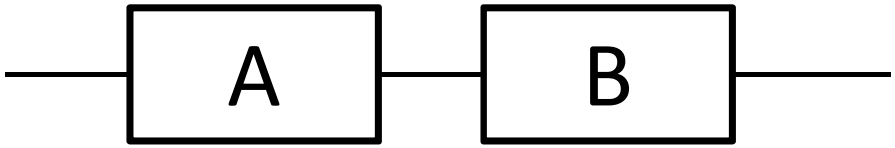
Homework Assignment 1

SYSTEMS WITH REDUNDANCY

Homework Assignment 1

Consider a series system with the following RBD:



The distributions of the components' failure time are listed in Table 2 according to your variant (see Table 1).

1. Plot the reliability, failure rate, and hazard rate functions for each of the components; calculate their MTTFs.
2. Using Mathcad define and plot the reliability function of the series system as well as its failure rate and hazard rate functions.
3. Find the MTTF of the series system.

Homework Assignment 1

4. Repeat paragraphs 2-3 after implementing hot parallel redundancy
   a. to the component A;
   b. to the component B;
   c. to the entire series system (system redundancy);
   d. to each component of the series system (component redundancy).

Compare MTTF of each redundancy scheme and the plots of the functions.

5. Repeat paragraphs 2-3 after implementing cold standby redundancy
   a. to the component A;
   b. to the component B;
   c. to the entire series system (system redundancy);
   d. to each component of the series system (component redundancy).

Compare MTTF of each redundancy scheme and the plots of the functions.

Homework Assignment 1

6. Repeat paragraphs 2-3 after for the k-out-of-n systems constructed of the original series system:

a. 2-out-of-3 redundancy;
b. 2-out-of-4 redundancy;
c. 3-out-of-4 redundancy.

Compare MTTF of each redundancy scheme and the plots of the functions.

7. Make an inference regarding reliability gain and MTTF gain of various redundant architectures.

Homework Assignment 1

Table 1

№	ФИО	F_A	параметры A		F_B	параметры B		
1	Алексеев Михаил Сергеевич	E	λ = 0,0005		GCEG	α = 0,5	b = 1,6	γ = 0,0005
2	Беляков Марк Владимирович	R	σ = 800		KwE	a = 1,5	b = 0,85	γ = 0,00155
3	Бурла Дарья Федоровна	W	η = 1100	β = 1,2	CEG	α = 0,3		γ = 0,00125
4	Вагнер Артур Максимович	E	λ = 0,0004		GW	β = 1,5	b = 2,5	γ = 0,00025
5	Груздев Андрей Андреевич	R	σ = 1000		ECEG	α = 0,75	a = 0,9	γ = 0,001
6	Данилов Григорий Олегович	W	η = 800	β = 1,8	CRG	α = 0,2		γ = 0,002
7	Добродеев Родион Евгеньевич	E	λ = 0,0015		EW	a = 1,75	β = 1,25	γ = 0,002
8	Жалюк Виктория Романовна	R	σ = 1250		CWG	α = 0,65	β = 1,15	γ = 0,0005
9	Колодюк Александр Петрович	W	η = 650	β = 1,4	EE	a = 1,3		γ = 0,002
10	Курило Петр Васильевич	E	λ = 0,0025		KwE	a = 1,25	b = 1,8	γ = 0,00125
11	Кучеренко Анастасия Михайловна	R	σ = 700		GW	β = 1,25	b = 0,5	γ = 0,00125
12	Маслов Константин Максимович	W	η = 1250	β = 1,35	ER	a = 0,8		γ = 0,0004
13	Миренков Данил Иванович	E	λ = 0,0008		ECEG	α = 0,4	a = 1,7	γ = 0,00125
14	Пилипенко Яна Владимировна	R	σ = 900		EW	a = 1,5	β = 1,75	γ = 0,00065
15	Плеханов Павел Владимирович	W	η = 1000	β = 1,75	GE	b = 1,4		γ = 0,00065
16	Пышкин Максим Игоревич	E	λ = 0,002		CWG	α = 0,15	β = 1,65	γ = 0,0035
17	Сегбатов Артур Витальевич	R	σ = 1500		GCEG	α = 0,1	b = 1,85	γ = 0,001
18	Хавелев Илья Алексеевич	W	η = 850	β = 1,25	GR	b = 1,6		γ = 0,001
19	Шатохин Фёдор Александрович	E	λ = 0,001		GCRG	α = 0,85	b = 1,35	γ = 0,001
20	Югай Никита Вячеславович	R	σ = 550		KwR	a = 1,5	b = 0,85	γ = 0,00155
21	Якупов Владислав Александрович	W	η = 1500	β = 1,15	W	η = 1000	β = 0,75	

