Fierheller Engineering
Corporation

2841 Saturn St Ste L
Brea, CA 92821

HSO/PLANCK

SPIRE Project

SPIRE-JPL-PRJ-001120

Failure Mode Effects and Criticality Analysis (FMECA)

PRELIMINARY REPORT

Analyst: Ernest Fierheller, PE

Tel: (714) 572-1180 • Fax: (714) 572-1182 • www.Fierheller.com

Introduction

This analysis was conducted on selected active and passive components. Circuit models were reviewed and hand calculations were used to verify operating conditions. The SPIRE System uses multiple bolometric detector arrays that are optically coupled through a feed horn. The bolometers operate at approximately 300m°K to detect infrared signals from 100 GHz to 857 GHz. Each bolometer output has a differential amplifier in the JFET Module that is self-heated to a temperature of approximately 120°K.

References/Attachments:

1. JPL D-5703: Reliability Analysis Handbook, July, 1990
2. JPL D-8545: JPL Derating Guidelines, Rev. B, Feb 1999
3. SPIRE-JPL-PRJ-000456, SPIRE Detector Subsystem Specification document, Rev 1.1, 4/17/01
4. 10209725, Wiring Schematic, Single Chain, SPIRE, Rev X1, 5/13/01
5. Verbal information from Jamie Bock, SPIRE Project Meeting, 5/31/01
6. S-52424, U401 Series Monolithic N-channel JFET Dual, Siliconix, Rev E, 4/14/97
7. VFM41R Series, Surface Mount EMI Filters, Chip Filters, muRata Manufacturer's Data Sheet

Assumptions:

1. This analysis was based upon review of the schematics, the performance specification and related documentation (Assembly Drawings and Manufacturer's data sheets, etc.) noted in the reference list.
2. This analysis assumed a board temperature from -272°C operating to 45°C in bake-out.
3. Duplicate circuits were not specifically analyzed, but were evaluated by similarity.
4. The analysis format and PASS/FAIL criteria were based on References 1 and 2 guidelines, respectively.

Analysis Brief

This analysis focused on the Bolometers and JFETs and their respective interface circuits to determine the failure modes effects and criticality in each circuit application. The Bolometers and JFETs are used in separate circuits.

Bolometer

The Bolometer is a custom-made neutron transmutated doped (NTD) Germanium element operated at cryogenic temperatures (below 1°K). The Bolometers are used in an array to detect photons by changing its resistance caused by changing temperature of the element. The Bolometer has a nominal resistance of 5MΩ at 300m°K. The interface circuit is shown in figure 1 below.

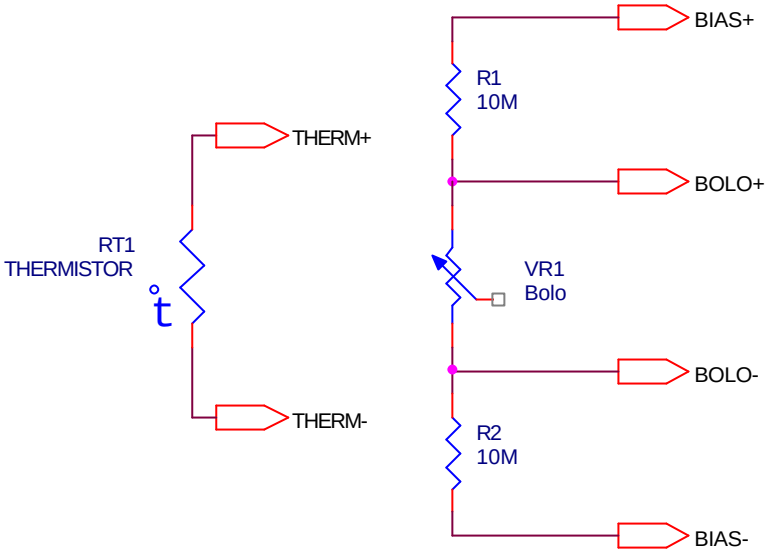

Figure 1: Bolometer Interface Circuit

Resistors

The bolometer and series resistors have the same failure mode, that is, open. An open of any of these elements would result in loss of signal and degraded data. This failure would be detected during the calibration cycle.

JFET: The JFET used is a U401; the interface circuit is shown in figure 2 below.

