Kierunek Elektronika i Telekomunikacja,
Studia II stopnia

Specjalność: Systemy wbudowane

Praktyczne aspekty prognozowania niezawodności systemów elektronicznych

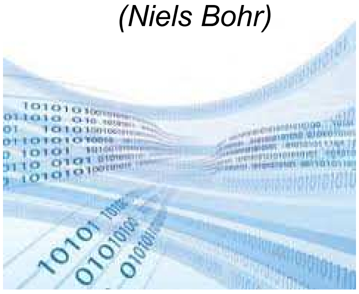
Program wykładu

- Cel wykładu/prezentacji
- Literatura
- Parametry niezawodności komponentów i modułów
- Przegląd metod prognozowania parametrów niezawodności systemów elektronicznych
- Kalkulatory MTBF
- Przykład analizy

Cel wykładu/prezentacji

„Prognozowanie jest trudne, zwłaszcza wtedy gdy dotyczy przyszłości”

(Niels Bohr)



Literatura

Zasoby Internetu
(wyszukiwarka Google 21.02.2018)
- **„niezawodność”** Około 2 200 000 wyników (0,42 s)
- **„reliability”** Około 167 000 000 wyników (0,44 s)

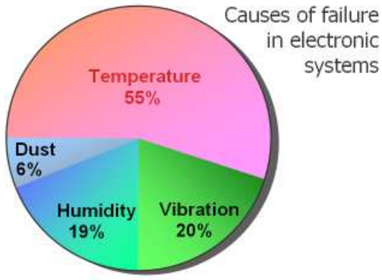
MIL-HDBK-217F-Notice2

FIDES guide 2009 Edition A September 2010 Reliability Methodology for Electronic Systems

•*Relaibility Guidelines to Understanding Reliability Prediction* Revision Date: 24 June 2005 EUROPEAN POWER SUPPLY MANUFACTURERS ASSOCIATION http://www.epsma.org/MTBF%20Report_24%20June%202005.pdf
•Norman B. Fuqua *Electronic Reliability Prediction Introduction* https://src.alionscience.com/pdf/pred.pdf
•Alion Systm Reliability Center https://src.alionscience.com/src/standards.do?action=search&name=General+Guidebooks%2FHandbooks&cats=2059
•Reliability in Electronics http://www.xppower.com/pdfs/Reliability.pdf
•http://reliawiki.org/index.php/Main_Page
•Eugene R. Hnatek *Practical Reliability of Electronic Equipment and Products*
•Mohamed Al-Kuwaiti,Nicholas Kyriakopoulos, and Sayed Hussein.A *Comparative Analysis of Network Dependability, Fault-tolerance, Reliability, Security, and Survivability*. IEEE Communications Surveys & Tutorials, 11(2):106–124, April/June 2009

Niezawodność systemów elektronicznych

Rozkład przyczyn uszkodzeń



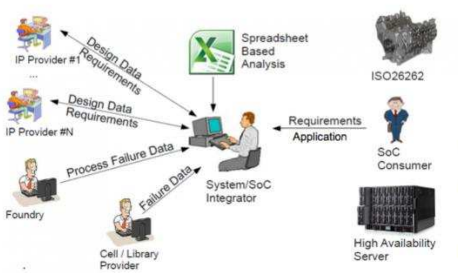
http://blogs.mentor.com/micred/blog/2010/11/16/how-thermal-testing-can-help-increase-reliability-of-electronic-systems/

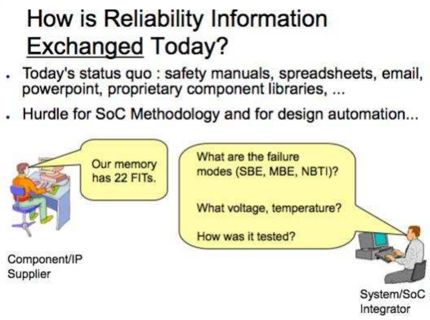
Niezawodność systemów elektronicznych

– bardzo szerokie zagadnienie, wiele uznawanych metodologii i różnych standardów

tekst

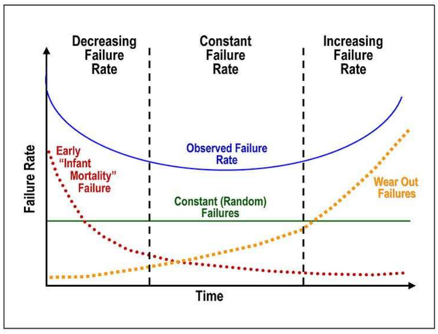
SoC Reliability Analysis – Status Quo

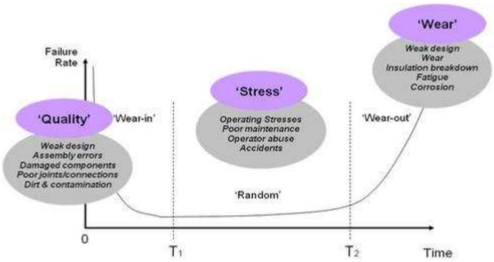




https://www.semiwiki.com/forum/content/2120-reliability-new-power.html

Krzywa wannowa – powszechna ale….





Quality	*Unrelated to stress*	*Eliminated by inspection process and Not time-dependent process improvements*
Reliability	*Stress-dependent*	*Eliminated by screening*
Wearout	*Time-dependent*	*Eliminated by replacement, part design, or new source*
Design	*May be stress- and/or time*	*Eliminated by proper application and dependent derating*

Niezawodność – miary …

MTBF

(ang. ***Mean Time Between Failures***)
– średni czas bezawaryjnej pracy, czyli okres wyrażony w godzinach, w którym urządzenie może działać bez przerwy (awarii).

MTTF

(ang. ***Mean Time to Failure***)
– średni czas bezawaryjnej pracy, czyli okres wyrażony w godzinach, w którym urządzenie może działać do przerwy (awarii) – podawany dla urządzeń które się nie naprawia.

