



**Aerospace
Systems Division**

ALSEP COMMUNICATIONS
PERFORMANCE MARGIN SUMMARY

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This document re-evaluates the ALSEP/MSFN communication performance margins as a result of performance measurements made upon existing ALSEP hardware. The results indicate that the performance margins calculated in the Interface Control Document SE-06, Rev. A, 3 September 1968 are still the best estimate of total performance. These performance margins are summarized herein and discussed where it is felt necessary.

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1.0 GENERAL DISCUSSION

Preliminary Integration Acceptance (PIA) tests made on the ALSEP antenna, switch/filter, receiver, and transmitter units for EASEP, Flight 1, Flight 3, and Flight 4, indicate that these units are individually within specification. The performance of these units when interconnected into the ALSEP system cannot be determined from these individual measurements since interconnecting cable VSWR or input/output impedance measurement were not made. Calculation of system performance based upon these measurements would not, therefore, when used in conjunction with the statistical MSFN parameters, be more meaningful than those made in the Interface Control Document SE-06, Rev. A.

1.1 COMMAND LINK

The meaning of the IF signal-to-noise ratio (S/N) margin indicated in SE-06, Rev. A, has not been clear to all readers.

Since the command receiver uses a combination limiter-FM-Discriminator-Integrator to demodulate the received phase modulated signal, so-called FM threshold exists. For received signal levels larger than this threshold, the full FM improvement factor of $3M^2$ is realized and a very large output S/N ratio exists. For received signal levels below this threshold, the full FM improvement factor is not obtained. In fact, the output S/N decreases very rapidly and impulse noise increases. This effect is thoroughly discussed in the literature.⁽¹⁾ At the time of writing SE-06, this threshold⁽²⁾ level was given as +12 db in the pre-detection bandwidth. Measurement made on ALSEP Receiver SN-01⁽³⁾ and the results evaluated by Bendix indicate that this threshold does occur at about +12 db. System performance below this threshold value is not highly reliable since a small probability of error cannot be readily measured in a reasonable length of time for a data rate of 1060 bps.

(1) Schwartz, Bennett, Stein, "Communication Systems and Techniques", McGraw-Hill, pp. 144-154.

(2) Downing, "Modulation System and Noise", Prentice Hall.

(3) Lockheed Electronics Co., Houston Aerospace Systems, ALSEP Gross Systems Test and Analysis Report, No. 701001.

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Using a value of +12 db for the threshold gives a S/N ratio high enough so that the desired 10^{-9} probability of error can theoretically be obtained.

1.2 TELEMETRY LINK

The calculations of the S/N circuit margins for the data and carrier components of the telemetry signal are straight forward and apparently have been clear to all readers. A recalculation of these margins based upon minor variations in measured ALSEP transmitter, switch/filter, and antenna losses would not be worthwhile since only statistical values of the MSFN parameters are available - especially system noise temperatures.

2.0 CIRCUIT MARGIN SUMMARY

2.1 COMMAND LINK (MSFN TO ALSEP)

The command link circuit margin is the IF signal-to-noise ratio (S/N) in excess of the FM demodulation threshold of +12 db. This S/N ratio is measured prior to the IF Amplifier and Limiter unit of the command receiver.

2.1.1 Command Link Ground Rules

- (a) Range: 210 K n. mi. , +10 K n. mi. , -13 K n. mi.
- (b) Frequency: 2119 MHz
- (c) MSFN Antenna gain: 30' dish; +43.0 db, +0.25 db, -0 db
85' dish; +52.0 db, +0 db, -2.0 db
- (d) MSFN Transmitter Power: +70 dbm, +0 db, -0 db.
- (e) ALSEP Antenna gain: +15.0 db, +0.2 db, -0.3 db
- (f) Other losses: See SE-06, Rev. A.



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2.1.2 Command Link Summary Chart

Parameter	Nominal Value	Worst Case
(1) 30' MSFN Antenna IF S/N Margin (db)	9.3	3.7
(2) 85' MSFN Antenna IF S/N Margin (db)	18.3	10.7

2.2 TELEMETRY LINK (ALSEP TO MSFN)

The telemetry link circuit margins are: (1) the data S/N ratio in excess of that required to provide a data probability of error of 10^{-4} , and (2) the carrier S/N ratio in excess of the +12 db threshold required for the carrier tracking loop.

2.2.1 Telemetry Link Ground Rules

- (a) Range: 210 K n. mi. , +10 K n. mi. , -13 K n. mi.
- (b) Frequency: 2275 - 2280 MHz
- (c) MSFN Antenna gain: 30' dish; +44.0 db, +0.25 db, -0 db
85' dish; +53.0 db, +0 db, -2.5 db
- (d) ALSEP Antenna gain: +15.8 db, +0.3 db, -0.6 db
- (e) ALSEP Transmitter power: +30.1 dbm, +0.1 db, -0.1 db
- (f) MSFN System Temperature: (Moon at Zenith)
30 - foot antenna with uncooled paramp: 255°K
85 - foot antenna with cooled paramp: 240°K
- (g) Other losses: See SE-06, Rev. A.



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2.2.2 Telemetry Link Summary Chart; $2 B_{LO} = 12 \text{ Hz}$

Parameter	Nominal Value	Worst Case
(1) 30' Antenna, R = 530 bps Carrier Margin (db) Data Margin (db)	14.5 10.2	8.3 4.9
(2) 30' Antenna, R = 1060 bps Carrier Margin (db) Data Margin (db)	14.5 7.2	8.3 1.9
(3) 85' Antenna, R = 10,600 bps Carrier Margin (db) Data Margin (db)	23.8 6.5	16.2 0.8*

*Corresponds to a probability of bit error of 2.9×10^{-4} instead of 1×10^{-4} .