Bendix

Aerospace Systems Division

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EASEP SOLAR PANEL OCCULTATION

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1. INTRODUCTION

This EATM describes the results of a detailed investigation and analysis performed to determine the effect upon the system during solar array occultation which can be encountered on the lunar surface during and after deployment by the astronaut or as a result of the terminator moving across the lunar surface.

In addition the effects of various rates of occultation were analyzed.

2. SUMMARY

As a result of this analysis it is indicated that occultation of the lunar array during and after deployment must be limited.

The amount of occultation is largely determined by the geometry of the lunar sunlight angle of incidence, astronaut and solar array.

3. DISCUSSION

The solar array and P. C. U. were analyzed to determine the effect of solar panel occultation during lunar sunlight angles of incidence from zero (0) to one hundred eighty (180) degrees. Short and long term transients are also covered.

The solar array power output capability is considered during three periods, these are, three panels exposed to lunar sunlight at angles of incidence from zero (0) to sixty (60) degrees, six panels from sixty (60) to one hundred five (105) degrees and three panels from one hundred five (105) to one hundred eighty (180) degrees.

The P. C. U. regulation limits are compared to input power variance, time constants of transient inputs and switchover levels.

3.1 The following tabulation indicates the solar array nominal output and distribution at lunar sunlight angles of incidence.

Sunlight Angle of Incidence to Solar Array	Three Panel "A" Power Output in Watts	Three Panel "B" Power Output in Watts	Solar Array Total Power Output in Watts
0 Degrees	37.0	0.0	37.0
15 "	41.5	0.0	41.5
30 "	43.0	0.0	43.0
45 "	41.0	0.0	41.0
60 "	37.0	0.0	37.0
75 "	28.0	10.0	38.0
90 "	20.5	20.5	41.0
105 "	10.0	28.0	38.0
120 "	0.0	37.0	37.0
135 "	0.0	41.0	41.0
150 "	0.0	43.0	43.0
165 "	0.0	41.5	41.5
180 "	0.0	37.0	37.0

3.2 The following table and graph reflect the solar array occultation limits in order to maintain satisfactory EASEP operation:

	Sunlight Angle of Incidence	Maximum Permissible Percent Occultation Three Panel "A"	Three Panel "B"
	0 Degrees	33.00	100.00
	15 "	40.25	
	30 "	43.00	
	45 "	39.50	
A	75 "	8.44	100.00
B	75 "	34.73	00.00
C	90 "	39.50	00.00
D	90 "	00.00	39.50
E	105 "	00.00	34.73
F	105 "	100.00	8.44
	120 "		33.00
	135 "		39.50
	150 "		43.00
	165 "		40.24
	180 "	100.00	33.00

NOTE 1

NOTE 1. (a) Occultation conditions may exist for: - A or B at 75°, C or D at 90°, E or F at 105°

(b) Occultation of both sides of the array is highly unlikely in a lunar environment with one astronaut, these data are included for continuity

3.3 The P.C.U. input power requirements and transient sensitivities are as follows:

3.3.1 Minimum input power to maintain regulation is 24.8 watts.

3.3.2 When the input power is reduced to 23.8 watts, the P.S.E. is switched to the standby mode.

3.3.3 Switchover from P.C.U. #1 to P.C.U. #2 will occur in the event that the power input decreases at a rate exceeding 5.42 watts per minute and remains at 19.8 watts for 300 milliseconds or more.

3.3.4 A rate of change in power input of 5.42 watts per minute or less decreasing to 19.8 watts or less will not cause switchover.

3.3.5 In the event that the power input decreases at a rate exceeding 5.42 watts per minute and remains at 19.8 watts for less than 290.00 milliseconds switchover will not occur.

4. RESULTS AND CONCLUSIONS

4.1 An increase in occultation of four (4) percent in addition to the limits shown by Figure I, paragraph 3.2, will cause the P.S.E. to be "rippled off" to a standby mode.

4.2 An occultation of twenty four (24) percent occurring in 0.833 minute in addition to the limits shown by Figure I, paragraph 3.2 and maintained for a period of 300 milliseconds or more will cause P.C.U. No 1 to switchover to P.C.U. No. 2. See Figure II B.

