Bendix
Aerospace
Systems Division

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PSEP POWER BALANCE

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PURPOSE

The purpose of this EATM is to present the results of a study of the power balance of the PSEP. The nominal operating conditions and the power balance effects of commands are described. The effects of the inadvertent introduction of any command into the PSEP are also considered from a power balance point of view.

CONCLUSIONS

As a result of this study it has been determined that:

1. The expected power output of the solar panel array is entirely adequate for the operation of PSEP.

2. The inadvertent turn-on of PDR #2 (CD-7) which draws 13.8 watts could result in an out-of-regulation condition for some power input conditions. It is therefore planned to reduce the amount of power drawn by PDR #2 from 13.8 watts to 3.5 watts by removing three of the associated four resistors in the Power Dissipation Module (PDM).

3. During normal operation, the inadvertent introduction of any other command does not result in an out-of-regulation condition.

4. As a contingency against the possibility of the need to operate with a partially degraded thermal control system, the heater, which is turned on when the transmitter is turned off, will be disconnected. As a result, the power dissipated in the central station can be reduced by turning off the transmitter as may be required during periods of peak heating.

5. The optimum regulator range is 36 watts.

SYSTEM INPUT POWER

The output of the solar panel array, with the nominal solar input will vary from 37 to 43 watts due to the changing sun angle relative to the array. In addition, uncertainties in the solar constant can add approximately another ± 3 watts to the expected output. It is possible, therefore, for the minimum input to the station to be as low as 34 watts for the worst sun angle and minimum solar intensity situation and as high as 46 watts for an optimum sun angle and solar intensity situation. The variations of the array outputs for these three cases as functions of sun angle are shown in Figure 1.

