Report 9831B
December 1995

Earth Observing System/ Advanced Microwave Sounding Unit-A (EOS/AMSU-A)

Reliability Prediction Report for Module A1 (Channels 3 through 15) and Module A2 (Channels 1 and 2)

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Section 1

INTRODUCTION

This report documents the final reliability prediction performed on the Earth Observing System/Advanced Microwave Sounding Unit-A (EOS/AMSU-A). The A1 Module contains Channels 3 through 15, and is referred to herein as "EOS/AMSU-A1". The A2 Module contains Channels 1 and 2, and is referred herein as "EOS/AMSU-A2".

This report was prepared by Aerojet of Azusa, California, under contract NAS 5-32314 for the National Aeronautics and Space Administration Goddard Space Flight Center (GSFC), and is submitted to show compliance with Paragraph 4.2.2, Mission Life Requirements, of GSFC, Performance and Operation Specification for EOS/AMSU.

1.1 *Summary*

The predicted reliability for three years orbital life at 30°C ambient temperature for the EOS/AMSU-A is as follows:

Module	Predicted	Specified	Configuration
EOS/AMSU-A1	70.2%	70%	Channels 3 through 15
EOS/AMSU-A2	87.3%	84%	Channels 1 and 2

The 'specified' figures were obtained from Aerojet Reports 8897-1 and 9116-1.

The predicted reliability figure for the EOS/AMSU-A1 meets the specified value and provides a Mean Time Between Failures (MTBF) of 74,390 hours.

The predicted reliability figure for the EOS/AMSU-A2 meets the specified value and provides a MTBF of 193,110 hours.

Several circuits are common to both assemblies, and the common data are utilized in each prediction without change. (See Appendix A)

1.2 *General*

This report provides the following information

a. Results of reliability analysis
b. Conditions for failure rate calculations
c. Reliability math model
d. Reliability block diagram
e. Functional description of EOS/AMSU-A1
f. System assembly diagram

Appendix A presents the failure rate calculations for specific subassemblies and subsystems of EOS/AMSU.

Appendix B presents the reliability calculation for the standby redundant Hybrid Tee/PLO system.

Section 2

APPLICABLE DOCUMENTS

This report has been prepared to comply with the relevant requirements and guidance contained in the following documents.

GSFC POS	Performance and Operation Specifications for the Earth Observing System/Advanced Microwave Sounding Unit (EOS/AMSU)
GSFC PAR	Performance Assurance Requirements for the Earth Observing System/Advanced Microwave Sounding Unit (EOS/AMSU)
MIL-HDBK-217	Military Handbook, Reliability Prediction of Electronic Equipment
MIL-STD-756	Military Standard, Reliability Modeling and Prediction
MIL-STD-785	Reliability Program for System Modeling and Prediction
MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts
NPRD-91	Non-Electronic Parts Reliability Data

Section 3

RELIABILITY ANALYSIS

The reliability prediction described herein was performed in accordance with Task 203 of MIL-STD-785. The failure rates used were derived primarily from MIL-HDBK-217. Other failure rate sources such as NPRD-91 (Nonelectronic Parts Reliability Data), GIDEP, Vendor data and Aerojet experience were also used.

Tables I and XI summarize the reliability prediction data for the A1 and A2 modules, respectively. This prediction was performed by analyzing each assembly listed in Appendix A, along with other subassemblies. (See Tables II through IX for the A1 Module subassemblies and Table XII through XVI for the A2 Module.)

The data in Appendix A are predictions performed using Microsoft Excel 5.0 and MIL-HDBK-217.

3.1 *Prediction Procedure/Ground Rules*

The prediction uses the guidelines of MIL-HDBK-217 and is based on the following ground rules:

a. The equipment operates in a spacecraft environment.

b. Component parts are properly derated.

c. An ambient temperature of 30°C is selected as the operating temperature.

d. Duty cycled failure rates are not utilized.

e. Part failures will occur randomly and independent from each other.

f. All component parts meet or exceed the reliability requirements specified.

g. Reliability and redundancy are based upon a three-year life; i.e., at the time of launch the instrument is fully operational, and it is energized when the desired orbit is achieved.

h. Redundancy utilized in this prediction is limited to the temperature monitor and 0.05 percent platinum resistor temperature (PRT) circuits with one allowable failure out of each seven PRT circuits.

i. Mission noncritical items (see 2.2) are not included.

j. Parts lists and other Aerojet drawings utilized are the latest versions.

k. Failure rates and reliability figures for various purchased items are vendor supplied. These items include:

1. DC/DC Converter
2. Dielectric Resonant Oscillators
3. Mixer/IF Amplifier
4. SAW Filters (A1 Module only)

3.2 *Excluded Items*

Nonessential items used in EOS/AMSU-A have not been included in this prediction. The object is to produce a reliability prediction for the essential items that are required to provide uncompromised data from all channels. The items excluded from this prediction include:

a. Ground support equipment, including test connector and interface assembly.

b. Analog telemetry circuit(s) and output connector.

c. Housekeeping circuits (temperature and voltage monitoring), including Temperature Sensor "B" boards and a portion of the PRT multiplexer.

d. Temperature transducers.

It is assumed that a failure of any of these items will not degrade essential system requirements for EOS/AMSU. This assumption has been partially verified, and will be included in the Failure Mode, Effects, and Criticality Analysis (FMECA).

Section 4

CONCLUSIONS

As shown in Table I, the failure rate for EOS/AMSU-A1 is 13.44 failures per million hours. This provides a reliability figure of

$$R_{A1} = \exp(-Slt)$$
$$= \exp[-13.44/10^6 hr (26,280 hr)]$$
$$= 0.702$$

This predicted reliability results in a Mean Time To First Failure of 74,390 hours. The specified reliability of 70% results in a Mean Time To First Failure of 73,681 hours.

Table XI shows the failure rate for EOS/AMSU-A2 to be 5.18 failures per million hours. This provides a reliability figure of

$$R_{A2} = \exp(-Slt)$$
$$= \exp[-5.18/10^6 hr (26,280 hr)]$$
$$= 0.873$$

This predicted reliability results in a Mean Time To First Failure of 193,110 hours. The specified reliability of 84% results in a Mean Time To First Failure of 150,728 hours.

Section 5

RELIABILITY BLOCK DIAGRAMS

The reliability block diagrams for the EOS/AMSU-A1 module are shown in Figures 1 through 8.

The reliability block diagrams for the EOS/AMSU-A2 module are shown in Figures 9 through 13.

Section 6

IMPROVEMENTS

The EOS/AMSU-A retained NOAA/AMSU-A design configurations except where a change:

a. Is required by EOS specification differences

b. Resulted from an inability to obtain components used in the NOAA/AMSU-A design

c. Has been shown to clearly reduce EOS/AMSU-A cost

The current limiting requirement on the Mixers/IF Amplifiers and IF Amplifiers is a reliability enhancement that prevents failure of one component to pull down the power supply to other components.

The failure rate for the RF Detectors was recalculated based on the design presented in Advanced Control Components, Inc., Reliability Prediction RP-1335923 for SSMIS, received April 23, 1991. A safety factor of twice the calculated failure rate is presented in Table III, V, VI, and XI.

Results of received subcontractor reliability reports have been incorporated into this report.