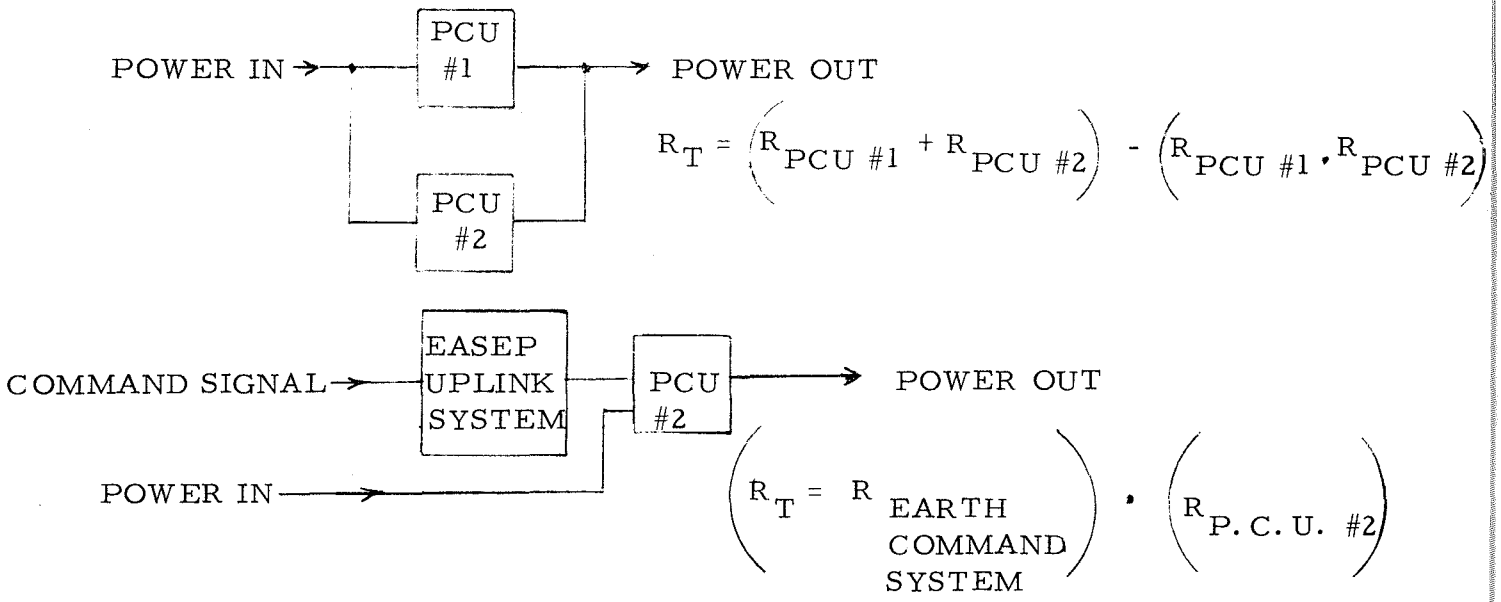
4.3 The complete solar array may be occulted 100% without cuasing P.C.U. switchover provided the rate of occultation does not exceed twenty (20) percent per minute, increasing to 100%. See Figure II C.