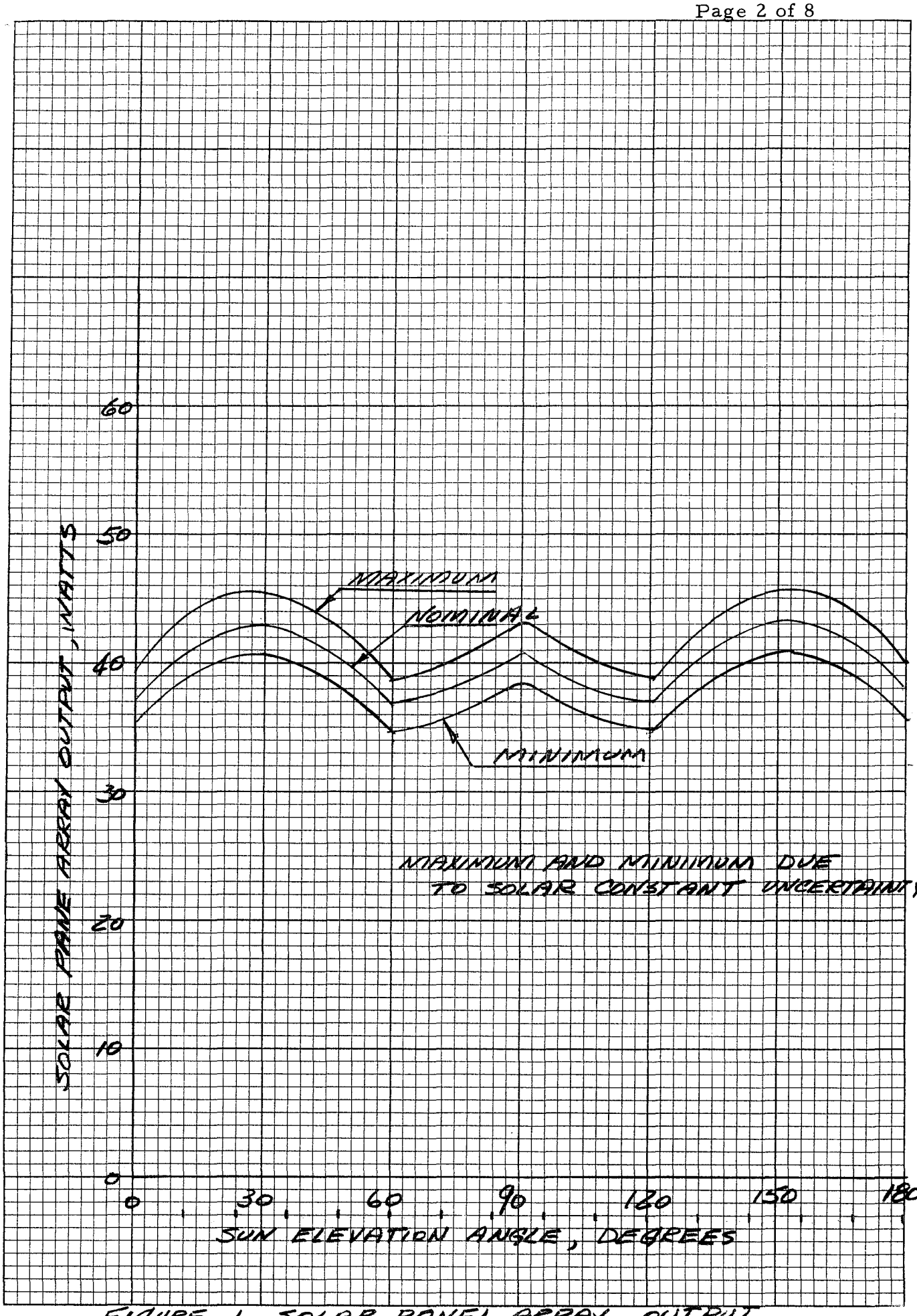

FIGURE 1. SOLAR PANEL ARRAY OUTPUT

POWER REQUIREMENTS

The nominal load on the PCU consists of the following:

Data Subsystem

Receiver	0.8 watts
Decoder	1.2
Analog Multiplexer	1.4
Data Processor	0.5
PDU	1.5
Transmitter	9.0
Dust Detector	0.3
	14.7 watts

PSE

Central Station Electronics	3.7
Sensor	0.7
	4.4
	19.1 watts

The PCU conversion losses for 19.1 watts are 4.7 watts bringing the absolute minimum power required for central station operation to 23.8 watts. If the input power decreased to this value the station would operate but the PCU regulator would be completely cut off, the PSE would be in standby and voltage regulation would be poor for any increases in load. The difference in power between the solar array output and the 23.8 watts is dissipated in the regulator. The nominal power balance condition is shown in Figure 2.

OTHER LOADS

In addition to the loads described above, the following ALSEP load changes can be achieved by command. Commands not listed do not result in a significant power status change.

