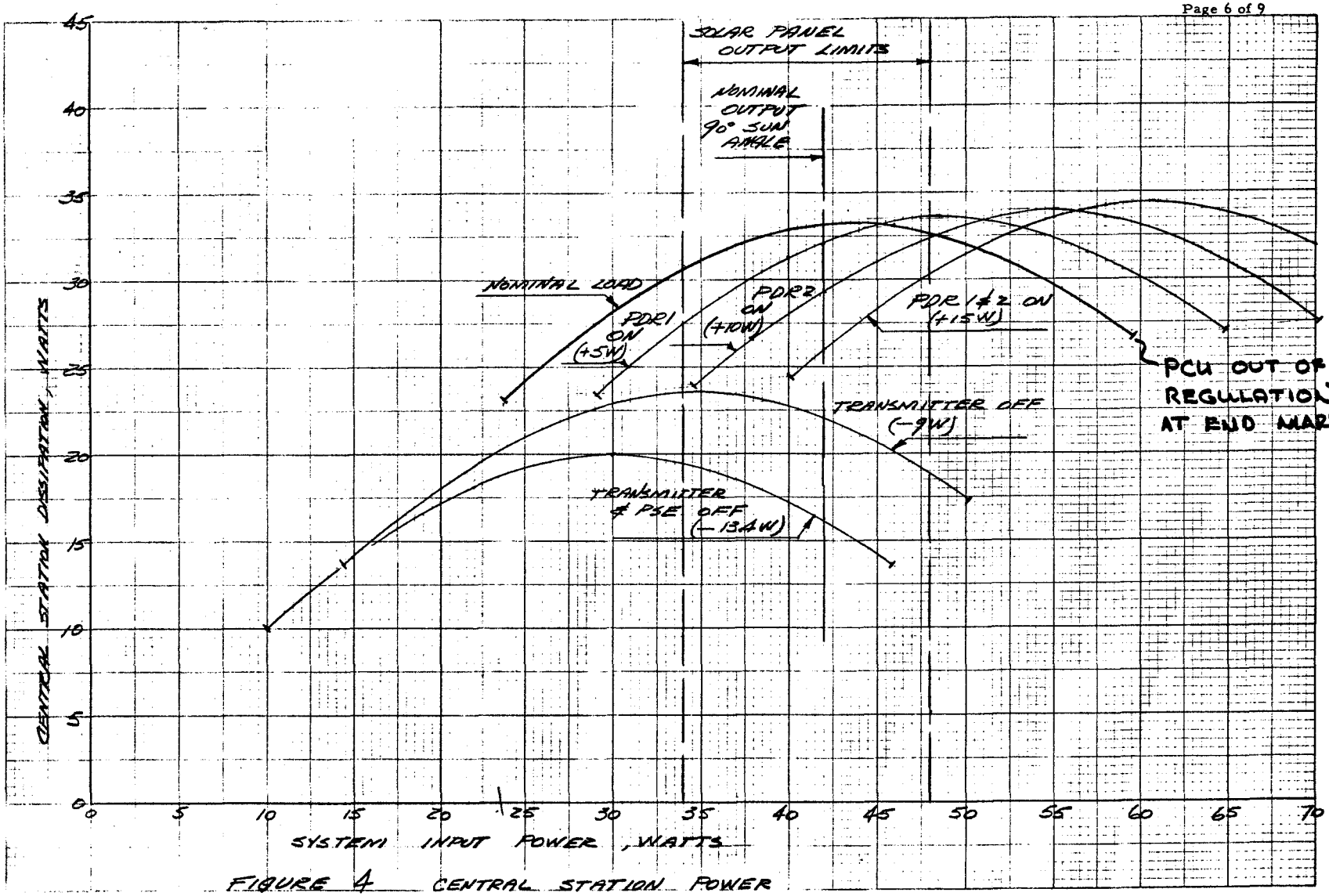

FIGURE 4 CENTRAL STATION POWER

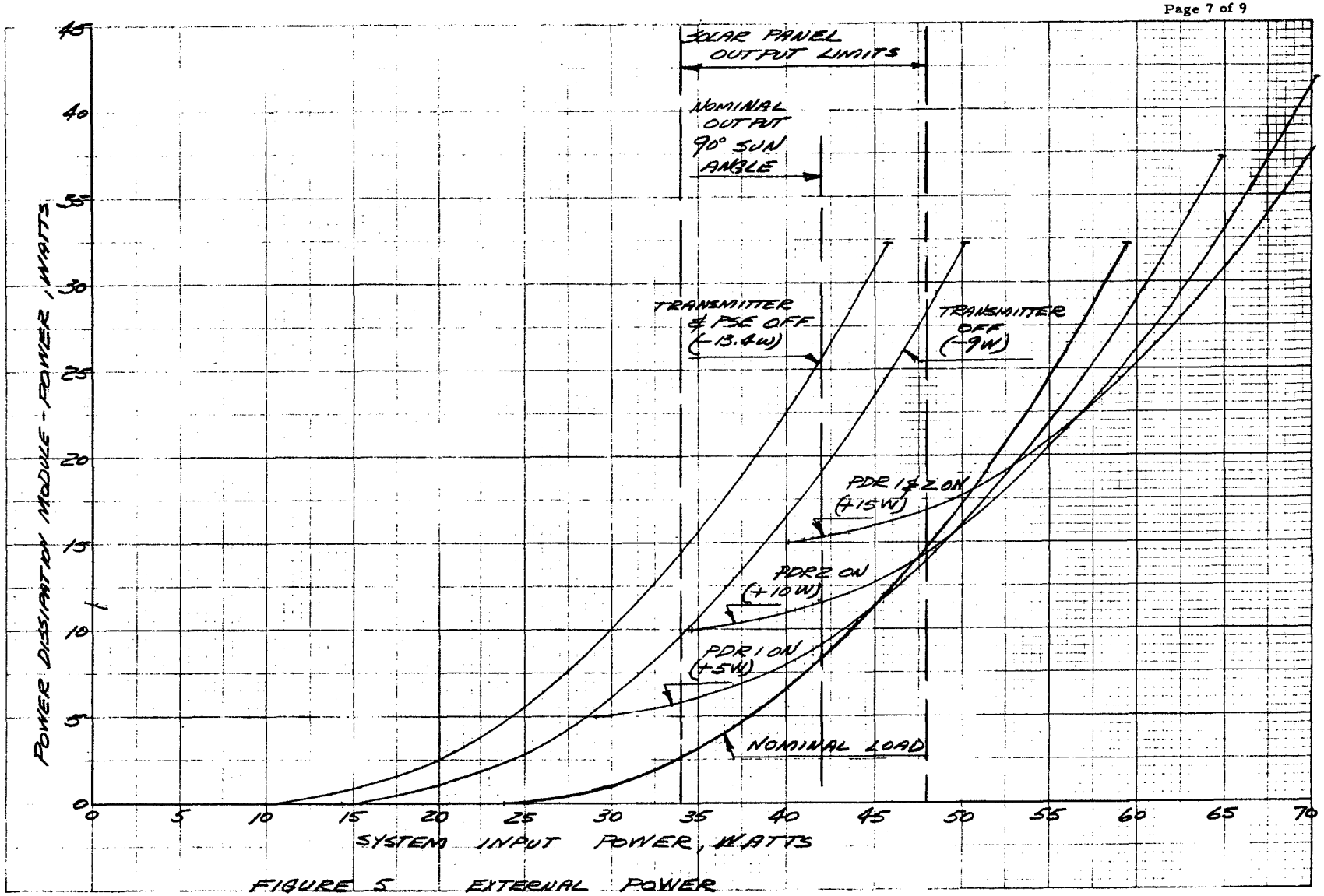

FIGURE 5 EXTERNAL POWER

The ALSEP power balance situation is different because the RTG input power is relatively fixed but the loads can vary widely, as experiments are cycled through various modes or are turned off and on. The reason for the dump loads on ALSEP is also to optimize central station dissipation but the causes of the changes are at the load end rather than at the input as on the PSEP.

OPERATIONAL CONSIDERATIONS

The PSEP thermal control system is sized for an average thermal plate peak temperature of 140°F. For this requirement, the radiator must be able to handle the peak central station electrical dissipation of about 33 watts, the isotope heater input of 30 watts, the sun load and the leakage from the structure. This is the design point but it is known that system reliability can be improved by operation at lower temperatures. This improvement can be achieved by the operational selection of an appropriate dump load value consistent with input power. The data presented in Figures 3 and 4 permit such a selection to be made.

It should be noted that neither of the "off" load conditions plotted are desirable for lunar operations. For nominal operating conditions the transmitter will be turned off only at sunset. As a contingency capability, the transmitter could be turned off periodically during the day to significantly reduce the central station load if the thermal control system should be degraded, for example. There should be no operational requirements to have both the transmitter and PSE off or to have only the PSE off. The power loads for the PSE on or in standby are essentially equal but the on and off conditions are quasi-stable because the ripple circuit can automatically change the experiment status from off or on to standby. Because of the ripple feature, it is not desirable to turn the PSE off because it is then possible for a load increase to occur during the sunset transient.