Table I EOS/AMSU-A1 Reliability Prediction Summary

Subsystem	Item	Quantity (n)	λ (f/10⁶ hr)	nλ	Σnλ
Horn - Multiplexer	All Channels	2	0.38343	0.76687	-
Receiver Channels	Channels 3 - 8, 15	7	0.58801	4.11610	-
Common Elements	Channels 9 - 14	1	0.37435	0.37435	-
Receiver Channels	Channels 9 & 10	2	0.48854	0.97708	-
Shared Elements	Channels 11 - 14	1	0.41566	0.41566	-
Common Elements	Channels 11 - 14	4	0.72347	2.89389	-
				9.5440	9.5440
Power Distribution	All Channels	1	1.06841	-	1.06841
Antenna Drive	All Channels	2	0.78461	-	1.56922
Processor - Microcomputer	All Channels	1	0.37904	-	0.37904
Temperature Calibration	All Channels	1	0.26806	-	0.26806
Software	-	-	-	-	0.50
Miscellaneous	-	-	-	-	0.11
				TOTAL	13.4427

Table II A1 Module Common Receiver Subsystem Units

Nomenclature	Part No.	Quantity (n)	λ (f/10⁶ hr)	nλ
Horn - Multiplexer (All Channels)				
Horn	1331381 / 1331410	1	0.001	0.001
Multiplexer (4 Port)	1331507 / 1331546	1	0.38243	0.38243

			TOTAL	0.3834

Table III A1 Module Receiver Channels 3-8 and 15

Nomenclature	Part No.	Quantity (n)	λ (f/10⁶ hr)	nλ
Isolator	1356680-X	1	0.01142	0.01142
Local Oscillator	1356610-X	1	0.19074	0.19074
Attenuator, Waveguide	1331509-X	1	0.00761	0.00761
Mixer/IF Amplifier	1331562-X	1	0.26730	0.26730
Bandpass Filter	1331559-X	1	0.03807	0.03807
Attenuator, IF	1331516-X	1	0.01142	0.01142
Coax Cable Connectors	SMA Type	3 (pair)	0.01312	0.03937
Detector, RF	1331577-1	1	0.01409	0.01409
Video Preamplifier	1331157	1/3	0.01452	0.00484
Integrate & Dump Filter	1338424	1/4	0.01269	0.00317

			TOTAL	0.5880

Table IV A1 Module Receiver Channels 9-14 Common Elements

Nomenclature	Part No.	Quantity (n)	λ (f/10^6 hr)	nλ
Isolator	1356610-X	1	0.01142	0.01142
Mixer/IF Amplifier	1331562-X	1	0.26730	0.26730
Power Divider, 3-Way	1356669	1	0.03807	0.03807
PLO/Hybrid Tee System	1348360/AE-24683	1 of 2*	-	0.01820
Coax Cable Connectors	SMA Type	3 (pair)	0.01312	0.03937
			Total	0.3743

* See Appendix B for derivation of this failure rate.

Table V A1 Module Receiver Channels 9 and 10

Nomenclature	Part No.	Quantity (n)	λ (f/10^6 hr)	nλ
IF Amplifier	1331579-9	1	0.37759	0.37759
Bandpass Filter	1331559-X	1	0.03807	0.03807
Attenuator, IF	1331516-X	1	0.01142	0.01142
Detector, RF	1331577-1	1	0.01409	0.01409
Coax Cable Connectors	SMA Type	3 (pair)	0.01312	0.03937
Video Preamplifier	1331157	1/3	0.01452	0.00484
Integrate & Dump Filter	1338424	1/4	0.01269	0.00317
			TOTAL	0.4885

Table VI A1 Module Receiver Channels 11-14

Nomenclature	Part No.	Quantity (n)	λ (f/10^6 hr)	nλ
Shared Elements				
IF Amplifier	1331579-7	1	0.37759	0.37759
4-Way Power Divider	1356670	1	0.03807	0.03807

			Subtotal	0.4157
Common Elements				
SAW Filter	1331576-X	1	0.25988	0.25988
Amplifier, IF	1331579-X [1]	1	0.37759	0.37759
Attenuator, IF	1331516-X	1	0.01142	0.01142
Detector, RF	1331577-1	1	0.01409	0.01409
Coax Cable Connectors	SMA Type	4 (pair)	0.01312	0.05249
Video Preamplifier	1331157	1/3	0.01452	0.00484
Integrate & Dump Filter	1338424	1/4	0.01269	0.00317

			Subtotal	0.7235

1 - The failure rate for part number 1331579-13 is used as a worst case default value.

Table VII A1 Module Power Distribution Subsystem

Nomenclature	Part No.	Quantity (n)	λ (f/10^6 hr)	nλ
Mux/Relay	1356000	1	0.02586	0.02586
DC/DC Converter	1356010-1	1	0.52106	0.52106
Power Control/Monitor	1356002	1	0.28827	0.28827
Miscellaneous			0.10	0.10
			Subtotal	0.9352
Power Input Cable	1356428-1	1	0.04413	0.04413
Power Out / Command Cable	1356427-1	1	0.08909	0.08909
			Subtotal	0.1332
			TOTAL	1.0684

Table VIII A1 Module Antenna Drive Subsystem*

Nomenclature	Part No.	Quantity (n)	λ ($f/10^6$ hr)	nλ
Drive Motor	1331392-1	1	0.20982	0.20982
Resolver	AE-24681	1	0.00713	0.00713
R-D Converter/Oscillator	1337739	1	0.08332	0.08332
Motor Driver	1331694	1	0.03864	0.03864
Interface/Converter	1331697	1	0.03492	0.03492
Resolver-Data Isolator	1334972	1	0.01716	0.01716
Bearings, Duplex**	1333663	1 (pair)	0.15	0.30
Scan Drive Cable	1356424-1	1	0.09363	0.09363

			TOTAL	0.7846

* Both A1 Antenna Subsystems are identical with respect to reliability
** From Report 8897-1

Table IX A1 Module Signal Processing-Microcomputer Subsystem

Nomenclature	Part No.	Quantity (n)	λ ($f/10^6$ hr)	$n\lambda$
Analog Mux and A-to-D Converter	1356418	1	0.04413	0.04413
Microcomputer				
CPU	1356413	1	0.03684	0.03684
Memory	1331126	1	0.01542	0.01542
Scan Control Interface	1331129	1	0.00731	0.00731
Timing and Control	1331135	1	0.02884	0.02884
Command and Data Interface	1355998	1	0.15342	0.15342
Spacecraft Interface Cable	1356425-1	1	0.09309	0.09309
			TOTAL	0.3790

Table X A1 Module Temperature Calibration Subsystem

Nomenclature	Part No.	Quantity (n)	λ ($f/10^6$ hr)	$n\lambda$
PRT Sensor	1331425	1	0.01522	0.01522
PRT Conditioner	1331697	1/10	0.01716	0.00172
Connections, Solder	-	2	0.00007	0.00014
	λ for 1 of 5 PRT Sensors			0.01708
Redundant calculation 1 of 5 for warm (5) and cold (5) PRT sensors				
Temp Sensor, Board 'A'	1338421	1	0.03278	0.03278
PRT Multiplexer	1331688	1/2	0.03864	0.01932
Redundant PRT Sensor	-	2	0.00008	0.00015
Analog Temp / PRT Cable	1356426-1	1	0.24859	0.24859
			TOTAL	0.2681

$$R = 5\varepsilon^{-4(\Sigma\lambda t)} - 4\varepsilon^{-5(\Sigma\lambda t)}$$

$$R = 0.999998$$

where $\Sigma\lambda = 0.017079439$

$t = 26280$ hours (3 years)

$$\lambda = -\ln R/t = 0.00008$$

Table XI EOS/AMSU-A2 Reliability Prediction Summary

Subsystem	Item	Quantity (n)	λ (f/10[6] hr)	Σnλ
Horn and Diplexer	Channels 1 and 2	1	0.38343	0.38343
Receiver Channels	Channels 1 and 2	2	0.90737	1.81473
RF Detector (Channel 1)	1331577-1	1	0.01409	0.01409
RF Detector (Channel 2)	1331577-2	1	0.01765	0.01765
Power Distribution	Channels 1 and 2	1	1.07491	1.07491
Antenna Drive	Channels 1 and 2	1	0.73984	0.73984
Processor - Microcomputer	Channels 1 and 2	1	0.32946	0.32946
Temperature Calibration	Channels 1 and 2	1	0.19026	0.19026
Software	-	-	-	0.50
Miscellaneous	-	-	-	0.11
			TOTAL	5.1784

Table XII A2 Module Common Receiver Subsystem Units

Nomenclature	Part No.	Quantity (n)	λ (f/10[6] hr)	nλ
Horn	1331231	1	0.001	0.001
Diplexer (3 Port)	1331084	1	0.38243	0.38243
			Total	0.3834

Table XIII A2 Module Receiver Channels 1 and 2

Nomenclature	Part No.	Quantity (n)	λ (f/10^6 hr)	$n\lambda$
Isolator	1331111 / 1331112	1	0.01142	0.01142
Attenuator, Waveguide	1331509-X	1	0.38243	0.38243
Local Oscillator	1356610-X	1	0.37759	0.37759
Mixer/IF Amplifier	1331562-X	1	0.03807	0.03807
Bandpass Filter	1331559-X	1	0.03807	0.03807
Attenuator, IF	1331516-X	1	0.01142	0.01142
Coax Cable Connectors	SMA Type	3 (pair)	0.01312	0.03937
Video Preamplifier (2 channels)	1331074-3	1/2	0.01166	0.00583
Integrate & Dump Filter (4 channels)	1338424	1/4	0.01269	0.00317
			Total	0.9074