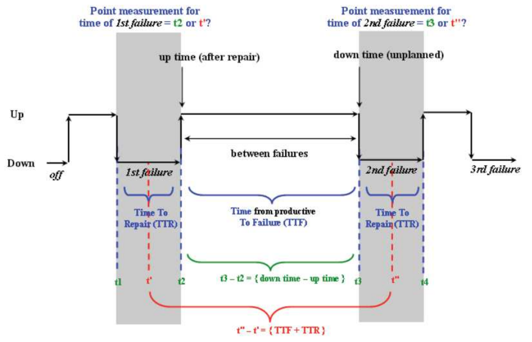
System Reliability Center
201 Mill Street
Rome, NY 13440-6916
888.722.8737
or 315.337.0900
Fax: 315.337.9932

Typical Equipment MTBF Values

Equipment Type	MTBF (Hours)
Communications Equipment	
Airborne Radio	500 - 10,000
Ground Jammer	500 - 2,000
Ground Radio	5,000 - 20,000
Portable Ground Radio	1,000 - 3,000
Ground Computer Equipment	
CD-ROM Drive	10,000 - 20,000
Clock	150,000 - 200,000
Color Display	5,000 - 10,000
Printer, Dot Matrix, Low Speed	2,000 - 4,000
Floppy Disk Drive	12,000 - 30,000
Hard Disk Drive	10,000 - 20,000
Printer, Impact, High Speed	3,000 - 12,000
Keyboard	30,000 - 60,000
Modem	20,000 - 30,000
Monochrome Display	10,000 - 15,000
Mouse	50,000 - 200,000
Personal Computer	1,000 - 5,000
Plotter	30,000 - 40,000
Tape Drive	7,500 - 12,000
Printer, Thermal	10,000 - 20,000
Workstation	2,000 - 5,000
Computer Controller	19,000 - 22,000
Switchgear (Insulated Bus)	240,000 - 2,500,000
Transformer, High Voltage	179,000 - 12,000,000
Uninterruptible Power Supply (UPS)	38,000 - 785,000
Radar Systems	
Airborne Fighter Fire Control Radar	50 - 200
Airborne Identification Radar	200 - 2,000
Airborne Navigation Radar	300 - 4,500
Airborne Search Radar	300 - 500
Ground Rotating Search Radar	100 - 200

Niezawodność – miary …

MTTF - MTTR - MTBF



Time Between Failures = Time between *1st failure* and *2nd failure*

= (time of *2nd failure*) – (time of *1st failure*)
= t3 – t2 ?
= t'' – t' ?

Availability = MTBF/(MTBF + MTTR)

Björn Franke University of Edinburgh Embedded Systems Lecture 9: Reliability & Fault Tolerance

Parametr MTBF – podawany bardzo często dla aplikacji przemysłowych

Cisco IE 3000 Switches

Mean time between failure (MTBF) hours

- Cisco IE-3000-4TC, Cisco IE-3000-4TC-E: 363,942
- Cisco IE-3000-8TC, Cisco IE-3000-8TC-E: 329,451
- Cisco IEM-3000-8TM=: 926,999
- Cisco IEM-3000-8FM=: 264,689
- Cisco PWR-IE50W-AC=: 1,662,359
- Cisco IEM-3000-4SM=: 8,887,990
- Cisco IEM-3000-8SM=: 7,732,890
- Cisco IEM-3000-4PC=: 1,494,990
- Cisco IEM-3000-4PC-4TC=: 1,291,440
- Cisco PWR-65W-PC-DC=: 2,468,430
- Cisco PWR-65W-PC-AC=: 2,488,401

ABB Model 266HRH high overload gauge pressure transmitter

……Thanks to the IEC61508 certification (SIL2/SIL3 loops) and the hardware/software redundancy with MTBF of over 100 years, the 266HRH represents the smartest solution in Safety loop applications.

Parametr MTBF
– dane prognozowane i rzeczywiste

Expected MTBF of Triorail TRC-5xx (8-Watt-GSM-R-Module)

The TRC-5 consists of 336 electronic components + 1 TRM-5 Module
For the TRM-5 under the following operation conditions:
14h/day IDLE @ 30°C component temperature 2h/day TALK @ 40°C 8h/day SLEEP @ 25°C

we calculated the following reliability figures based on our return statistics:

MTBF/fit: 344
MTBF/h: 2.906.977
MTBF/year: 331,8
Rate: 0,30%

The TRM-5 consists of 182 components similar to the 336 components on the TRC-3 main board.
Assuming similar mean failure rates $\lambda_p=\lambda_b\pi_T\,\pi_P\pi_S\pi_Q\pi_E$ of each component in both groups of components and taking the overall number of components (336+182=518) into consideration:

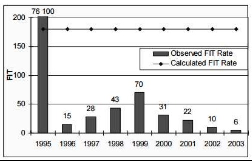
Leads to the following reliability figures of the TRC-5 module under the same operation conditions mentioned above:

MTBF/fit: 979
MTBF/h: 1.200.000
MTBF/year: 116,6
Rate: 0,86%

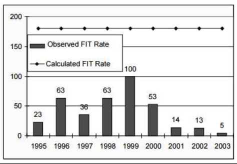
„Przyzwoite”
firmy podają wartości prognozowane i na podstawie danych serwisowych

Parametr MTBF
– dane prognozowane i rzeczywiste

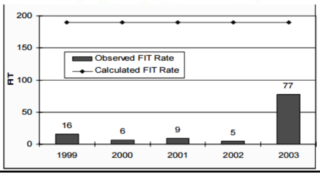
The high failure rate of **Product A**, Figure 5.1, below, during 1995 was due to one poor batch of one component. The whole batch was taken back and was registered as poor components. The failure rate for that year was calculated from a relatively small number (approx. 5k). For all other years the number of delivered units is higher than 150k.



Product C, **Figure 5.3** below, has been manufactured in more than 100k per year, except for 1995, where the numbers was 32k. The design has not changed, but during 2000 one component type was replaced by another type. However, they will both still have the same predicted failure rate as they have the same basic data and are from the same component category. The failure mode that was dominant during the years 1998-2000 has gradually disappeared as the weak population of the components of the old component has disappeared (the same change has been performed for all three modules in this study). This is an example of reliability growth.



Product B, Figure 5.2 below, has been manufactured in more than 500k each year. One can see that the failure rate is very low, though it has increased during 2003. Most of the failures during 2003 are “No failure found”, which illustrates another problem with failure reporting. There may be an intermittent failure in the product, or e.g. the customer has not been able to solder the product properly. Then, when the product is replaced with another, the circuit suddenly starts to work however the product is still considered to be faulty.



