Presented in this ATM are the Lunar Mass Spectrometer (LMS) reliability prediction and mathematical models.

The A Revision herein has been updated to include the Lock Out Switching Circuit (page 11).

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Introduction

Presented herein are the mathematical models and results of the updated numerical reliability analysis as performed on the Lunar Mass Spectrometer. Two types of logic are presented, one type for before experiment deployment, and the other type for after experiment deployment. The former considers all elements as serially connected while the later excludes those elements whose final function is executed during deployment and also provides for degraded mode analysis.

Results

Table I presents a summary of the results of this analysis.

Assumptions

The following assumptions were applied to the numerical reliability analysis herein:

1) Operating temperature of the electronic parts are in accordance with Table II.

2) Derating factors are in accordance with ATM 241E.

3) Failure rates were developed from ATM 605 Rev A.

4) Expected semiconductor or integrated circuit junction thermal rises were extrapolated from "ALSEP, Array E Electronic Packaging Thermal Design Guidelines," Letter No. 9712-101.

5) Probability of success was calculated through the mathematical formulation

\[ R = e^{-\lambda t} \]

where

- \( R \) is the probability of success
- \( \lambda \) is the electronic component part failure rate given in \%/1000 hours
- \( t \) is the mission or storage time
6) The dormant or storage failure rate was calculated as follows:

Active Failure Rate X 0.01

7) The transient failure rate (non-operating from Launch to Experiment deployment) was calculated as follows:

Active Failure Rate X 0.1

8) The storage time used in the mathematical models was two years or 17,520 hours.

9) The transient time used in the mathematical models was 109 hours.

10) The mission time used in the mathematical models was two years or 17,520 hours.

11) Degraded Modes were defined by expansion of \((R+Q)^3\) reference "Lunar Mass Spectrometer Reliability Block Diagram" (After Experiment Deployment).

12) Junction temperatures for discrete devices (transistors and semiconductors) were normalized in accordance with MIL-HDBK 217A and ATM 605A tables as follows:

\[
\theta_{J-A} = \frac{T_J - T_S}{P_J_{\text{max}}}
\]

where

\(\theta_{J-A}\) is thermal resistance from junction to circuit board (°C/W)

\(T_{J_{\text{max}}}\) is the maximum rated temperature (°C)

\(T_S\) is the ambient temperature, 25°C

\(P_{J_{\text{max}}}\) is the maximum power rating for the device (watts)
where:

\[ T_j = T_a + (\theta_{J-A}) P_j \]

1) \( T_j \) is the actual junction temperature in the application or design.

2) \( T_a \) is the actual ambient temperature at the circuit board in °C.

3) \( \theta_{J-A} \) is the thermal resistance from junction to the circuit board in °C/watt.

4) \( P_j \) is the average power dissipated (watts in the circuit application or design).

13) It is to be noted that the reliability prediction herein reflects the results of the component application analysis and not the failure modes and effects analysis.

14. Loading of 54L and 54 series I.C.'s:

The "limiting parameter" loading must be followed when determining the maximum fan out for a device. This is summarized in T.I.'s catalog CC201-R pages 12-1 through pages 12-3.

To summarize the tables:

1) A 54 series loaded by a 54 series: \( N = 10 \) where \( N = 1 \) is -1.6 Ma (limiting parameter).

2) A 54L series loaded by a 54L series: \( N = 10 \) where \( N = 1 \) is -0.18 Ma (limiting parameter).

The above values must be derated in accordance with ATM 241E to 75 percent. This limits the TTL devices to:

1) A 54 series may be loaded with as many as seven 54 series single inputs or thirty-two 54L series single inputs.
2) A 54L series may be loaded with as many as seven 54L series single inputs or one 54 series single input.

Under no circumstances may a circuit be loaded over 80%.

Conclusions

Section I - The overall reliability goal for the Lunar Mass Spectrometer is .90. The Reliability prediction for two years operation on the lunar surface using failure rates from the Parts Application Analysis, is .858. This value is increased to .876 when using the Q values from the Failure Modes and Effect Analysis.
6. MATHEMATICAL MODELS

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<th>CHANNELS FAILING</th>
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<td>B</td>
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<td>C</td>
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<td>A, C</td>
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7. ADD PART 7 AND THE DESIGNED PATHS, 1 TO 6.

8. TO DETERMINE TOTAL EXPERIMENT RELIABILITY WITH ACCOUNTED MODES.
### TABLE I

#### LMS RELIABILITY SUMMARY

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#### Notes
- E.A.C.: Early Acceptance Criteria
- E.A.E.: Early Acceptance Evaluation
- E.A.O.: Early Acceptance Operation
- E.A.R.: Early Acceptance Rejection
Lock Out Switch

This switch was added to prevent accidental turn on of the ion source filaments (numbers 1 or 2) during ground test when the chamber is back filled with argon. The switch is mounted on the base plate and is a normally closed switch. The switch, when activated, will open the +29 volt supply to the emission control inverter circuit. The switch is activated by a pin inserted through the base plate from outside the LMS. The pin is "flaged" DO NOT FLY and will be removed after final test. The switch will also be hard wired for a short circuit prior to flight.

For the reason that the switch is to be hard wired and shorted out before flight, the reliability of this switch will not affect the reliability of the LMS.

The switch is controlled by BxA SCD number 2346242-1. The Emission Control Schematic number is 151-702. The circuit is shown below.