Space Mission Partner

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Reliability Prediction of EEE Parts for Space Application using FIDES and MIL-HDBK-217 and HIREC's Future Approach to FIDES Reliability Analysis Services

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*Miyuki Miyaoka, Ayaka Hamada and Tae Mochizuki
HIREC Corporation, Japan

1. Reliability Prediction of EEE Parts for Space Application using FIDES and MIL-HDBK-217

2. HIREC's Approach to FIDES Reliability Analysis Services

Background

In Japan, MIL-HDBK-217 is used as major reliability prediction method for EEE parts onboard spacecraft – But MIL-HDBK-217 has not been updated since 1995.

In order to examine the advantages of FIDES, the failure rate calculation results of EEE parts for space application using FIDES and MIL-HDBK-217 were compared and considered here.

EEE Parts Considered

Type	Parts Considered
Diodes	Zener diode, Schottky diode and Switching diode
Transistors	Low noise transistor, Power MOSFET and Bipolar transistor
Resistors	Film resistor, Wire wound resistor and Network resistor
Optoelectronics	Photodiode optocoupler and Phototransistor optocoupler
Analog ICs	Operational amplifier, A/D converter, D/A converter and Comparator
Digital ICs	Transceiver, SRAM and FPGA
Ceramic Capacitors	MLCC with defined and non-defined temperature coefficient
Tantalum Capacitors	Solid tantalum capacitor and Wet tantalum capacitor
Magnetic Components	Transformer and Inductor
Connectors	D-sub connector and Round connector

Assumptions for Calculations using FIDES (1)

- Failure rates were calculated according to FIDES Guide 2009 Edition A.
- Mission profile of an equipment of a geostationary satellite, defined in New Reliability Prediction Methodology for Space Applications (NRPM), was used.
- Values recommended by NRPM were used for following factors.
  - $\Pi_{application}$: 1.13 (launch, time to reach orbit and on-orbit phase)
  - $\Pi_{Ruggedising}$: 1.0 (suppliers in the space industry)

Assumptions for Calculations using FIDES (2)

- Considering prime contractor of space sector, process factor was determined as follows.
  - $\Pi_{Process}$: 1.484.
- Launch phase through the on-orbit phase was considered.
- FIDES ExperTool (compatible with FIDES Guide 2009 Edition A) was used as calculation tool.

Mission Profile Summary

			Temperature	Temperature cycling			
Phase name	ON/OFF	Calendar time	Reference temperature	Δt	Cycle duration	Number of cycles	Maximum temperature during cycling
Launch	ON	2h	15°C	0°C	2h	1	15°C
Time to reach orbit	ON	48h	15°C	10°C	24h	2	20°C
On-orbit	ON	131400h	25°C	5°C	24h	5475	27.5°C

			Humidity	Mechanical
Phase name	ON/OFF	Calendar time	Relative humidity	Random vibrations
Launch	ON	2h	70%RH	18Grms
Time to reach orbit	ON	48h	0%RH	0Grms
On-orbit	ON	131400h	0%RH	0Grms

Assumptions for Calculations using MIL-HDBK-217

- Failure rates were calculated according to MIL-HDBK-217F, Notice 2 (1995).
- Stress analysis method was used for calculation.
- "SF (Space, Flight)" was used as the environmental factor π_E.
- Only on-orbit operations were considered, since launch time was very short.
- "Class S" was used as the quality factor π_Q of EEE parts for space applications.

Failure Rate Calculation Results

Type	Number of Parts (Qty)	MIL-HDBK-217 (FIT)	FIDES (FIT)
Diodes	3	2.78	0.45
Transistors	3	25.70	0.44
Resistors	3	0.15	0.05
Optoelectronics	2	12.75	1.03
Analog ICs	4	35.41	3.88
Digital ICs	3	130.86	2.48
Ceramic capacitors	2	0.05	1.26
Tantalum capacitors	2	0.07	1.14
Magnetic components	2	12.81	0.01
Connectors	2	36.66	0.11
Total:	26	257.25	10.86

Summary of Calculation Results (1)

- The total failure rate using MIL-HDBK-217F (257.25FIT) was approximately 24 times the total failure rate using FIDES (10.86FIT).
  - The total failure rate using FIDES is considered to be closer to the actual value, since it is generally known that the failure rate using MIL-HDBK-217 is calculated to be approximately 10 to 100 times higher than the actual value.

Summary of Calculation Results (2)

- For ceramic capacitors, the failure rate using FIDES (1.26FIT) was approximately 25 times that using MIL-HDBK-217F (0.05FIT).
  - The failure rate using MIL-HDBK-217 is considered to be closer to the actual value, since there is field data showing a failure rate of 0.0122~0.130FIT for automotive MLCCs.

Summary of Calculation Results (3)

- For tantalum capacitors, the failure rate using FIDES (1.14FIT) was approximately 16 times that using MIL-HDBK-217F (0.07FIT).
  - The failure rate using MIL-HDBK-217 is considered to be closer to the actual value, since there is field data showing a failure rate of 0.0034FIT for industrial solid tantalum capacitors.

Further Study Plan

- **Failure rates calculation of EEE parts onboard LEO satellites, taking into account all phases from launch to mission completion.**

- **Reliability Prediction of COTS EEE parts onboard spacecraft.**

  - **COTS: Commercial-Off-The-Shelf**

1. Reliability Prediction of EEE Parts for Space Application using FIDES and MIL-HDBK-217

2. HIREC's Approach to FIDES Reliability Analysis Services

HIREC's Approach to FIDES Services(1)

- Currently coordinating with FIDES consortium to market the Japanese translation of the FIDES Guide 2023 in Japan.
- HIREC will offer following services to customers in Japan:
  - Reliability analysis services using FIDES.
  - FIDES reliability analysis training services.

HIREC's Approach to FIDES Services (2)

- In order to predict the reliability of COTS EEE parts onboard LEO spacecraft using FIDES, HIREC started joint research with a Japanese new space company.

Thank you!

Any questions / comments?
Please e-mail to:
m-miyaoka@hirec.co.jp