EUROPEAN POWER SUPPLY MANUFACTURERS ASSOCIATION
RELIABILITY Guidelines to Understanding Reliability Prediction Revision Date: 24 June 2005

„Metodyki projektowania i modelowania systemów” Cyganek & Kasperek & Rajda © 2018 Katedra Elektroniki AGH

MTBF – jak to się liczy? wyznacza?

$$MTBF = \frac{1}{\lambda}$$

MTBF – średni czas bezawaryjnej pracy **(ang. *Mean Time Between Failures*)**

λ – intensywność uszkodzeń **(ang. *Failure Rate*) (zwykle) jednostka FIT (ang. *Failure In Time*) 1 FIT = 1 uszkodzenie w 10^9 godzinach pracy**

$$R(t) = e^{-\lambda t} = e^{\frac{-t}{MTBF}}$$

R(t) – funkcja prawdopodobieństwa uszkodzenia (w czasie)

Właściwa interpretacja MTBF

- to nie jest gwarancja ☺
- dla dużej reprezentatywnej liczby danego produktu po czasie t=MTBF NIE ULEGNIE uszkodzeniu 37% z nich !
- dla pojedynczego produktu prawdopodobieństwo osiągnięcia czasu pracy=MTBF wynosi 37%
- Np. podanie marketingowej wartości MTBF = 500000 godzin 58 lat daje prawdopodobieństwo prawidłowego działanie po 10 latach 84%; jeżeli klient ma 700 takich urządzeń około 12 urządzeń będzie ulegało rocznie awarii

Techniki kontroli wpływające na niezawodność

A study of 72 non defense corporations revealed that the product reliability techniques they preferred and felt to be important were the following (listed in ranked order) (1):

- *Supplier control 76%*
- *Parts control 72%*
- *Failure analysis and corrective action 65%*
- *Environmental stress screening 55%*
- *Test, analyze, fix 50%*
- *Reliability qualification test 32%*
- *Design reviews 24%*
- *Failure modes, effects, and criticality analysis 20%*

Criscimagna NH. Benchmarking Commercial Reliability Practices. IITRI, 1997.

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Metody predykcji niezawodności

Reliability prediction describes the process used to estimate the constant failure rate during the useful life of a product. This however is not possible because predictions assume that:

- *The design is perfect, the stresses known, everything is within ratings at all times, so that only random failures occur*
- *Every failure of every part will cause the equipment to fail.*
- *The database is valid*

These assumptions are sometimes wrong. The design can be less than perfect, not every failure of every part will cause the equipment to fail, and the database is likely to be at least 15 years out-of-date. However, none of this matters much, if the predictions are used to compare different topologies or approaches rather than to establish an absolute figure for reliability. This is what predictions were originally designed for.

ANALIZA DAJĘ SZANSĘ NA PROWADZENIE PORÓWNAŃ NP. ARCHITEKTURY URZĄDZENIA LUB WYBORU PRODUCENTA KOMPONENTÓW

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Ocena (predykcja) niezawodności we wstępnej fazie projektu

Failure rate predictions are useful for several important activities in the design phase of electronic equipment in addition to many other important procedures to ensure reliability.

Examples of these activities are:

- *to assess whether reliability goals can be reached,*
- *to identify potential design weaknesses,*
- *to compare alternative designs,*
- *to evaluate designs and to analyse life-cycle costs,*
- *to provide data for system reliability and availability analysis,*
- *to plan logistic support strategies,*
- *to establish objectives for reliability tests.*

ANALIZA DAJĘ SZANSĘ NA UNIKNIĘCIE BŁĘDÓW PROJEKTOWYCH, WSKAZANIE STRATEGII TESTOWANIA URZĄDZENIA LOGISTYKI ITP.

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Założenia analitycznych metod predykcji niezawodności

Failure rate predictions are based on the following assumptions:

- *The prediction model uses a simple reliability series system of all components, in other words, a failure of any component is assumed to lead to a system failure.*
- *Component failure rates needed for the prediction are assumed to be constant for the time period considered. This is known to be realistic for electronic components after burn-in.*
- *Component failures are independent.*
- *No distinction is made between complete failures and drift failures*
- *Components are faultless and are used within their specifications.*
- *Design and manufacturing process of the item under consideration are faultless.*
- *Process weaknesses have been eliminated, or if not, screened by burn-in.*

Limitations of failure rate predictions are:

- *Provide only information whether reliability goals can be reached.*
- *Results are dependent on the trustworthiness of failure rate data.*
- *The assumption of constant component failure rates may not always be true. In such cases this method can lead to pessimistic results.*
- *Failure rate data may not exist for new component types.*
- *In general redundancies cannot be modelled.*
- *Other stresses as considered may predominate and influence the reliability.*
- *Improper design and process weaknesses can cause major deviations.*

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Założenia analitycznych metod predykcji niezawodności

Dla całego urządzenia zakładamy proste sumowanie dla wszystkich komponentów

$$\lambda_{Si} = \sum_{i=1}^{n} \left(\lambda_{ref}\right)_i$$

Skąd zdobyć λ_{ref} ? (referencyjną intensywność uszkodzeń)
albo z konkretnej bazy danych albo od producenta

Reference conditions include statements about

- *operating phase,*
- *failure criterion,*
- *operation mode (e.g. continuous, intermittent),*
- *climatic and mechanical stresses,*
- *electrical stresses.*

It is assumed that the failure rate used under reference conditions is specific to the component, i.e. it includes the effects of complexity, technology of the casing, different manufacturers and the manufacturing process etc. Data sources used should be the latest available that are applicable to the product and its specific use conditions. Ideally, as said before, failure rate data should be obtained from the field.

„Metodyki projektowania i modelowania systemów" Cyganek & Kasperek & Rajda © 2018 Katedra Elektroniki AGH

Przykład danych producenta Maxim Integrated

www.maximintegrated.com/qa/reliability/general/

Login Register English

maxim integrated.

Products Solutions Design Buy Support About Us My Maxim

Maxim > Quality Assurance and Reliability > Reliability Information > General Reliability Reports

- Quality Assurance and Reliability Overview
- Quality Policy
- Reliability Information
  - General Reliability Reports
  - Product Reliability Reports
  - Lead-Free Package Tin (Sn) Whisker Reports
  - Reliability Monitor Program
  - Maxim Device FIT Information
  - Product Change Notices
  - Maxim: Product Reliability Specification (10-3006) (PDF, 54kB)
- Failure Analysis

General Reliability Reports

Maxim Process Reliability Reports

PR-1 (PDF, 29kB)
In response to the increasing demand for plastic packaged products for use in critical applications, Maxim has developed a high-reliability screening flow for plastic encapsulated packages, including SOICs. Products screened to this flow can be used in high-reliability applications where hermetically sealed devices, screened to MIL-STD-833, may not be justified. SOICs with full burn-in and screening not only offer excellent reliability but also save valuable PC board space. This screening includes many of the requirements common to -883 devices, such as burn-in at +125°C and electrical screening at -55°C to +125°C.