Table XIV A2 Module Power Distribution Subsystem

Nomenclature	Part No.	Quantity (n)	λ ($f/10^6$ hr)	$n\lambda$
Mux/Relay	1356000	1	0.02586	0.02586
DC/DC Converter	1356010	1	0.52106	0.52106
Power Control/Monitor	1356002	1	0.28827	0.28827
Miscellaneous		-	0.10000	0.10000

			Subtotal	0.9352
Power Input Cable	1356431-1	1	0.04543	0.04543
Power Out / Command Cable	1356432-1	1	0.08274	0.08274
Satellite Power Cable	1356817-1	1	0.00204	0.00204
Power Out Extention Cable	1356818-1	1	0.00710	0.00710
Receiver Power Cable	1356819-1	1	0.00241	0.00241

			Subtotal	0.1397
			TOTAL	1.0749

Table XV A2 Module Antenna Drive Subsystem

Nomenclature	Part No.	Quantity (n)	λ (f/10^6 hr)	nλ
Channels 1 and 2				
Drive Motor	1333648-1	1	0.20982	0.20982
Resolver	AE-26017A	1	0.00713	0.00713
R-D Converter/Oscillator	1337739	1	0.08332	0.08332
Motor Driver	1331694	1	0.03874	0.03874
Interface Converter	1331697	1	0.03492	0.03492
Bearings, Duplex	1333663	1 (pair)	0.15000	0.30000
Resolver-Data Isolator	1334972	1	0.01716	0.01716
Scan Drive Cable	1356433-1	1	0.04876	0.04876
			Total	0.7398

Table XVI A2 Module Signal Processing-Microcomputer Subsystem

Nomenclature	Part No.	Quantity (n)	λ ($f/10^6$ hr)	nλ
Analog Multiplexer A/D Converter	1356418	1	0.03684	0.03684
Microcomputer				
CPU	1356413	1	0.02334	0.02334
Memory	1331126	1	0.01542	0.01542
Scan Control Interface	1331129	1	0.00731	0.00731
Timing and Control	1331135	1	0.02884	0.02884
Command and Data Interface	1355998	1	0.15342	0.15342
Spacecraft Interface Cable	1356434-1	1	0.06430	0.06430
			TOTAL	0.3295

Table XVII A2 Module Temperature Calibration Subsystem

Nomenclature	Part No.	Quantity (n)	λ ($f/10^6$ hr)	$n\lambda$
PRT Sensor	1331425	1	0.01522	0.01522
PRT Conditioner	P/O 1331697	1/10	0.01716	0.00172
Connections, Solder	-	2	0.00014	0.00028
	λ for 1 of 7 PRT Sensors			0.0172
Redundant calculation 6 of 7 for warm PRT sensors $R = 7\varepsilon^{-6(\Sigma\lambda t)} - 6\varepsilon^{-7(\Sigma\lambda t)}$ $R = 0.9999957$ where $\Sigma\lambda = 0.017219439$ $t = 26{,}280$ hours (3 years) $\lambda = -\ln R/t = 0.00016$				
Temp Sensor, Board 'A'	1338421	1	0.03278	0.03278
Analog Mux Temp. Sensor	1331688	7/20	0.07868	0.02754
Redundant PRT Sensor	-	2	0.00016	0.00033
PRT Cable	1356816-1	1	0.12961	0.12961
			TOTAL	0.1903