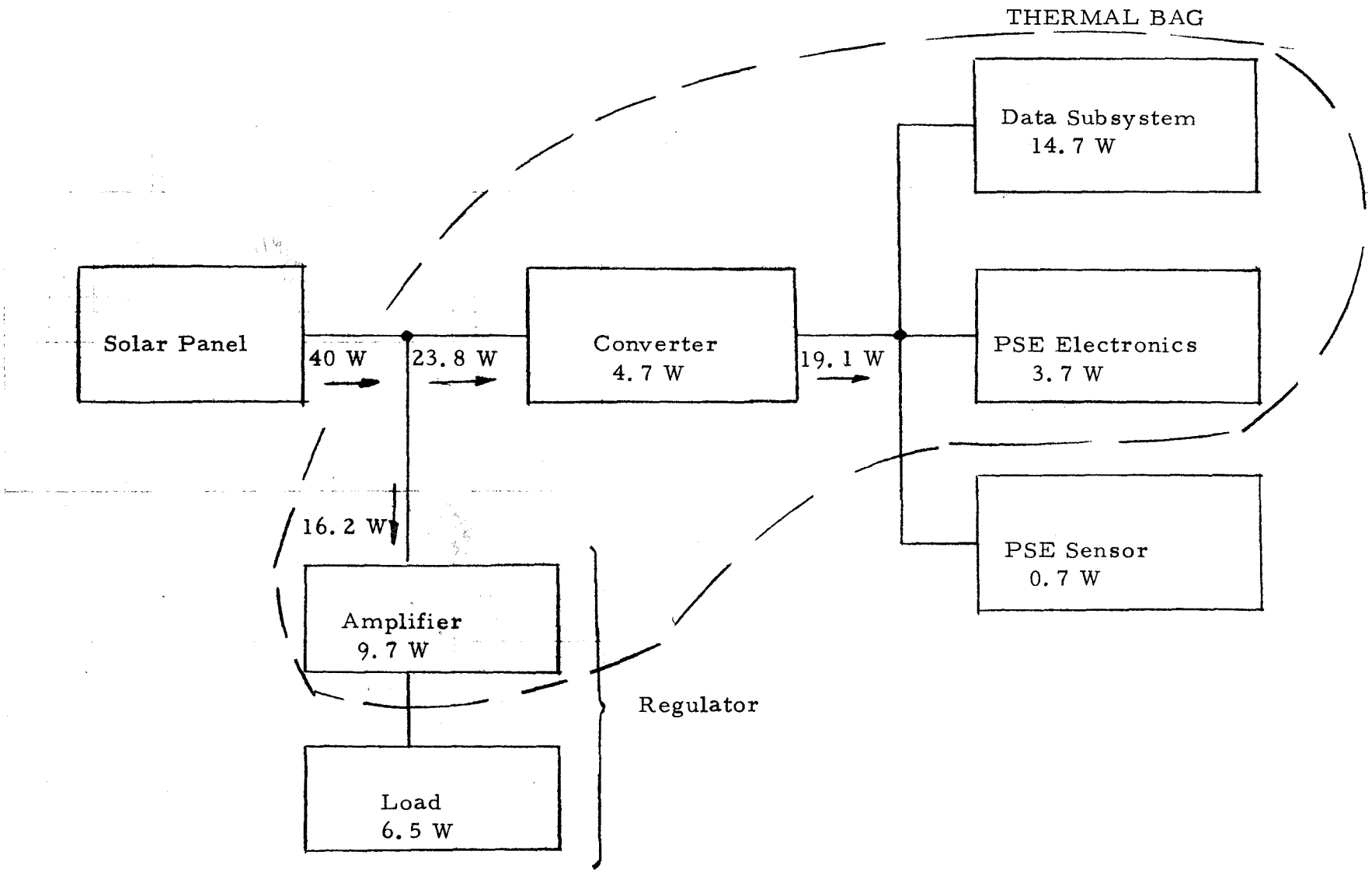

Figure 2. PSEP Nominal Power Balance Condition

Octal Command	Command Symbol	Command Nomenclature	Power Change from Nominal Operating Condition
017	CD-5	PDR #1 ON	+6.9 watts
021	CD-6	PDR #1 OFF	0
022	CD-7	PDR #2 ON	+13.8
023	CD-8	PDR #2 OFF	0
024	CD-9	DSS HTR 3 ON	+9.9
025	CD-10	DSS HTR 3 OFF	0
036	CD-13	PSE Operational Power ON	0
037	CD-14	PSE Standby Power	+0.1
041	CD-15	PSE Standby OFF	-4.4
055	CD-25	DSS HTR 1 Select	+9.9
056	CD-26	DSS HTR 2 Select	+4.9
057	CD-27	DSS HTR OFF	0
070	CL-6	Level Motor X ON/OFF	+3.0[2]
071	CL-7	Level Motor Y ON/OFF	+3.0
072	CL-8	Level Motor Z ON/OFF	+3.0
076	CL-12	Thermal Control Mode, Auto/Manual[1]	+ 0 to 2.8
027	CX-1	Dust Detector - ON	0
031	CX-2	Dust Detector - OFF	-0.3
		TRANSMITTER ON	0
		TRANSMITTER OFF	-9.0