RR-1G (PDF, 89kB)
Product reliability data for Maxim's analog products, separated into four groups: Standard Metal-Gate CMOS (SMG); Medium-Voltage Metal-Gate CMOS (MV); Silicon-Gate CMOS (SG); and bipolar (BIP) processes. For 1990 to 1992.

RR-1H (PDF, 134kB)
Product reliability data for Maxim's analog products, separated into six fabrication processes: (1) Standard Metal-Gate CMOS (SMG); (2) Medium-Voltage Metal-Gate CMOS (MV); (3) Medium-Voltage Silicon-Gate CMOS (MV2); (4) 3µm Silicon-Gate CMOS (SG3); (5) 5µm Silicon-Gate CMOS (SG5); and (6) Bipolar (BIP) processes. For January 1990 to January 1994.

Przykład danych producenta Maxim Integrated

Witryny Google | Maxim Device FIT Informa

www.maximintegrated.com/en/qa/reliability/fit.cfm?upn=MAX3232

By using this website, I accept the use of cookies. Learn

maxim integrated.

中文 | 日本語 Share MyBookmarks MyCart Search MyMaxim Login | Regi
Parametric Search

PRODUCTS
SOLUTIONS
DESIGN
ORDER
SUPPORT
ABOUT US

Maxim > Quality Assurance and Reliability > Reliability Information > Maxim Device FIT Information

MAXIM DEVICE FIT INFORMATION

Part: MAX3232 Go

Device	Fab Process	Technology	Sample Size	Rejects	FIT @25°C	FIT @55°C
MAX3232ECTE	B3	CMOS	5830	2	0.12	2.10
MAX3232ECTE+	B3	CMOS	5830	2	0.12	2.10
MAX3232ECUE+	B3	CMOS	5830	2	0.12	2.10
MAX3232EETE	B3	CMOS	5830	2	0.12	2.10
MAX3232EETE+	B3	CMOS	5830	2	0.12	2.10
MAX3232EETE+T	B3	CMOS	5830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10
[illegible]	[illegible]	[illegible]	830	2	0.12	2.10

Witryny Google | Maxim Device FIT Informa

www.maximintegrated.com/en/qa/reliability/fit.cfm

maxim integrated.

中文 | 日本語 Share

PRODUCTS
SOLUTIONS
DESIGN
ORDER
SUPPORT
ABOUT US

Maxim > Quality Assurance and Reliability > Reliability Information > Maxim Device FIT Inform

MAXIM DEVICE FIT INFORMATION

Part: Go

Przykład danych producenta Maxim Integrated

RR-1K

Product Reliability Report

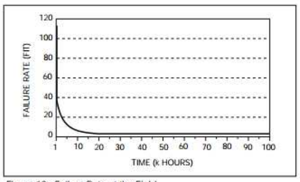


Figure 10. Failure Rate at the Field (55°C for Metal-Gate CMOS Process)

TABLE 3. LIFE TEST RESULT OF MAXIM PRODUCTS FOR EACH PROCESS
(Combined Test Conditions: 135°C and 1000 Hrs.)

PROCESS	SAMPLE SIZE	REJECTS	FIT@ 25°C	FIT@ 55°C
SMG	2250	0	0.09	1.59
MV1	385	0	0.54	9.23
MV2	467	0	0.45	7.68
SG3	1602	0	0.13	2.24
SG5	846	1	0.54	9.36
SG1.2	1618	2	0.28	4.89
BIP	1799	1	0.26	4.4
Total	8967	4	0.13	2.3

http://www.maximintegrated.com/qa/reliability/general/RR-1K.pdf

TABLE 4. LIFE TEST DATA SUMMARY

PRODUCT FAMILY	NUMBER OF LOTS	NUMBER OF FAILURES	TOTAL UNITS TESTED	DEGREE OF FREEDOM	X^2 60% VALUE	X^2 90% VALUE	FIT @ 25°C	
							60% CONF. LEVEL	90% CONF. LEVEL
Converters (Note 1)	73	11	5399	24	24.7	32.5	1.21	1.60
Linear (Note 2)	251	46	19,530	94	96.4	111.3	1.31	1.51
Timers/Counters/ Display Drivers	3	0	240	2	1.38	3.62	1 .52	4.0
Sum Total of All Product Lots	327	57	25,169	116	118.8	135.3	1.25	1.42

Note 1: *A/D Converters, D/A Converters*
Note 2: *Voltage References, Operational Amplifiers, Power-Supply Circuits, Interface, Filters, Analog Switches, and Multiplexers*

Założenia analitycznych metod predykcji niezawodności

Dla całego urządzenia pracującego w rzeczywistych warunkach proste sumowanie dla wszystkich komponentów uzupełniamy o tzw. czynniki przyspieszające

$$\lambda = \sum_{i=1}^{n} \left(\lambda_{ref} \times \pi_I \times \pi_U \times \pi_T \times \pi_? \times \pi_{??} \times .... \right)_i$$

gdzie

λ_{ref} referencyjna intensywność uszkodzeń

π_U czynnik przyspieszające od napięcia pracy;

π_I czynnik przyspieszające od prądu pracy;

π_T czynnik przyspieszające od temperatury pracy;

$\pi_?$ czynnik przyspieszające od ....
wybranej metodologii ☺ ;

n – liczba wszystkich komponentów

Metodologie predykcji oceny niezawodności

Method	Number of EPSMA Users*	% of EPSMA Users*
MIL-HDBK-217F Parts count only	1	6
MIL-HDBK-217F Parts stress only	6	38
MIL-HDBK-217F Both Parts count and Parts stress	2	13
Bellcore TR332	3	19
Telcordia SR332	3	19
Bellcore TR332 and Telcordia SR332	2	13
Siemens SN29500	1	6
British Telecom HRD4 and HRD5	2	13
Field Returns	1	6
Life Testing	4	25
RAC Prism and Relex tools used with several of these methods.		