OPERATIONS PLAN

The preliminary operations plan as presented in EATM-38 will be updated with the following information consistent with the changes described above:

1. Page 1. Delete reference to Commandable Heaters 1, 2 & 3.

2. Page 3. Delete the recommended turn-off sequence for lunar night and substitute the following sequence:

   a. As lunar sunset approaches turn on (or verify that) one of the dump loads is on. This must be accomplished with adequate reserve power. It is desirable to turn on PDR 2, however at least PDR 1 must be turned on.

   b. As reserve power decreases to 2 to 3 watts command the PSE to standby.

   c. Monitor housekeeping

   d. When reserve power reaches about 1 watt, turn the transmitter off.

This sequence puts the PSE in the stable standby condition and replaces the transmitter with an equivalent load so that the chances of PCU switchover during the transient are minimized.

3. Page 3. Delete the recommended second-day initial operation and substitute the following sequence:

   a. Do not send any commands for at least 20 hours after it is estimated that the solar panels are illuminated. This time allows the central station, and in particular the transmitter, temperature to rise above the -10°F minimum operating temperature.

   b. Command PDR 2 off.

   c. Command the transmitter on.

   d. Evaluate housekeeping. If the link is not established, command the transmitter off and wait several hours and try again.

   e. When the link is established, turn the PSE on.