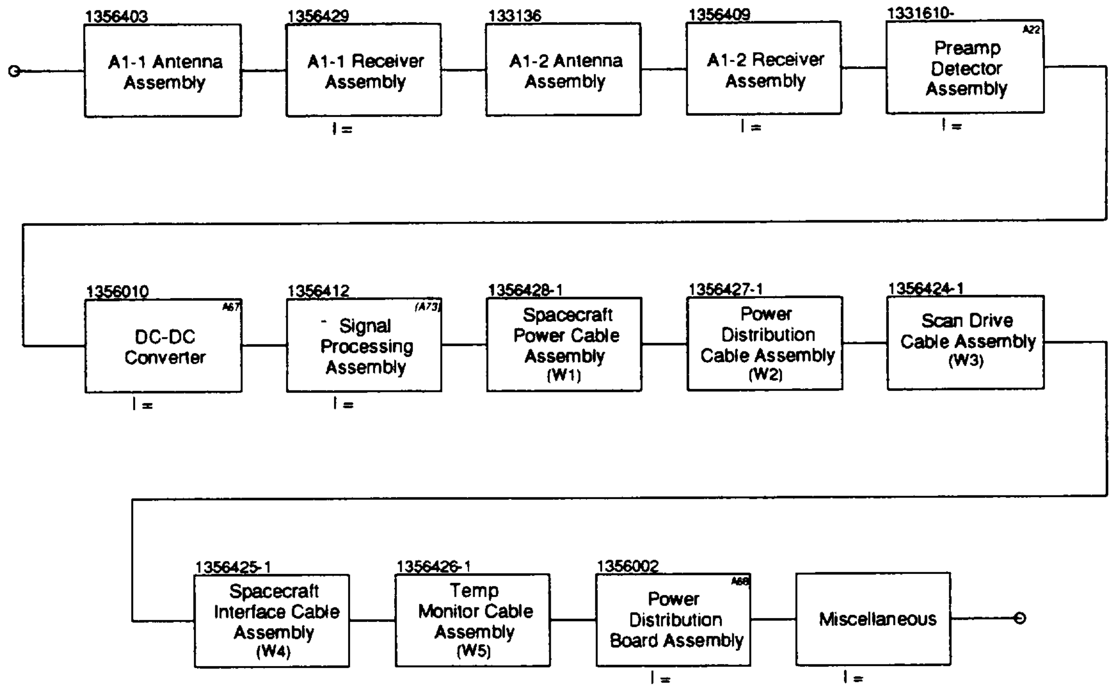

Figure 1 Top Level EOS/AMSU-A1 Reliability Block Diagram

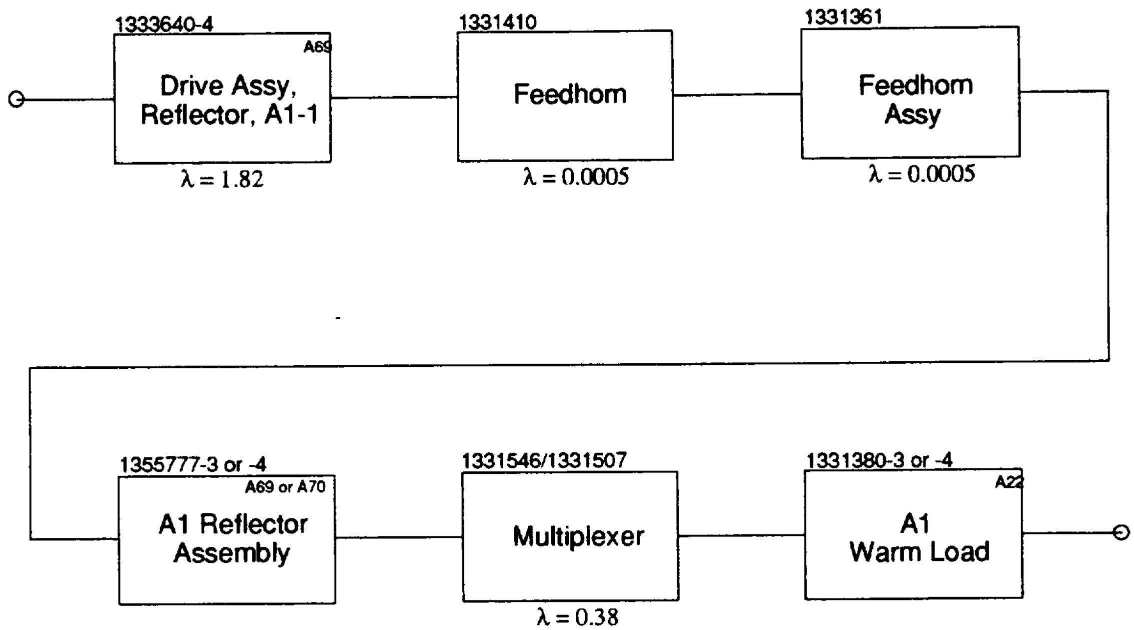

Figure 2 A1 Antenna Reliability Block Diagram

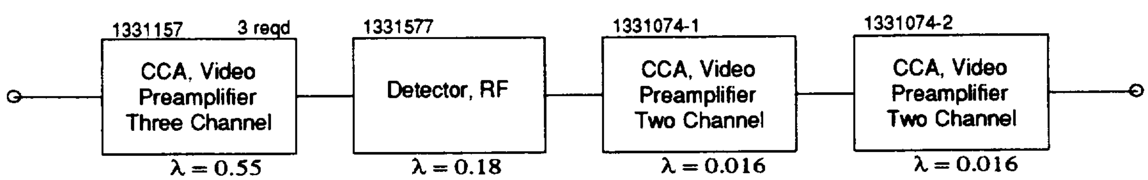

Figure 3 A1 Detector Preamp Reliability Block Diagram

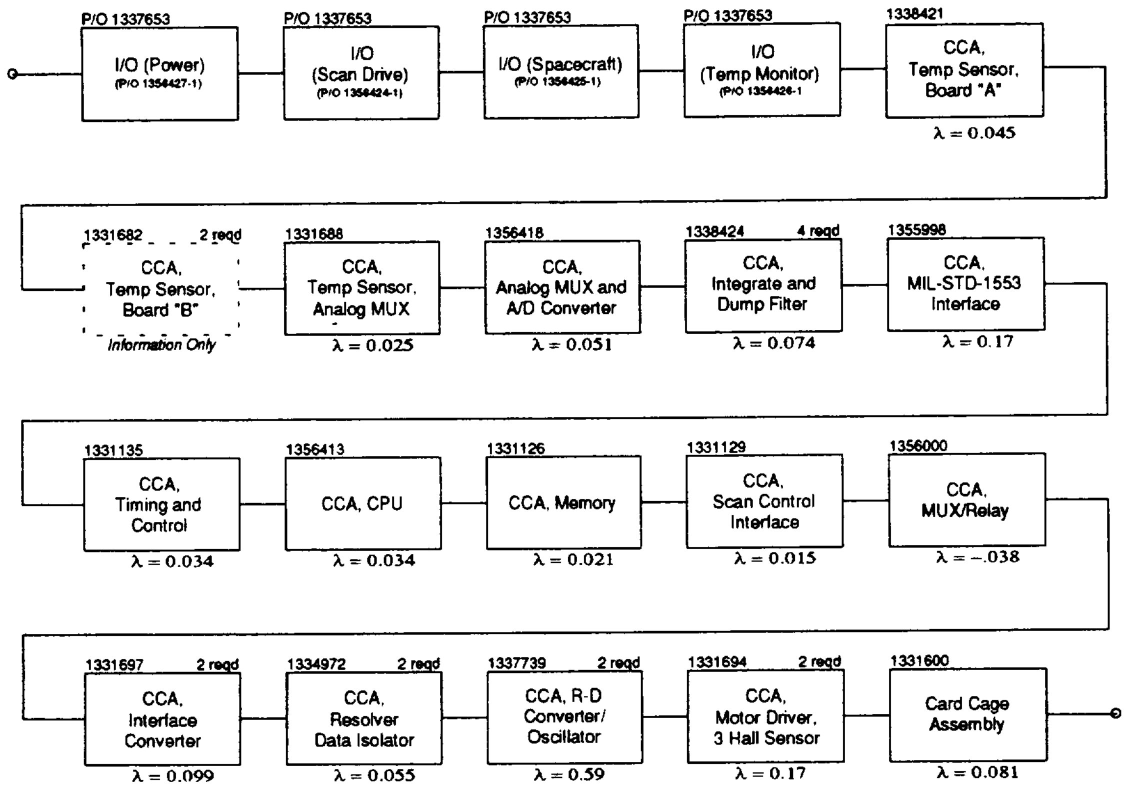

Figure 4 A1 Signal Processing Subsystem Reliability Block Diagram

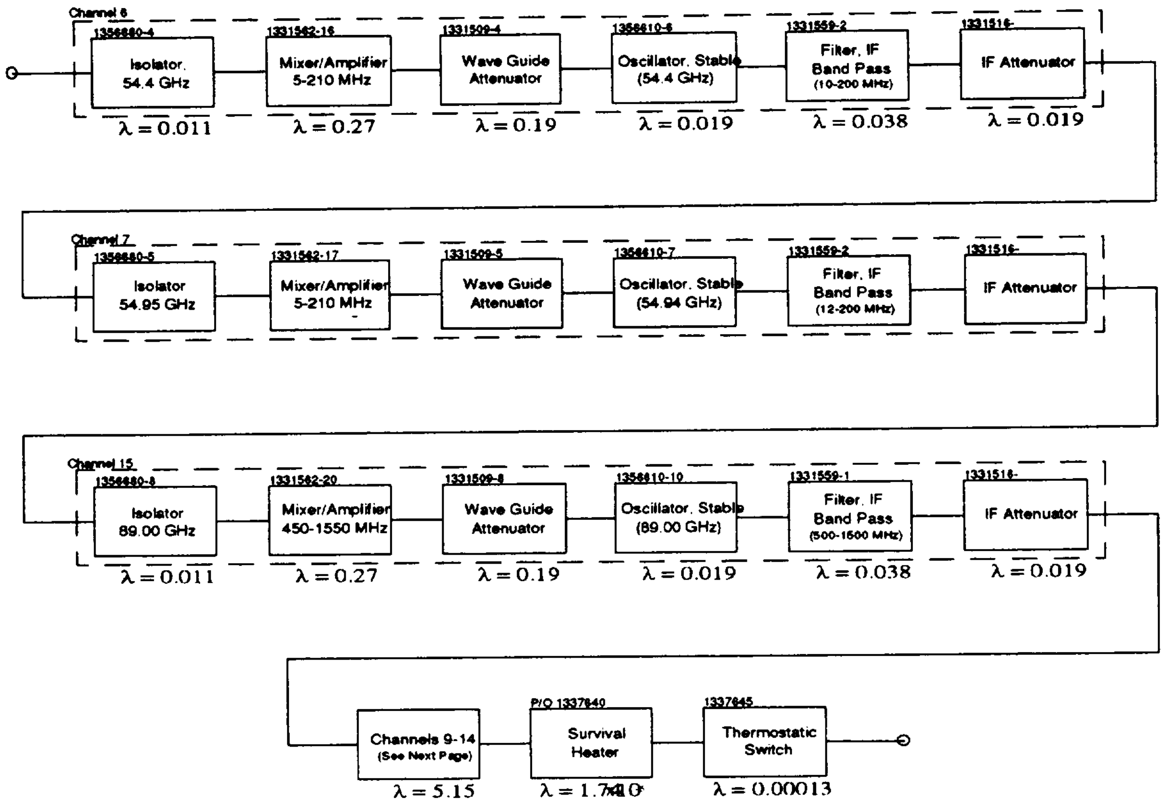

Figure 5 A1-1 Receiver Subsystem Reliability Block Diagram

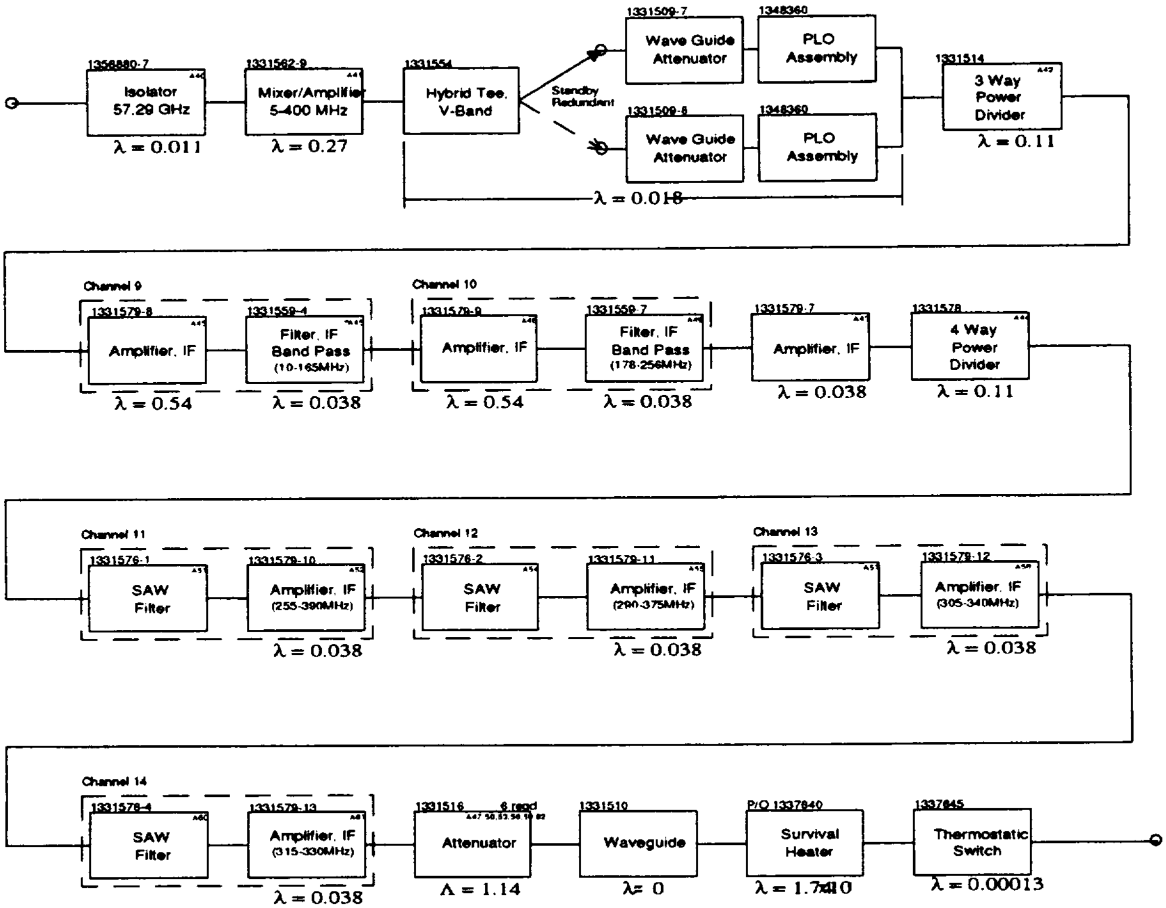

Figure 6 **A1-1 Receiver Subsystem (Channels 9-14) Reliability Block Diagram**

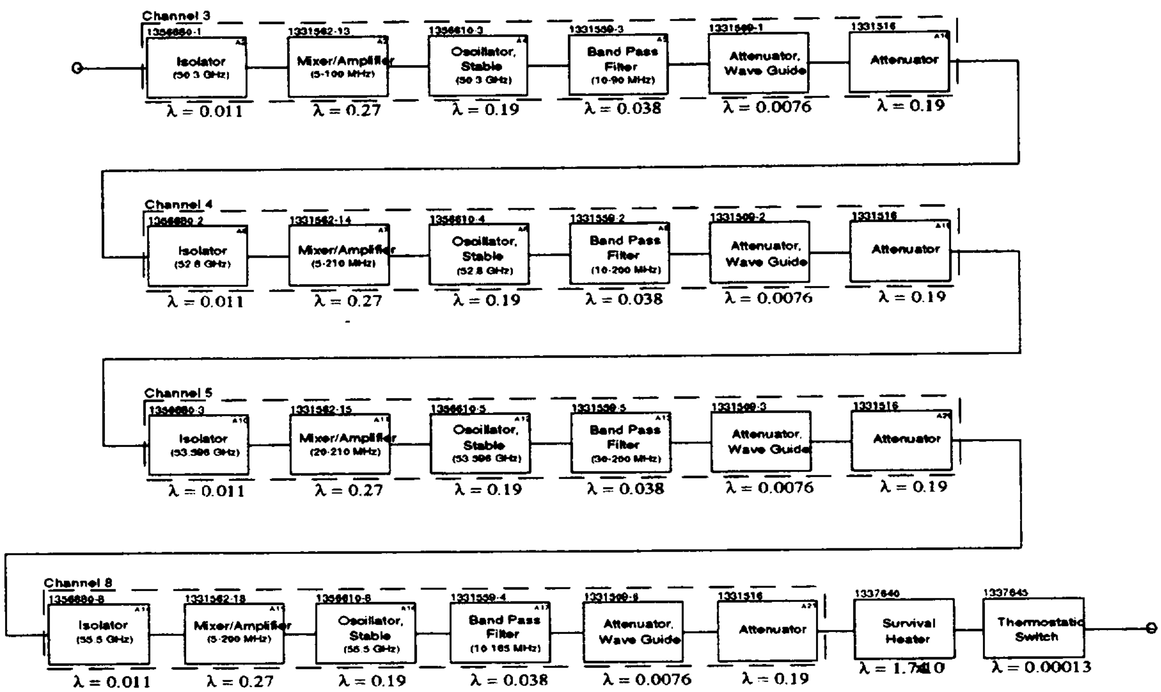

Figure 7 A1-2 Receiver Subsystem Reliability Block Diagram

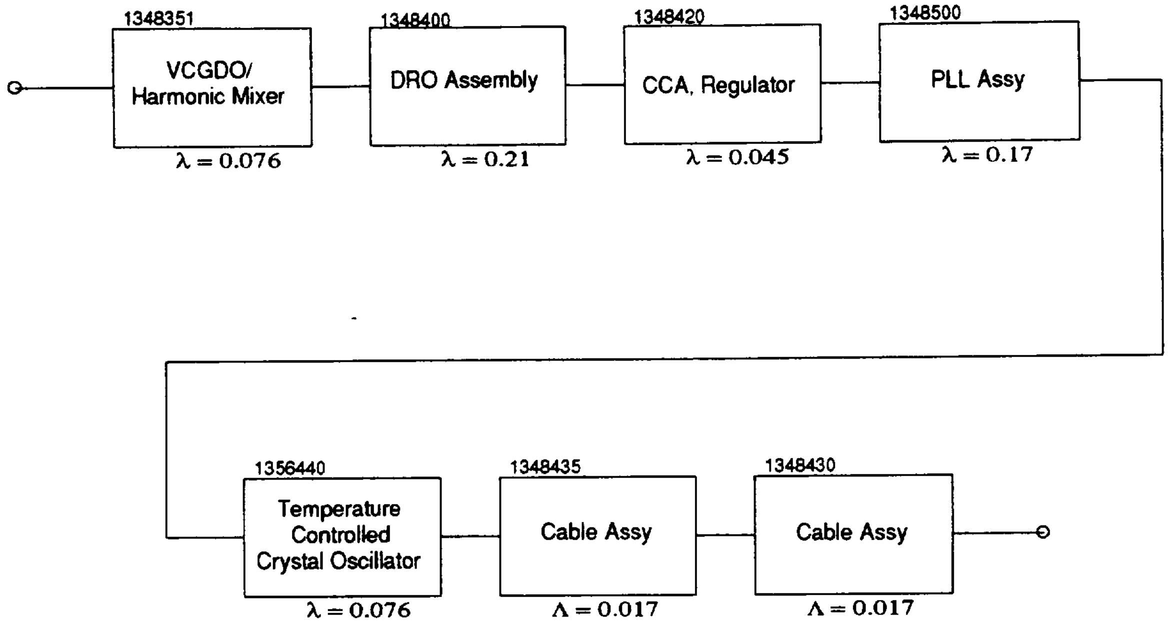

Figure 8 PLO Reliability Block Diagram

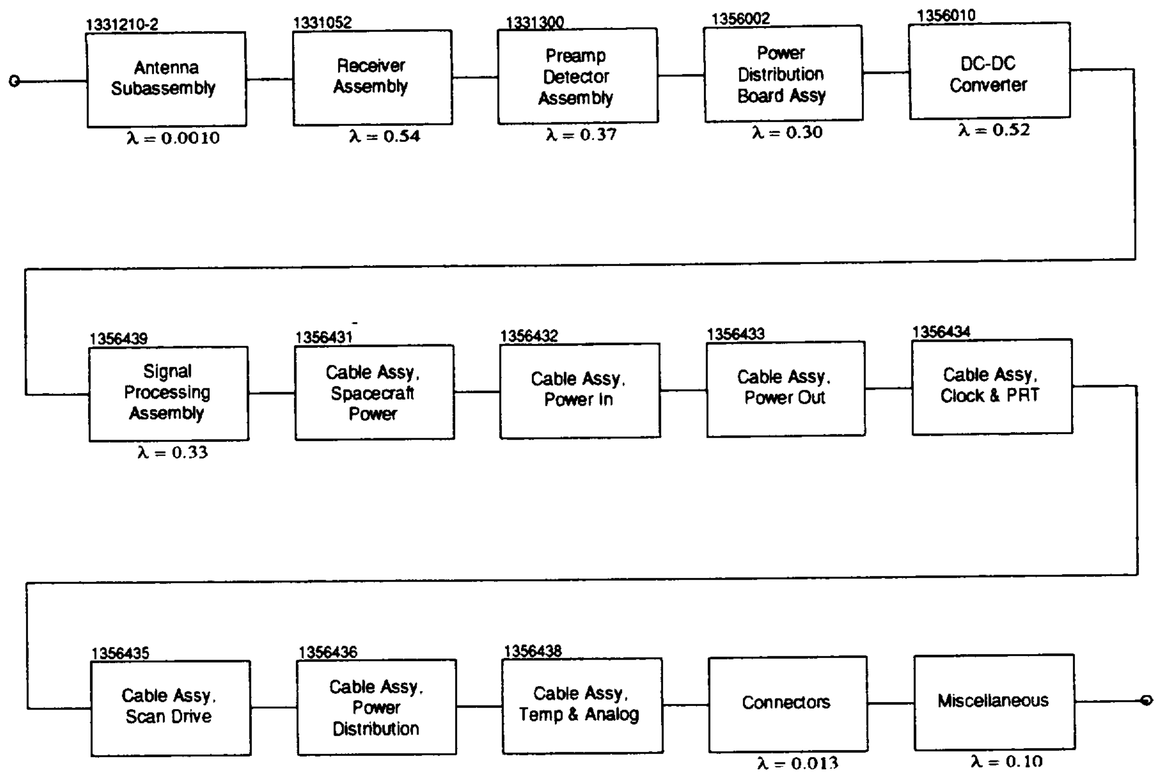

Figure 9 EOS/AMSU-A2 Module Top Level Reliability Block Diagram

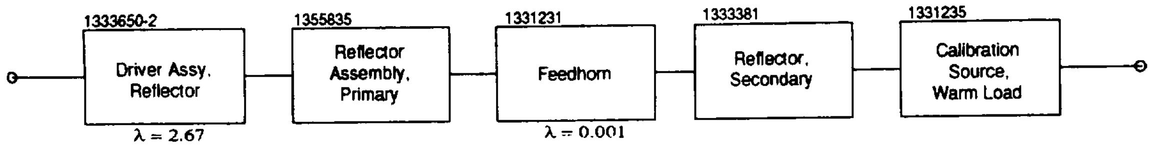

Figure 10 A2 Antenna Subsystem Reliability Block Diagram

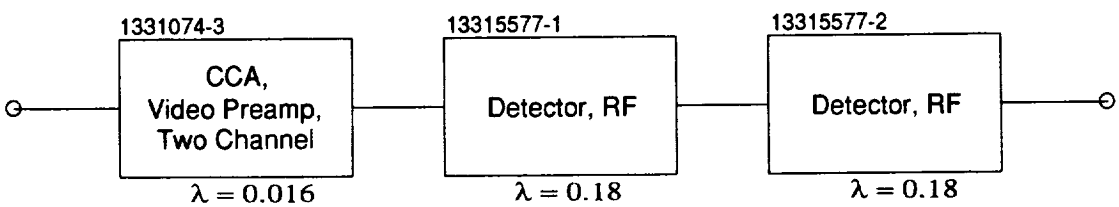

Figure 11 A2 Preamp/Detector Subsystem Reliability Block Diagram

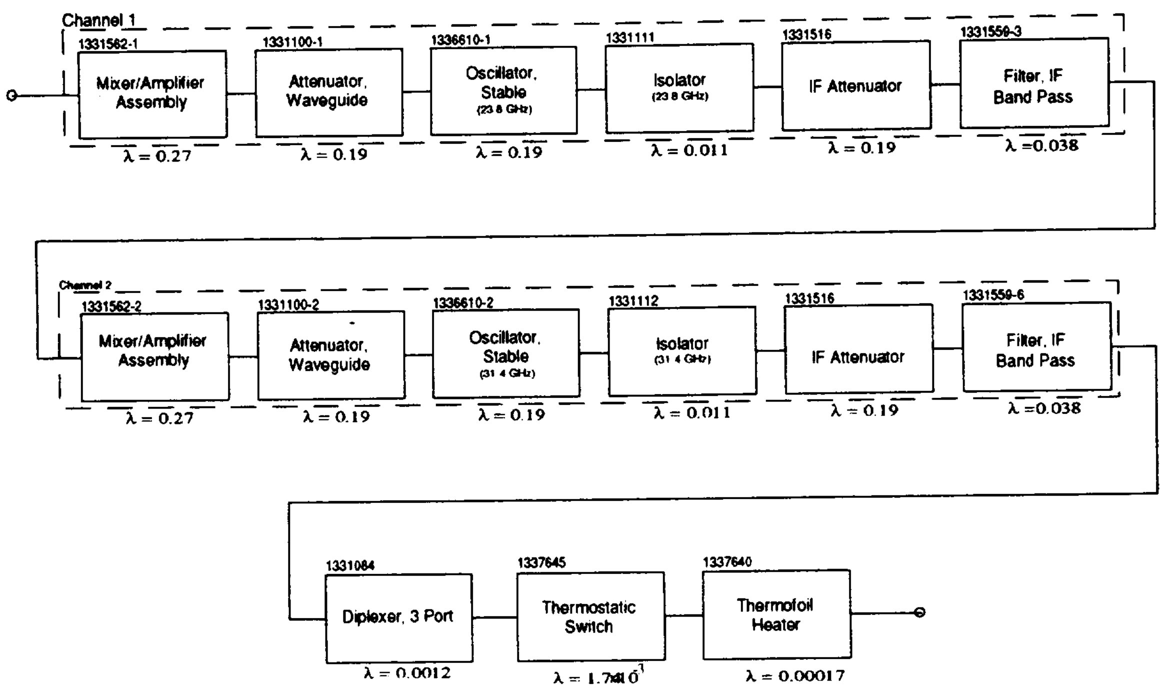

Figure 12 A2 Receiver Subsystem Reliability Block Diagram

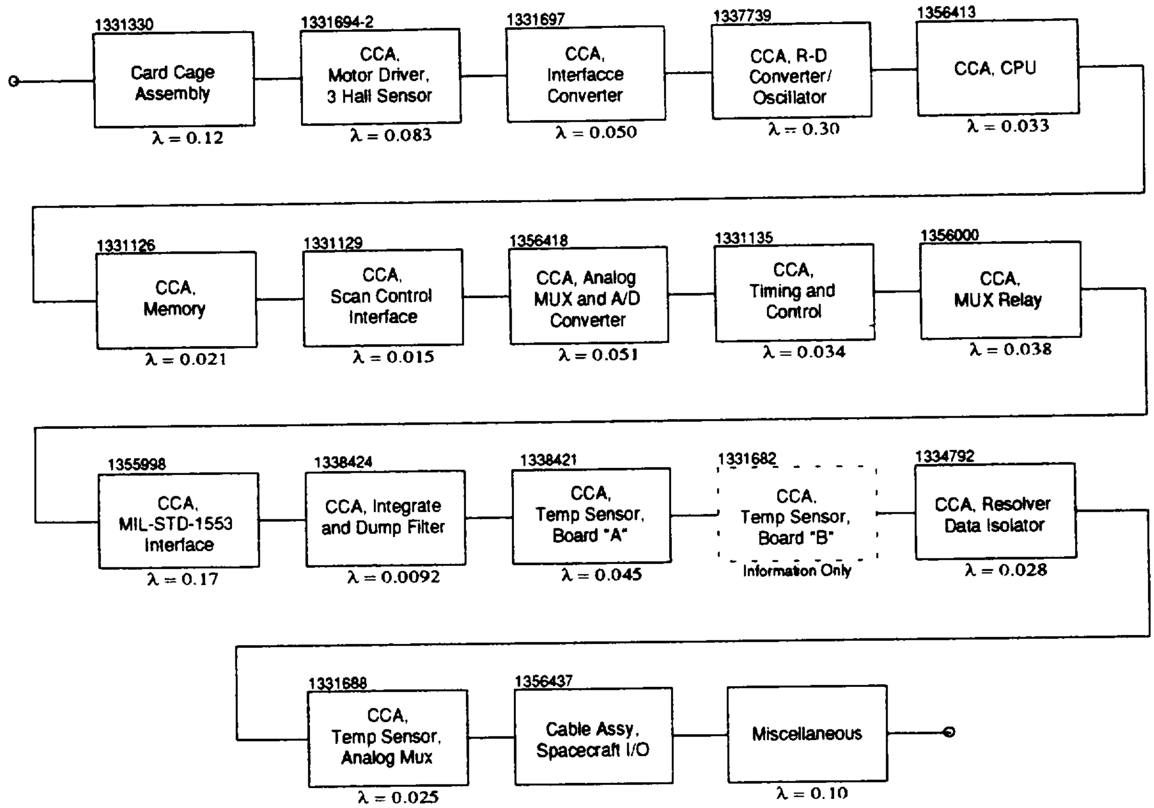

Figure 13 A2 Signal Processing-Microcomputer Subsystem Reliability Block Diagram

Section 7

EOS/AMSU-A FUNCTIONAL DESCRIPTION

7.1 Introduction

The EOS/AMSU-A is a multichannel microwave radiometer that will be used for measuring global atmospheric temperature profiles from the EOS-A platform spacecraft.

The EOS/AMSU-A is a line-scan microwave sensor designed to measure scene radiance in 15 channels to permit the calculation of the vertical temperature profile from the surface of the Earth to approximately the 3 millibar pressure height.

The ability of passive microwave sensors to operate in the presence of clouds is the essence of their effectiveness, and has led to their development for this EOS/AMSU-A instrument.

The EOS/AMSU-A has two separate modules, A1 and A2. The two lowest frequencies (Channels 1 and 2) are processed in the A2 module, and the remaining 13 frequencies (Channels 3 through 15) are processed in the A1 module. The lower-frequency antenna, for the A2 module, is about 11 inches in width. The A1 module uses two smaller antennas, each about 5 inches in width.

The basic operation of the two modules is very similar. They use the same approach and techniques to perform their function, and have many identical subassemblies, circuit card assemblies (CCA), and other items.