* The survey represents 16 EPSMA Companies/Divisions

EPSMA European Power Supply Manufacturers Association

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Metodologie predykcji oceny niezawodności

Reliability Prediction Model[1]	Company	1 Watt DC-DC Converter[2]				100W AC-DC PSU[3]	
		25°C		85°C		40°C	
		Hours	Years[4]	Hours	Years[4]	Hours	Years[4]
MIL-HDBK-217F (EXAR 7.0)	A	31,596,574	3606.9			686,771	78.4
MIL-HDBK-217F Notice 2	B	832,000	95.0	86,000	9.8		
MIL-HDBK-217F Notice 1	C	156,000	17.8	124,000	14.2		
Telcordia SR332 Parts count	D	89,380,000	10203.2	29,260,000	3340.2		
Telcordia SR332 Parts stress	D	104,200,000	11895.0	57,160,000	6525.1		
Siemens SN29500 (IEC61709)	A	80,978,217	9244.1			1,554,055	177.4
HRD5 Parts stress	B	2,465,000	281.4	849,000	96.9		
HRD4 Parts count	B	1,132,000	129.2	1,132,000	129.2		
MIL-HDBK-217F (EXAR 7.0)	A	31,596,574	3606.9			686,771	78.4
Telcordia SR332 Parts count	E					1,418,000	162.0

[1] Reliability Prediction Model is based on parts stress analysis except where stated otherwise.

[2] 1 Watt DC-DC Converter prediction assumes ground benign environment, hybrid assembly, 5 ceramic capacitors, 2 transistors, 1 diode (resistor and transformer not included in the calculations).

[3] 100W AC-DC PSU prediction assumes ground benign environment, 156 components including, 37 capacitors, 9 transistors, 18 diodes, 71 resistors, 2 power semiconductors, 1 relay switch, 2 opto's, 2 analogue IC's, 1 standard IC, electrical connections, 1 connector socket and 12 'other' components.

[4] Years based on 1 year = 365 days x 24 hours = 8760hrs/yr.

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Metodologie predykcji oceny niezawodności

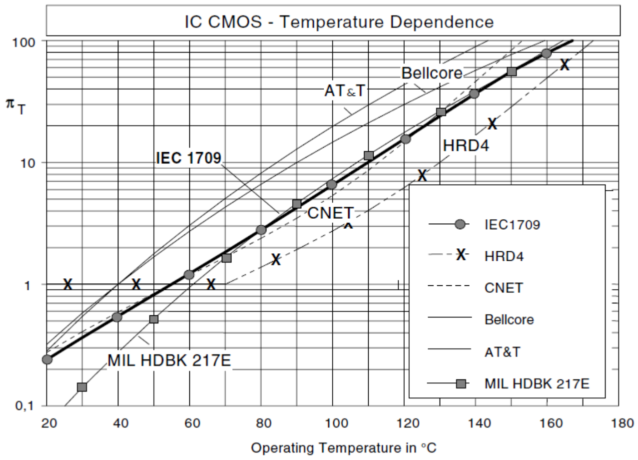
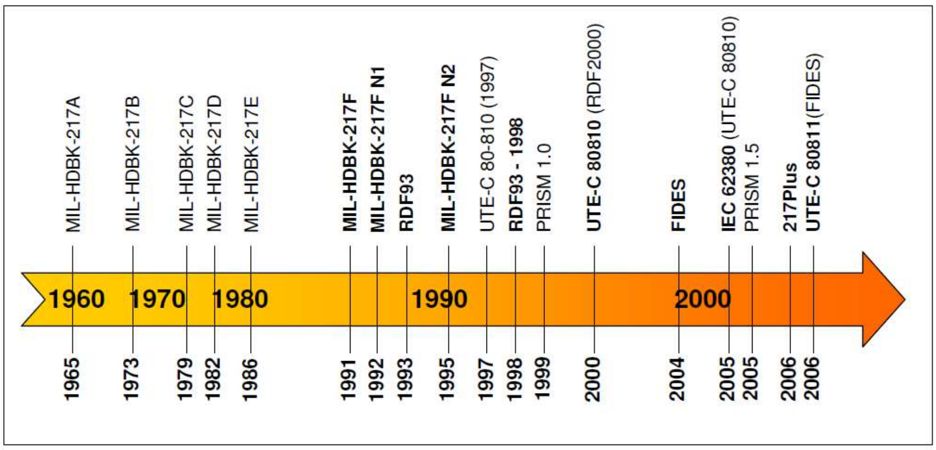


Figure 7.1 - Comparison of the temperature dependence for CMOS IC (Sept. '90)

Eugene R. Hnatek Practical Reliability of Electronic Equipment and Products

Metodologie predykcji oceny niezawodności



Selection Guide for electronic components predictive reliability models IRdM

Porównanie metodologii predykcji oceny niezawodności

CALCE Electronic Products and Systems Consortium
http://www.calce.umd.edu

C99-01

DRAFT Assessment of Reliability

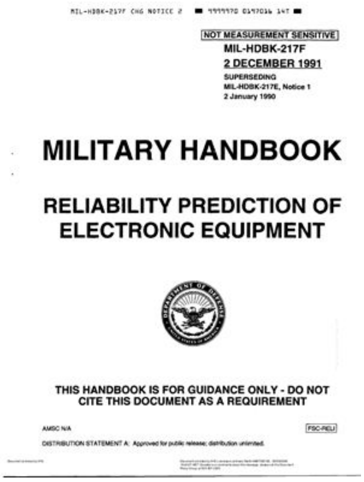
Prediction Methodologies

J. Cartwright (Honeywell), T. Stadterman (Army AMSAA)

M. Jackson, Zhenya Huang

Standard MIL-HDBK-217

The MIL-HDBK-217 (A issue) reliability handbook was first developed in the 1960s by the US Navy. It was at the time rather a reliability data base than a predictive model. The changes (from B to F) were developed by the RAC (Reliability Analysis Centre) of the US Air Force. The last version of the handbook (F issue) dates back to 1990 with an overhaul in 1995 (Notice 2). It has not been updated since, and is not maintained anymore. In spite of that, it is nowadays considered as an international reference.


MIL-HDBK-217F CHG NOTICE 2

NOT MEASUREMENT SENSITIVE
MIL-HDBK-217F
2 DECEMBER 1991
SUPERSEDING
MIL-HDBK-217E, Notice 1
2 January 1990

MILITARY HANDBOOK

RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT

THIS HANDBOOK IS FOR GUIDANCE ONLY - DO NOT CITE THIS DOCUMENT AS A REQUIREMENT

AMSC N/A FSC-RELI

DISTRIBUTION STATEMENT A. Approved for public release; distribution unlimited.