Homework Assignment 1

Table 2

Distribution*	CDF (Failure Probability)	Parameters
Kw-E	$F(x) = 1 - (1 - (1 - e^{-\gamma x})^{a})^{b}$	$a, b, \gamma > 0$
Kw-R	$F(x) = 1 - \left(1 - \left(1 - e^{-(\gamma x)^2}\right)^{a}\right)^{b}$	$a, b, \gamma > 0$
GCEG	$F(x) = 1 - \left(\frac{e^{-\gamma x}}{\alpha + (1-\alpha)e^{-\gamma x}}\right)^{b}$	$0 < \alpha < 1$ $b, \gamma > 0$
GCRG	$F(x) = 1 - \left(\frac{e^{-(\gamma x)^2}}{\alpha + (1-\alpha)e^{-(\gamma x)^2}}\right)^{b}$	$0 < \alpha < 1$ $b, \gamma > 0$
GW	$F(x) = 1 - \left(e^{-(\gamma x)^{\beta}}\right)^{b}$	$\beta, \gamma, b > 0$
ECRG	$F(x) = \left(\frac{\alpha\left(1 - e^{-(\gamma x)^2}\right)}{\alpha + (1-\alpha)e^{-(\gamma x)^2}}\right)^{a}$	$0 < \alpha < 1$ $a, \gamma > 0$
ECEG	$F(x) = \left(\frac{\alpha(1 - e^{-\gamma x})}{\alpha + (1-\alpha)e^{-\gamma x}}\right)^{a}$	$0 < \alpha < 1$ $a, \gamma > 0$

Homework Assignment 1

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Distribution*	CDF (Failure Probability)	Parameters
EW	$F(x) = \left(1 - e^{-(\gamma x)^{\beta}}\right)^{a}$	$a, \beta, \gamma > 0$
CWG	$F(x) = \dfrac{\alpha\left(1 - e^{-(\gamma x)^{\beta}}\right)}{\alpha + (1-\alpha)e^{-(\gamma x)^{\beta}}}$	$0 < \alpha < 1$ $\beta, \gamma > 0$
CEG	$F(x) = 1 - \dfrac{e^{-\gamma x}}{\alpha + (1-\alpha)e^{-\gamma x}}$	$0 < \alpha < 1$ $\gamma > 0$
CRG	$F(x) = 1 - \dfrac{e^{-(\gamma x)^2}}{\alpha + (1-\alpha)e^{-(\gamma x)^2}}$	$0 < \alpha < 1$ $\gamma > 0$
EE	$F(x) = (1 - e^{-\gamma x})^{a}$	$a, \gamma > 0$
ER	$F(x) = \left(1 - e^{-(\gamma x)^2}\right)^{a}$	$a, \gamma > 0$
GE	$F(x) = 1 - (e^{-\gamma x})^{b}$	$\gamma, b > 0$
GR	$F(x) = 1 - \left(e^{-(\gamma x)^2}\right)^{b}$	$\gamma, b > 0$

Homework Assignment 1

Table 2

Distribution*	CDF (Failure Probability)	Parameters
W (Weibull)	$F(x) = 1 - e^{-\left(\frac{x}{\eta}\right)^{\beta}}$	$\eta, \beta > 0$
R (Rayleigh)	$F(x) = 1 - e^{-\frac{x^2}{2\sigma^2}}$	$\sigma > 0$
E (Exponential)	$F(x) = 1 - e^{-\lambda x}$	$\lambda > 0$

Homework Assignment 1

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Two-parameter Distributions:

- CEG – Complementary Exponential-Geometric
- CRG - Complementary Rayleigh-Geometric
- EE – Exponentiated Exponential
- ER – Exponentiated Rayleigh
- GE – Generalized Exponential
- GR – Generalized Raylegh

Three-parameter Distributions:

- Kw-E – Kumaraswamy-Exponential
- Kw-R – Kumaraswamy-Rayleigh
- GCEG – Generalized Complementary Exponential-Geometric
- GCRG – Generalized Complementary Rayleigh-Geometric
- GW – Generalized Weibull
- ECEG – Exponentiated Complementary Exponential-Geometric
- ECRG - Exponentiated Complementary Rayleigh-Geometric
- EW – Exponentiated Weibull
- CWG – Complementary Weibull-Geometric