The modules are configured in the same fashion. Each consists of three major subassemblies: (a) antenna/drive/calibration subassembly, (b) electronics subassembly (receiver and signal processor), and (c) mechanical/structural subassembly. In each, the basic design of each subassembly is the same, differing only as a result of the specific frequencies.

EOS/AMSU-A1, the 13-channel module, has two separate and independent antenna/calibration subassemblies and electronic subassemblies that are integrated with a single common mechanical/structural subassembly and thermal subassembly.

The two-channel EOS/AMSU-A2 has only one antenna drive subsystem.

7.2 *Antenna*

The antenna step-scans cross-track over the Earth scene with a dwell of 165 milliseconds (msec) for the A1 module and 158 msec for the A2 at each of 30 Earth-viewing angles and a 370 msec dwell at the cold- and warm-calibration angles. Each antenna remains at a viewing scene for 200 msec. The antenna is stepped rapidly, so there is a complete rotation of the antenna in 8 seconds. During each rotation of the antennas, the modules are calibrated with a cold reference by a view of the 3K cosmic background and with a warm reference by a view of independent ambient radio frequency (RF) targets at a nominal 300K temperature.

Each antenna receives the antenna command signal at the start of 30 Earth-viewing scenes, so the antennas operate on the same scene throughout each rotation.

Each antenna subassembly is configured with a shrouded parabolic reflector assembly that is fed by a wideband conical horn to provide a symmetrical beam and high-beam efficiency. A closed-path calibration system provides a completely guided path to the calibration source, eliminating extraneous signals.

7.3 *Receiver*

Within the electronics subassembly are the radiometer receiver and the signal processor. To minimize the system temperature sensitivity, total-power, superheterodyne receivers are utilized. A combination of Dielectric Resonant Oscillators, Gunn diode oscillators and phase-locked oscillators are used to provide frequency stability in channels 9 through 14.

These oscillators feed mixers which translate RF to intermediate frequencies (IF). Predetection gain and passband characteristics are defined by IF amplifiers in conjunction with bandpass filters.