AGH

Standard MIL-HDBK-217

Components families covered by the MIL-HDBK-217

The electronic or electromechanical components families covered by the reliability handbook MIL-HDBK-217 are:

– semiconductors :
  - Integrated circuits,
  - Hybrids,
  - Diodes, Thyristors,
  - Transistors,
  - Optoelectronics,
– Passive components:
  - Resistances, Potentiometers,
  - Capacitors,
  - Inductors (coils, transformers),
  - Quartz,
  - Filters,
– Active components (except from semiconductors) :
  - Tubes,
  - Lasers,
– Electromechanical components:
  - Relays,
  - Switches,
  - Rotating devices (motors, resolvers…),
  - Meters (voltmeter, amperemeter…),
– Miscellaneous
  - Fuses,
  - Lamps,
– Printed circuit board (PCB)

AGH

Standard MIL-HDBK-217

	MIL-HDBK-217	
General information	Emitter	RAC (Department of Defence – USA)
	Principle of construction	Statistic on operational feedback
	Privileged application domain	Military
	Modelled failures	Intrinsic
	Unit of the modelling	Failures per hour
	Date of the last issue	1995
	Handbook still maintained	No
	Software tools	Integrated in almost all the reliability calculation software packages
	Price (paper handbook)	Free
Modelling	Mathematical formula	$\lambda = \lambda_b.\pi_S.\pi_Q.\pi_E$
	Methods	- Part count - Part stress
	Environment modelling	- Environment categories
	Generic parameters (part count)	- Technology of the component - Category of environment
	Generic parameters (part stress)	- Technology of the component - Environment - Thermal stress – Electrical stress - Quality
	Excluded parameters	-
Remarks		- Internationally known handbook - Easy appropriation - Only one element in the mathematical formula (except for the integrated circuits) - No explicit consideration of the non operating phases - Soldering not integrated into the failure rate of the component (separate calculation)

Następca MIL-HDBK-217

217Plus
NEXT GENERATION RELIABILITY PREDICTION

ale już nie za darmo...

The Army Memo to Stop Using Mil HDBK 217

January 3, 2018 · Predictions · Fred Schenkelberg

The Army Memo to Stop Using Mil HDBK 217

Over 20 years ago the Assistant Secretary of the Army directed the Army to not use MIL HBK 217 in a request for proposals, even for guidance. Exceptions, by waiver only.

217 is still around and routinely called out. That is a lot of waivers.

MTBF

http://nomtbf.com/2018/01/army-memo-stop-using-mil-hdbk-217/

AGH

Standard 217+

The 217Plus reliability handbook prediction was developed by the Reliability Information Analysis Centre (RIAC), formerly Reliability Analysis Centre (RAC), after the last version of the MIL-HDBK-217 reliability handbook. The 217Plus reliability handbook was worked out in order to answer the obsolescence problems of the MIL-HDBK-217 reliability handbook which is no longer maintained since the publication of the F version note 2 in 1995. ***The 217Plus reliability handbook corresponds to the update of version 1.5 of the electronic reliability evaluation software called PRISM.***

Mathematical modelling

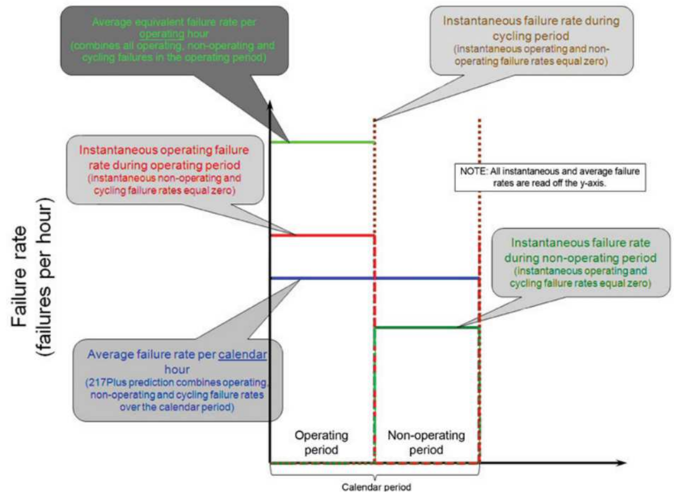
The mathematical model used in the 217Plus reliability handbook is of additive type for the physical contribution assessment and of multiplicative type for the influence of the $\pi_{Process}$ on the total reliability.

It consists in:

$$\lambda = \Big[\underbrace{(\lambda.\pi)_O}_{operating} + \underbrace{(\lambda.\pi)_E}_{environment} + \underbrace{(\lambda.\pi)_C}_{cycling} + \underbrace{\lambda i}_{induced} + \underbrace{(\lambda.\pi)_{SJ}}_{soldering}\Big]_{\text{Physical contribution}} \cdot \underbrace{\pi_{Process}}_{\text{Process contribution}}$$

http://www.theriac.org/

Uwzględnienie cyklu pracy



http://www.theriac.org/DeskReference/PDFs/2009Q2/2009Q2-article3.pdf

Standard CNET RDF 93

The generic mathematical model used in the RDF93 reliability handbook is of multiplicative type. It consists in:

$$\lambda = \lambda_b.\pi_S.\pi_Q.\pi_E$$

The RDF93 reliability handbook general model is identical to that of the reliability handbook MIL-HDBK-217 .

This model corresponds to the general case. As for the MIL-HDBK-217 reliability handbook, some components such as the integrated circuits use a different equation.

Components families covered

Compared to the components families covered by MIL-HDBK-217 reliability handbook, the RDF93 reliability handbook presents the following differences:

- Additional components:
  - LED,
  - Accumulators,
  - Arrestors,
  - Keyboards,
- Not modelled components:
  - Tubes,
  - Lasers,
  - Rotating devices (motors, resolvers…),
  - Meters (voltmeter, amperemeter…),
  - Lamps.

The RDF93 reliability handbook covers almost all the components families used nowadays (2009).