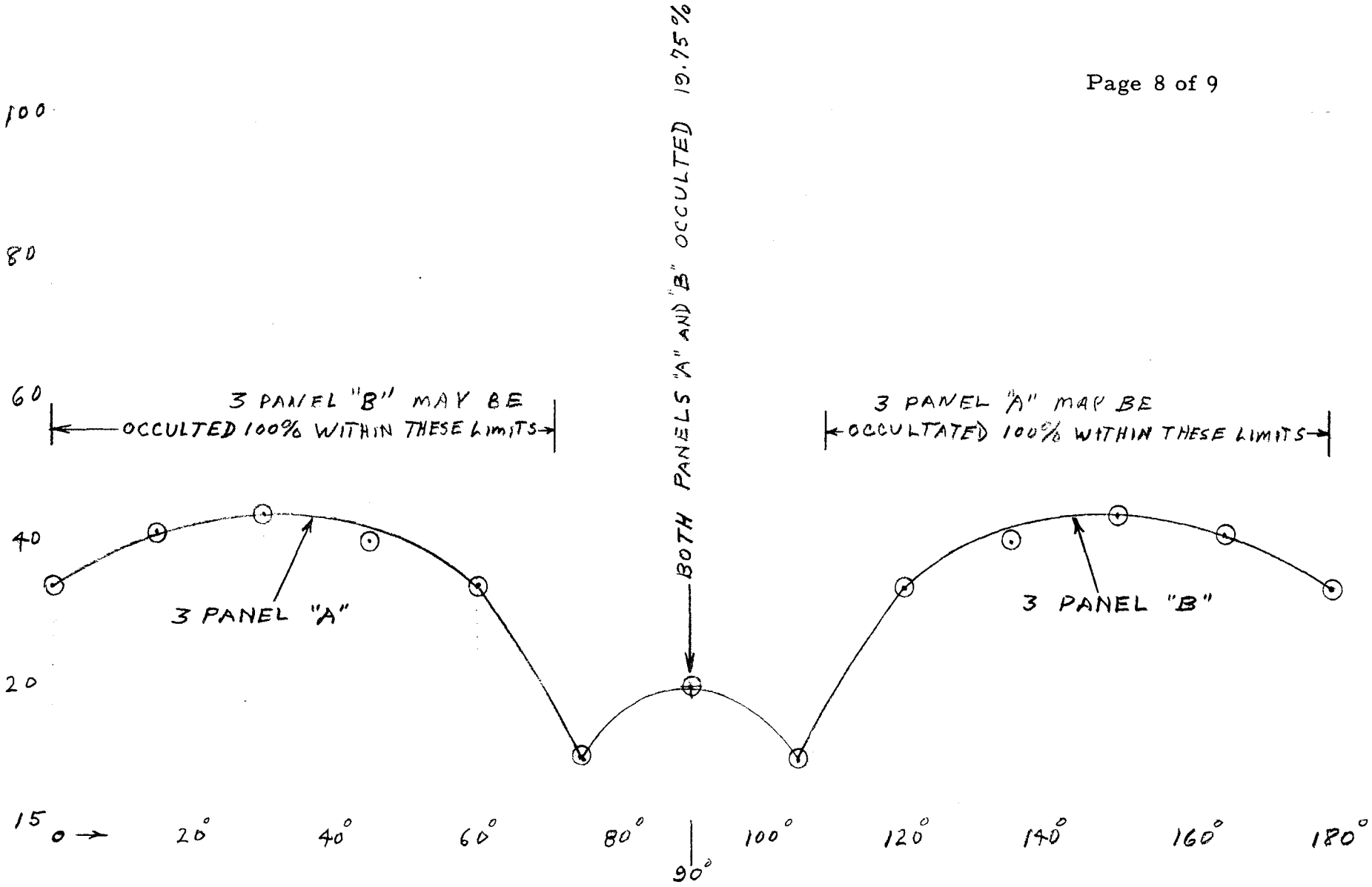
4.4 On occultation of twenty four (24) percent occurring in 0.833 minute in addition to the limits shown by Figure I, paragraph 3.2 and maintained for a period of 290 microseconds or less will not cause P.C.U. switchover. See Figure II A.

4.5 The time constant of the solar panels, (i.e., The solar panel output power decreases to thirty (30) percent of maximum, ten (10) microseconds after 100% instantaneous occultation,) is not considered in view of the solar panels rapid response to sunlight exposure variations.

4.6 Transient occultation of the solar arry for durations of less than 290.00 milliseconds and within the magnitude and distribution limits described in paragraphs 3.2 and 3.3 will not effect system operation. See Figure I and II A.

4.7 Occultation of the solar array in excess of the limits described in paragraph 3.2 can result in the P.C.U. switchover and the resultant loss of redundancy, decreasing the system reliability. The P.C.U. may be restored to the initial mode (i.e. swithcover of P.C.U. No. 2 to P.C.U. No. 1) via earth command. This mode places the EASEP UPLINK system reliability in series with the P.C.U and P.C.U switch-over system, decreasing the overall system reliability. The decrease in reliability from the initial mode to the switched-over mode is shown by the following block diagram.