Compensated IF amplifier gain is selected to provide a predictable power level to each square law detector. Symmetric passbands in Channels 11 through 14 are established in the megahertz (MHz) frequency region to generate the required RF signal spectra. The dual-summed filter provides a $\sqrt{2}$ sensitivity improvement in these channels. For Channels 11 through 14, surface acoustic wave filters provide sharp skirts and center frequency stability. The planar diode square law detectors feed an integrator to convert receiver output power to a DC voltage proportional to temperature.

7.4 *Data Processing, Multiplexing*

Signal processor subsystems provide radiometric temperature from the square law detectors, thermometric temperature, and housekeeping data to the spacecraft system. The subsystems also provide command processing and control timing for all periodic functions of the instruments.

DC-coupled video amplifiers, are contained in the same shielded enclosure as the square law detectors, amplify low-level outputs from the detectors to levels sufficient for subsequent processing. Following amplification, an offset voltage is added to the signals to optimize the system transfer characteristic. Integrate-and-dump (I&D) filter circuits integrate the signals during each scan step, hold the integrated levels for digitization, and return the stored charge to zero prior to the next scan step.

Signals from the I&D filters are multiplexed prior to digitization in the A/D converter. During calibration periods the multiplexer samples outputs from onboard temperature sensors.

The digitized signals are then directed to the serial converter by the CPU.

The A/D converter range accommodates long-term channels gain variations, and the resolution keeps digitization noise components within system DT budgets.

7.5 *Central Processing Unit* (CPU) and Control (Microcomputer)

All processing, clock, command, and telemetry functions of the EOS/AMSU units are controlled within the signal processing section of the electronic subassembly by a space-qualified microprocessor.

The microprocessor-based CPU controls all data operations within the radiometer processing subsystem. During each scene segment scanned by the antenna, digitized scene brightness temperature and antenna position data are reported to the CPU. The CPU/Digital Processing Subsystem consists of seven circuit card assemblies:

a. CPU
b. Memory
c. Scan control interface
d. Timing and control
e. Parallel-to-serial converter