„Metodyki projektowania i modelowania systemów" Cyganek & Kasperek & Rajda © 2018 Katedra Elektroniki AGH

Standard RDF93

RDF 93		
General information	Emitter	CNET and French companies
	Principle of construction	Empirical
	Privileged application domain	Ground installation (telecom) and railway equipment
	modelled failures	Intrinsic
	Unit of the modelling	Failure rate per hour in the calculation environment
	Date of the last issue	1998
	Handbook still maintained	No
	Software tools	Not many
	Price (paper handbook)	Non available
Modelling	Mathematical equation	$\lambda = \lambda_b.\pi_S.\pi_Q.\pi_E$
	Environment modelling	Environment categories
	Methods	- Part stress
	Generic parameters (part stress)	- Technology of the component - Environment - Thermal stress – Electrical stress - Quality
	Excluded parameters	-
Remarks		- Very similar to the MIL-HDBK-217 handbook. - Easy to handle - Only one element in the components reliability models(except for the integrated circuits) - No explicit consideration of the non operating phases - Soldering not integrated into the failure rate of the component (separate calculation)

Następcy

RDF2000
(UTE-C 80-810)
TR62380
(RDF2000 issue 2003)

Standard UTE-C 80-810

UTE-C 80810		
General information	Emitter	UTE and French companies
	Principle of construction	Empirical
	Privileged application domain	Ground installation (telecom) automotive and aircraft equipments
	modelled failures	Intrinsic and residual overloads
	Unit of the modelling	Failure rate per calendar hour
	Date of the last issue	2005
	Handbook still maintained	No
	Software tolls	Main reliability calculation software
	Price (paper handbook)	160€
Modelling	Mathematical equation	$\lambda = \lambda_{die} + \lambda_{casing} + \lambda_{overstress}$
	Environment modelling	Parameterised
	Methods	- Part stress
	Generic parameters (part stress)	- Technology of the component - Annual environment (thermal cycles, ambient temperature, operating phases) - Thermal stress – Electrical stress
	Excluded parameters	- Mechanical stresses - Stresses related to humidity - Stresses related to chemical aggressions
Remarks		- Failure rate per calendar hour - Consideration of the non operating phases - Distinction in the models of the die and the casing - Some parameters (thermal cycling) seem to contain some mistakes - Component's quality influence not taken into account

Rozbudowany model addytywny

Standard FIDES - od 2006 UTE-C 80811

Reliability handbook FIDES was developed by various French companies of the aeronautical and military sectors under the aegis of the "Délégation Générale pour l'Armement" (DGA). These companies are: AIRBUS France - Eurocopter - GIAT Industries - MBDA missile systems – Thales Airborne Systems - Thales Avionics - Thales Research & Technology - Thales Underwater Systems. This reliability handbook was published for the first time at the beginning of 2004. An update was issued later that year in order to correct some minor defects.

The FIDES reliability handbook is the reference handbook for the electronic components reliability assessment of the DGA and AIRBUS (since October 2007) projects. However, it does not enjoy an international recognition to date and is not often used in the industrial sectors.

http://fides-reliability.org/

Standard FIDES - od 2006 UTE-C 80811

Mathematical modelling

The mathematical model used in the FIDES reliability handbook is of additive type for the physical contribution assessment and of the multiplicative type for the influence of the π_{Proces}s on the total reliability.

It consists in:

$$\lambda = \underbrace{\left\{ \Sigma \left(\left[\underbrace{(\lambda.\pi)_{TH}}_{\text{Thermoelectrical}} + \underbrace{(\lambda.\pi)_{TCyboitier}}_{\text{cycling/casing}} + \underbrace{(\lambda.\pi)_{TCyjoints}}_{\text{cycing/soldering}} + \underbrace{(\lambda.\pi)_{RH}}_{\text{humidity}} + \underbrace{(\lambda.\pi)_{Méca}}_{\text{mechanical}} \right] . \tau_{phase} \right) . \underbrace{\pi_{induit}}_{\text{overstress}} \right\}}_{\text{Physical contribution}} . \underbrace{\pi_{Process}}_{\text{Process contribution}}$$

The modelling type used is additive. As well as for the UTE-C 80810 reliability handbook, this modelling enables to dissociate the independent failure mechanisms categories.

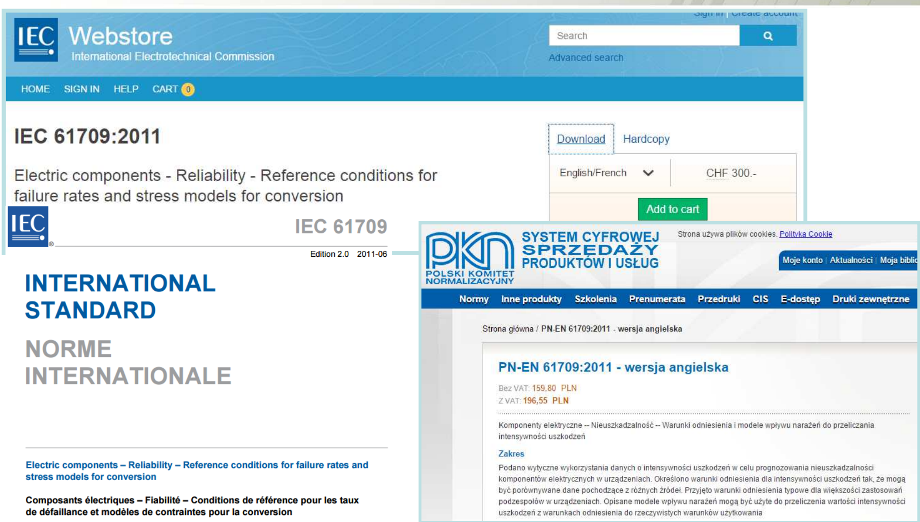
Standard FIDES - od 2006 UTE-C 80811

		FIDES
General information	Emitter	DGA and French companies (AIRBUS, GIAT, THALES, MBDA, EUROCOPTER)
	Principle of construction	Modelling of the failures and calibrations using the operational feedback
	Privileged application domain	Military and aeronautic equipment
	modelled failures	Intrinsic and design/manufacturing processes
	Unit of the modelling	Failure rate per calendar hour
	Date of the last issue	2004
	Handbook still maintained	Yes – V2 in progress
	Software	Limited number
	Price (paper handbook)	Free
Modelling	Mathematical equation	$\lambda = \Sigma(\lambda_{thermal}+\lambda_{casing}+\lambda_{soldering}+\lambda_{humidity}+\lambda_{mechanical})_{phase} \cdot \Pi_{induced}$
	Environment modelling	- Parameterised
	Methods	- Part stress
	Generic parameters (part stress)	- Component technology - Annual environment (thermal cycles, ambient temperature, operating phases, humidity, vibration level) - Thermal stress – Electrical stress
	Excluded parameters	-
Remarks		- Failure rate per calendar hour - Consideration of the non operating phases - Modelling based on the physics of failure - Requires a fine definition of the environment (suggest however some default parameters for some typical environments) - Covers COTS - Takes into account external failures related to the design or the manufacturing