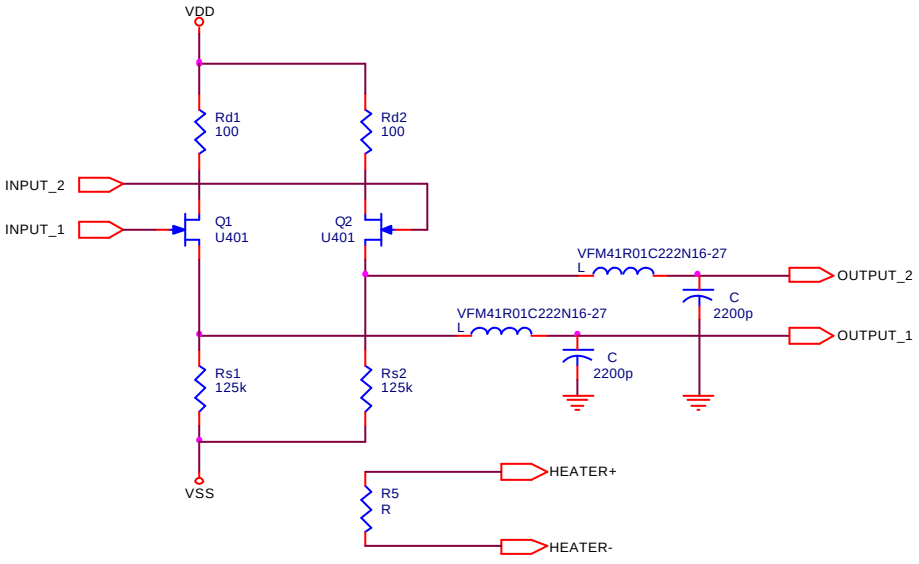

Figure 2: JFET Interface Circuit

Power Supply

The JFET has a dc bias source located in the Warm Electronics (120°K) Unit. Each voltage can fail open or shorted. If Vdd is open or shorted the amplifier will not have any output voltage. This condition may be detected during calibration; although it may not be distinguished from the bolometer failure noted above.

If Vss is open, the amplifier has no return to ground and will have no output voltage. If Vss is shorted, the amplifier will operate in a normal condition. This failure may not be detected and will result in loss of redundancy of the heater circuit.

Resistors

The heater and bias resistors have the same failure mode, that is, open. An open of any of these elements would result in loss of signal and degraded data. This failure would be detected during the calibration cycle.

JFET: three failure conditions

Shorted drain-source results in loss of signal and is detected during calibration.

Shorted gate-source results in loss of signal and is detected during calibration.

Open circuit, gate, drain or source results in loss of signal and is detected during calibration.

Filter

If the filter inductor is open, there is loss of signal on one side and the signal is degraded. This may be detected in calibration.

If the filter capacitor is open, the signal is degraded and may not be detected. If the filter capacitor is shorted, this results in loss of signal and is detected during calibration.

Summary

Item	Failure Mode	Failure Effect	Probability/ Criticality	Failure Mode Detection	Remarks
Bolometer					
Resistors	OPEN	Loss of Signal	Loss of function	No response in calibration	
JFET					
Power Supply					
Vdd	OPEN SHORTED	Loss of Signal Loss of Signal	Loss of function Loss of function	No response in calibration	
Vss	OPEN SHORTED	Loss of Signal Normal Signal	Loss of function Loss of redundant heater	No response in calibration None	
Resistors, heater and bias	OPEN	Loss of Signal	Loss of function	No response in calibration	
JFET	SHORTED drain-source SHORTED gate-	Loss of Signal	Loss of function	No response in calibration No response in	

Item	Failure Mode	Failure Effect	Probability/ Criticality	Failure Mode Detection	Remarks
	source OPEN gate, drain or source	Loss of Signal Loss of Signal	Loss of function Loss of function	calibration No response in calibration	
Filter					
Inductor	OPEN	Loss of Signal	Degraded Measurement	No response in calibration	
Capacitor	OPEN SHORTED	Normal Signal Loss of Signal	Increased Noise Loss of function	None No response in calibration	

Conclusion

There were no major discrepancies found in this FMECA assessment. Full acceptance is recommended for this FMECA in its present form.