f. Analog Telemetry Interface Card
g. Redundant MIL-STD-1553 Interface Card

The EOS/AMSU CPU and the spacecraft operate asynchronously, and a register is employed at the output of the parallel-to-serial converter for temporary storage of data prior to retrieval by the spacecraft.

The data for a single eight-second scan is contained in a subframe. Each subframe consists of 1112 bytes for the A1 module and 245 bytes for the A2, each eight bits wide. It represents one antenna revolution (scan), and contains scene brightness temperatures, calibration brightness temperatures, reflector position data, and a scan identification.

The spacecraft provides a timing pulse for scan synchronization by the instrument and polls the instrument for the latest science and engineering data each scam during normal operation.

To control the antenna, the CPU uses position data from the memory and routes an address signal (position command) through the scan control interface to the motor control circuit(s). Feedback of the antenna position is provided by a precision resolver. Its outputs are opto-isolated and then digitized by the R/D Converter CCA. The CPU compares the commanded versus the actual position of the antenna, and supplies correction signals as necessary.

The two spacecraft interface CCA provide data and command avenues between the spacecraft and the EOS/AMSU. They receive control signals, decode them to provide operating mode commands, and condition temperature and other instrument parameters monitored by the spacecraft. A special interface for Ground Support Equipment is also provided.

The microprocessor and other CMOS logic operates at +5Vdc to minimize power consumption, and has response sufficient to complete all data control requirements with considerable time margin.

7.5.1 *Clock and Command*

The microcomputer controls: analog multiplexer selection; integrate, hold, and dump intervals; digitization and reflector stepping functions. The CPU operates from its own 1.248 MHz clock.

The module power commands, through the interface CCA, control the instrument turn-on as well as the power to each antenna scan subsystem.

7.5.2 *Test Points and Telemetry*

Both instruments provide test points and analog telemetry outputs. Test points monitor selected signals for assistance in instrument integration and test, in addition to expediting fault isolation. Calibrated analog telemetry outputs provide a monitor of all supply voltages and scan motor current.