1 Sequence of commands is: Auto ON (0.2 to 2.4w.)/Auto OFF (0 w.)/Manual ON (2.8 w)/Manual OFF (0 w)

2 Plus a short transient

REGULATION RANGE

The ALSEP regulator will dissipate up to 55 watts of power, which is more than adequate for PSEP, but the change in power dissipated within the central station for an input change from 34 to 46 watts would be about 7 watts. Because of the critical thermal balance for PSEP it is desirable to minimize the power dissipated in the central station during the day and also to minimize any automatic change in central station power as loads change. To accomplish these desires it is planned to reduce the regulator range by removing some of the eight resistors which are part of each regulator. With this change, the power dissipated in the central station is reduced as much as practical and the change over the 34 to 46 watt input variation is reduced to a minimum.

The intent of this study is to show that there is adequate system power and that the change in regulator range can be made without jeopardizing system operation considering the effect of the deliberate or inadvertent introduction of any command.

RESERVE POWER

The data presented in the above sections can be combined and presented as in Figure 3 which shows reserve power for several load conditions as functions of input power.

On Figure 3 the middle sloping line shows reserve power as input power changes, with the PSE on and no heaters or "dump" loads on. The lower lines show the effects of adding various ALSEP loads. The 4.9 watt CD-26 or the 6.9 watt CD-5 do not affect regulation since there is always reserve power within the solar panel limits. If CD-9 or CD-25 at 9.9 watts are added the load may slightly exceed the capability if the input is at the extreme lower end of the panel output. This would only occur for a short time for sun angles of 60^{o} and 120^{o} under worst case solar panel output conditions. Even so, the voltages would probably not be depressed enough to prevent getting a command into the system. This situation is not considered sufficient justification for disconnecting the two 9.9 watt central station heaters.

If the 13.8 watt CD-7 is added the system will go out of regulation if the input is less than 39 watts. To prevent this situation from occurring it is planned to reduce the value of PDR #2 from 13.8 watts to 3.5 watts by removing three of the associated resistors located on the power dissipation module located at the rear of the primary structure. Leaving a dump capability of 3.5 watts gives system flexibility in case loads need to be adjusted.

It should be noted that the potential out-of-regulation conditions described above are not dependent on the regulator range since there is no reserve power for these conditions.

On the upper side of Figure 3, the effect of reduction of load is shown in several steps. Two regulator ranges are shown: 30.6 watts which results if 4 of the 8 regulator resistors are disconnected and 36 watts which results if 3 of the 8 resistors are disconnected.

The only significant reduction in load possible without modifications within the central station is the turn-off of the PSE. This reduces the PCU load by 4.4 watts. Without central station modifications the 30.6 watt regulator is entirely adequate to handle this 4.4 watt change with any expected input power level.

OTHER CONSIDERATIONS

The thermal control of the PSEP is different from the ALSEP in that power from the primary power source is not continuous and isotope heaters are mounted on the central station to minimize the lunar night excursion. A disadvantage of this concept is the need to dissipate the 30 watts from the isotope heaters during the day. In the event the thermal control surfaces should become degraded, the day-time station temperatures would rise.

As a contingency the transmitter heater will be disconnected to allow some thermal relief in central station dissipation on a temporary basis. In ALSEP the transmitter heater is turned on when the transmitter is turned off to keep a power balance. In a contingency situation, the transmitter could be turned off (and PSE if desired) from time-to-time for reducing the temperature. During the time it is off the equivalent load would be "dumped" outside the station by means of the PDR #1 and #2. If both dumps are turned on, up to 10.4 watts can be dissipated externally as well as a portion of the load picked up in the external portion of the regulator.

Referring to Figure 3 the upper two lines show the result of unloading the system with the 9 watts of the transmitter and the sum of the transmitter and the PSE without picking up additional load. Because of this possibility it is necessary to have a regulator range of 36 watts. This can be achieved by disconnecting three of the eight regulator resistors associated with each PCU regulator.