FIDES

MBDA, THALES, nexter ELECTRONICS, eurocopter, THALES, AIRBUS, THALES

IEC 61709 – EN 61709

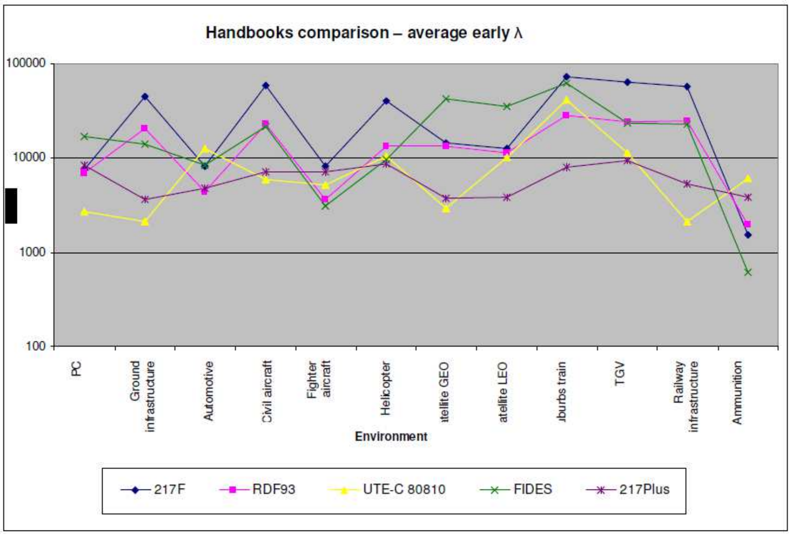


Standard SN29500

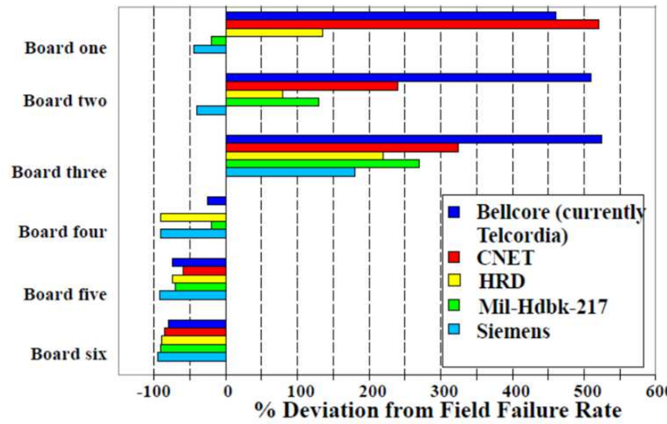
SN 29500 provides frequently updated failure rate data at reference conditions and stress models necessary for parts count and parts stress predictions. The reference conditions adopted are typical for the majority of applications of components in equipment.

Under these circumstances parts count analysis should result in realistic predictions. The stress models described in this standard are used as a basis for conversion of the failure rate data at reference conditions to the actual operating conditions in the case that operating conditions differ significant from reference conditions

Porównanie standardów



Porównanie standardów



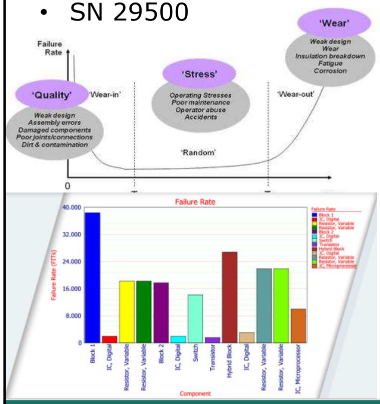
Jones, J. and Hayes, J., "A Comparison of Electronic Reliability Prediction Models," *IEEE Transactions on Reliability*, Vol. 48, No. 2, pp. 127-134, 1999

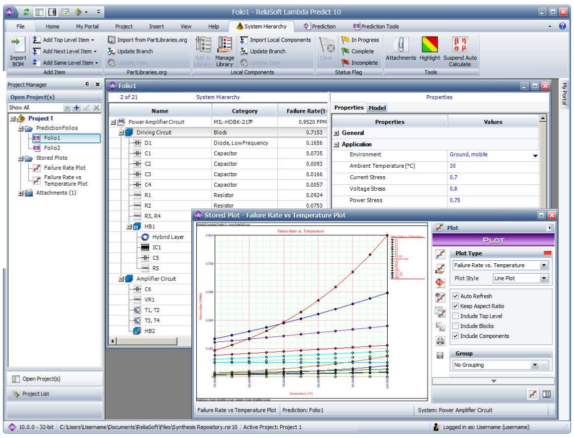
13

Predykcja niezawodności

Środowisko *LambdaPredict* Reliasoft(HBMPrensia)
Metodologie predykcji MTBF:

- MIL-HDBK-217F
- FIDES
- SN 29500





Kalkulatory MTBF

http://aldservice.com/en/download/download-reliability-and-safety-software.html

RAM Commander	Comprehensive software tool for **Reliability** and **Maintainability** Prediction, Reliability Analysis, **Spares** Optimization, **FMEA/FMECA**, Testability, **Fault Tree Analysis**, MSG-3, Event Tree Analysis and **Safety** (SAE ARP 4761, MIL-STD-882E). More about RAM Commander ...	FREE DEMO Presents all RAM Commander features. FULL VERSION Full version of RAM Comm... Requi... Code. Other... 8.3 , R... ST... Fully-f... datab... educa... studer... Autho...
D-LCC	Advanced tool for **life cycle cost** calculation, total ownership cost and sensitivity **cost analysis**. A key tool for managers, decision-makers, engineers, ILS personnel, and other staff involved in system acquisition, proposal writing, management, development, production and through-life support. More about D-LCC ...	FR... Prese... featur... FULL VERSION Full version of D-LCC 7.4.2. Requires Authorization Code.

FavoWeb (WEB FRACAS)	FavoWeb is ALD's third generation, web based and user configurable **Failure Reporting, Analysis and Corrective Action System (FRACAS)** that captures information about equipment or the processes throughout its life cycle, from design, production testing, and customers support. More about FavoWeb FRACAS ...	ONLINE DEMO Presents all FavoWeb features.
Free MTBF Calculator	Free Reliability Prediction software tool for **MTBF (or failure rate) calculation** supporting 26 reliability prediction standards - **MIL-HDBK-217**,Siemens SN 29500, Telcordia, FIDES, IEC 62380, BELLCORE etc. More about Free MTBF Calculator ...	FULL VERSION Freeware

Przykłady analizy FMEDA

exida® FMEDA

Failure Modes, Effects and Diagnostic Analysis

Project:
Temperature transmitter PR5337 / PR6337 with 4..20 mA output

Temperature transmitter PR5337 and PR6337

Dziękujemy…