MAXIMUM PERMISSIBLE OCCULTATION

FIGURE I

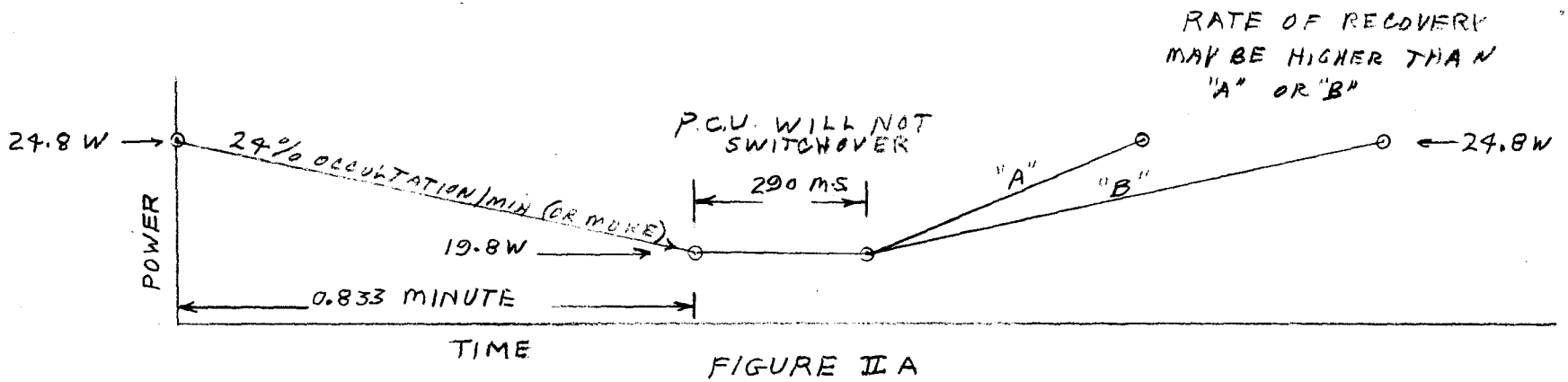


FIGURE II A

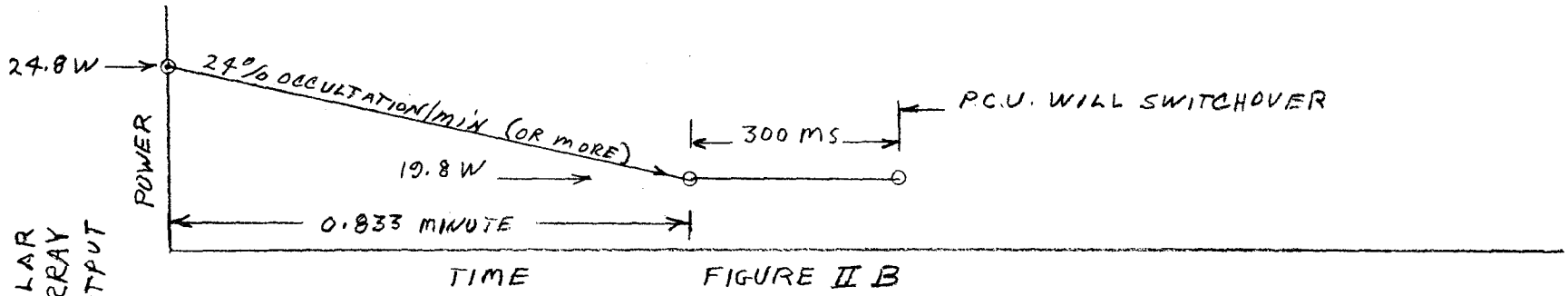


FIGURE II B

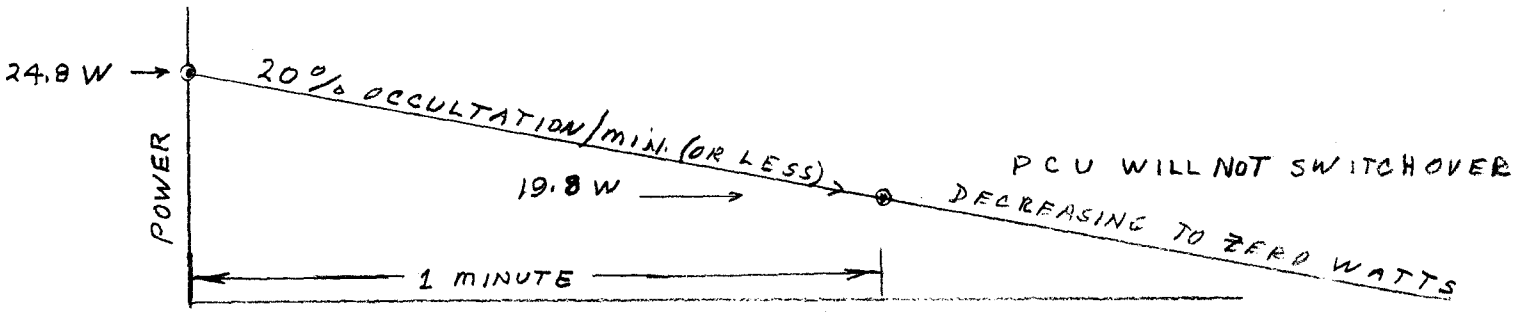


FIGURE II C

FIGURE II

SOLAR ARRAY TRANSIENT OCCULTATION LIMITS