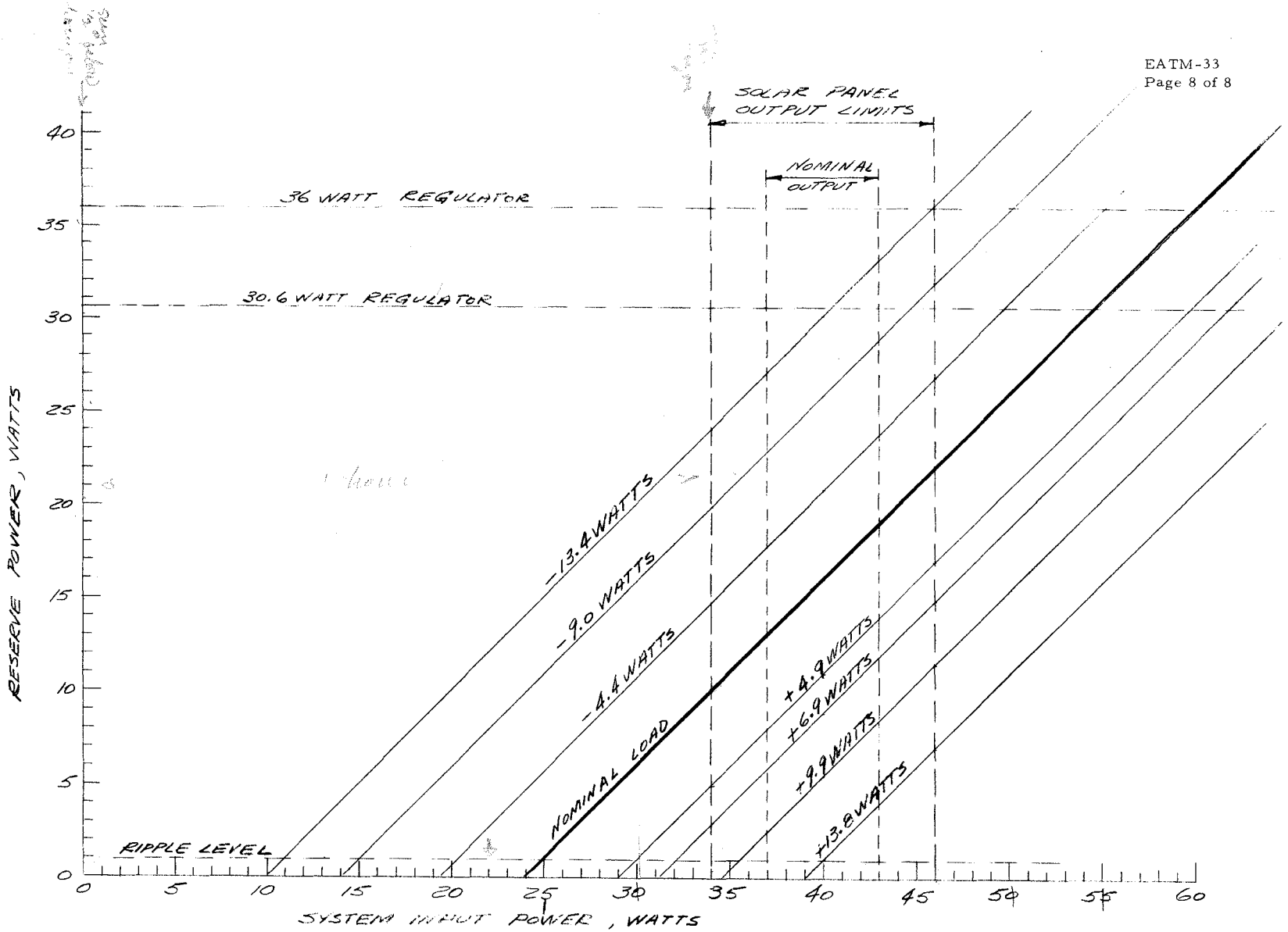

FIGURE 3 RESERVE POWER