7.5.3 *Temperature Monitoring*

Throughout the instrument, resistive temperature sensors provide temperature status to the spacecraft. Additional platinum resistor temperature (PRT) sensors provide accurate measurement of the warm load temperatures.

A subset of temperature transducers is located at critical locations within each module. The transducers are powered from the spacecraft, and the data are fed out on a separate external connector. They have no electrical interface with the rest of the instrument, and they are isolated.

7.6 *DC/DC Converter and Control*

From the +28-volt spacecraft primary power buss, EOS/AMSU power systems provide regulated voltages to receiver and radiometer processor subsystems.

A single DC/DC converter in each unit isolates receiver and radiometer processor voltages from the 28-volt quiet busses supplied by the spacecraft. The 28-volt converter input is selected by latching relays in Power Control and Monitoring CCA. The DC/DC converter provides the various regulated outputs required by the receiver and signal processing circuits.

In absence of the clock signal, the converter oscillator will run asynchronously. Input diodes protect the converter from polarity reversal damage. Output voltage regulation is maintained for main power buss input voltages of +24 to +35 volts plus a 3-volt peak-to-peak ripple.

Scan motors operate from the noisy +28-volt buss. Power to the scan motors is selected from one of the two redundant power supplies by means of latching relays on the Power Control and Monitoring CCA. Instrument commanded switching further controls the power to the scan drive motor.

Current in the pulse buss is continually monitored and averaged. All events from the DC/DC Converter are also monitored and reported to the through the engineering data set.

Appendix A

EOS/AMSU-A

FAILURE RATE DATA

The Millimeter Wave Subsystem Reliability/Failure Rate Tabulations

and the Detector/Preamp Failure Rate Data

Environment: SF Temperature: 30°C

		Ref/Qty		Failure Rate			% Assembly	
Part Number	Description	A1	A2	Unit	A1	A2	A1	A2
1331074-1	CCA, 2-Channel Video Preamp	1		0.01163	0.0116		4.7	
1331074-2	CCA, 2-Channel Video Preamp	1		0.01163	0.0116		4.7	
1331074-3	CCA, 2-Channel Video Preamp		1	0.01166		0.0117		26.9
1331157	CCA, 3-Channel Video Preamp	3		0.01452	0.0436		17.4	
1331577-1	Detector, RF (AE-24694E)	13	1	0.01409	0.1831	0.0141	73.3	32.5
1331577-2	Detector, RF (AE-24694E)		1	0.01765		0.0176		40.7

A1 Module: 0.24994

A2 Module: 0.04339

The Phase-Locked Oscillator Assembly Failure Rate

Environment: SF Temperatu 30°C

Part Number	Description	Ref/Qty	Failure Rate	Reliability	% Assembly
1348351-1	VCGDO/Harmonic Mixer	1	0.07618	0.998	10.65
1348400-1	DRO Assembly	1	0.23748	--	33.21
1348420-1	Regulator CCA	1	0.04359	--	6.09
1348500-1	PLL Assembly	1	0.16956	--	23.71
1348325-1	TCXO	1	0.07410	0.99805	10.36

				Source	% Assembly
1348430-1	Cable Assembly, RF	1	0.00564	Mil-217F	0.79
1348430-2	Cable Assembly, RF	1	0.00564		0.79
1348430-3	Cable Assembly, RF	1	0.00564		0.79
1348435-1	Cable Assembly, RF	1	0.00564		0.79
1348435-2	Cable Assembly, RF	1	0.00564		0.79
1348435-3	Cable Assembly, RF	1	0.00564	Mil-217F	0.79

			Failure Rate			
Part Number	Description	Ref/Qty	Total	Unit	Source	% Assembly
1007-7985-00	Connector	1	0.02500	0.025	NPRD-91	3.50
M28861/06-002SB	Feedthru	6	0.00321	0.0005	Mil-217	0.45
1084-1100-02	Connector	1	0.02500	0.025	NPRD-91	3.50
RER60F10R0R	Resistor,10-ohm, 5W	1	0.02722	0.02722	Mil-217	3.81

Total Failure Rate: 0.7152

Part Number: 1348360

PLO Assembly

PLO.XLS
12/13/95

Note: RF cable with two RF Connectors.

lp = lb pK pP pE

lb = .431exp{[-2073.6/(T+273)] + [(T+273)/423]^4.66}
pK = 1.0 (Mate/Unmate <= 0.05 cycles/1000 hrs)
pP = exp[{(N-1)/10}^0.51064]   (N=2)
= 1.361
pE = 0.50 (Mil-Spec, Space Flight)

Each with two soldered connections.

lp = lb pQ pE

lb = 0.0026 (Hand Solder w/o Wrap)
pQ = 1.0 (All Except Crimp)
pE = 0.50 (Space Flight)

lP2 = 4lp = 4(0.0026)1.0(0.50)
= 0.0052

Note: Resistor, Fixed, Wirewound, Power, Chassis Mounted, Inductively Wound

lp = lb pR pQ pE

lb = .00015 exp(2.64(T+273)/298) x exp(S/.466((T+273)/273))
pR = 1.0
pQ (R level) = 0.10
pE (SF) = 0.50

Part Number: 1348360

Environment: SF Temperature: 30°C

Part Number	Description	Ref/Qty	Failure Rate Total	Failure Rate Unit
1331126	Memory	1	0.01542	0.01542
1331129	Scan Control Interface	1	0.00731	0.00731
1331135	Timing and Control	1	0.02884	0.02884
1331688	Temp Sensor Analog Mux	1	0.00914	0.00914
1331694	Motor Driver	2	0.07728	0.03864
1331697	Interface Converter	2	0.06984	0.03492
1334972	Resolver Data Isolator	2	0.03431	0.01716
1337739	R-D Converter/Oscillator	2	0.16664	0.08332
1338421	Temp Sensor "A" Assy	1	0.03278	0.03278
1338424	Integrate and Dump Filter	4	0.05075	0.01269
1355998	MIL-STD-1553B Interface	1	0.15342	0.15342
1356000	Mux/Relay	1	0.02586	0.02586
1356002	Power Control/Monitor	1	0.28827	0.28827
1356413	CPU	1	0.02334	0.02334
1356418	Analog Mux and A-to-D Converter	1	0.03684	0.03684
W1	Power Input Cable	1	0.04413	0.04413
W2	Power Out / Command Cable	1	0.08909	0.08909
W3	Scan Drive Cable	1	0.09363	0.09363
W4	Spacecraft Interface Cable	1	0.09309	0.09309
W5	Analog Temp / PRT Cable	1	0.24859	0.24859

The Signal Processing Subsystem Failure Rate Data

Appendix B

Standby Redundancy Calculation for the Hybrid Tee/PLO System

Standby Redundancy Calculation for the Hybrid Tee/PLO System

The PLO/Hybrid Tee subsystem operates in a standby redundant arrangement which connects the standby PLO Assembly to the Mixer/IF amplifier used for Channels 9 through 14. The system life X may be represented as the sum of the subsystem lives, $X = X_1 + X_2$.

$$F(x) = 1 - \sum \frac{e^{-\lambda x}(\lambda x)^k}{k!}$$

The probability that the system will operate at least x hours is denoted by R(x), the reliability function for the PLO assembly alone is:

$$\begin{aligned} R(x) &= 1 - F(x) \\ &= \sum_{k-0}^{1} e^{-\lambda x}(\lambda x)^k / k! \\ &= e^{-\lambda x}(1 + \lambda x) \\ &= e^{-[0.6953\times10^{-6}(26,280)}[1 + 0.6953\times10^{-6}(26,280)] \\ &= 0.9998 \end{aligned}$$

Factoring in the Hybrid Tee we get

$$\begin{aligned} R_{TEE}R_{PLO} &= 0.9997(0.9998) \\ &= 0.9995 \end{aligned}$$

for the redundant PLO/Hybrid Tee system.

Which results in a PLO/Hybrid Tee System failure rate (l) of:

$$\begin{aligned} \lambda_{SYS} &= \frac{-\ell n(R_{SYS})}{t} \\ &= \frac{-\ell n(0.9995)}{26{,}280 hrs} \\ &= 17.69\times10^{-3} \text{ failures per million hours.} \end{aligned}$$

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