# Estimation of reliability and safety of the FM transmitter R&S®NR8215

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***Abstract - In this paper was conducted calculation of key indexes of reliability of the FM transmitter and well as the safety analysis of the systems, including data on measures to improve safety. Were identified events, that may lead to accidents and system failures.***

Key words – reliability, safety, reliability block diagram, fault tree analysis, FMEA/FMECA.

Reliability and safety - one of the most important indexes of the effectiveness of any devices and systems, that laid at the stage of system technical design, to subsequently select appropriate system, schematic, design and technological decision.

Reliability of the system can be estimated experimentally or using mathematical models. But reliability estimated the need at the design stage, should be used simulation system to test of reliability indexes for compliance specifications.

Safety estimation is also important. In most cases, when assessing the reliability of the system, neglecting safety assessment. This is explained to the fact, that in the standards of reliability our country no methods for estimation safety. It is therefore necessary to develop a technique to estimate the reliability and safety. This problem is complicated and time-consuming and requires multiple analysis. Therefore, for this task to choose customized software.

Software should take into account model and recommendation to estimate the reliability and safety and comply requirements of the following standards as: MIL-HDBK-217, Telcordia, FIDES, MIL-217, NPRD-95, CNET 2000, NSWC-98[1,2]. Also in this software should be the following tools to analysis: Reliability Prediction Module, Reliability Block Diagram Module, Fault Tree Module , Safety Module.

The main leaders it software for estimate of the reliability and safety is Relex (Relia Soft), RAM Commander (A.L.D.), ITEM TOOLKIT (ITEM Software)[3].

As the tool selected software RAM Commander from A.L.D.

## I. Description of the system

The object of study is the Transmitter R & S ® NR8215 with air cooling and power output 2.5 kW, is executed on the semiconductor element base, in particular power amplifier made by advanced technology MOSFET. The transmitter has means of remote control and monitoring via interface SNMP or HTTP.

The structure of the transmitter consists of the following components:

1. Digital exciter R&S®SU800
2. Power amplifier R&S®VU825
3. Control unit R&S®NetCCU®800
4. Transmitter rack with cooling system
5. Power distribution

Block diagram of the transmitter is shown in Fig. 1

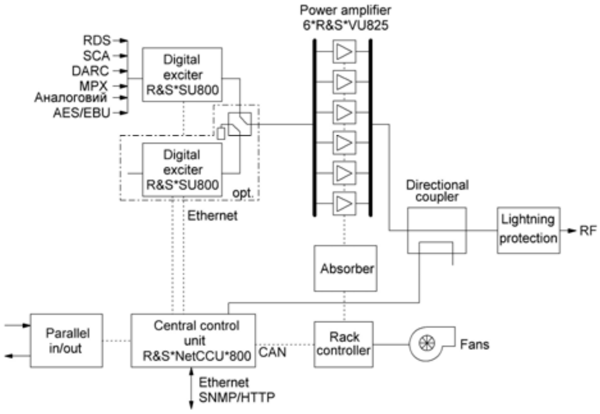



Fig. 1. Block diagram of the transmitter

In this paper will be conducted analysis of the reliability in particular:

1. Building a system tree.
2. Building a the fault tree.
3. Reliability block diagram analysis.
4. Will be define the basic indicators of reliability of the system.

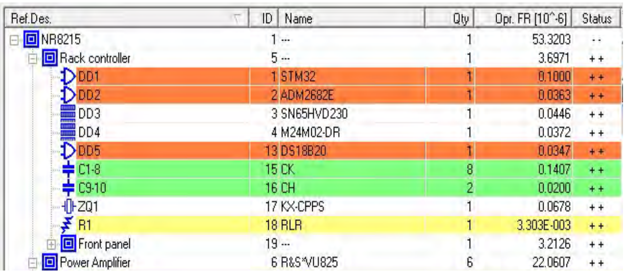
For safety evaluation conducted:

1. Failure Mode and Effects Analysis - FMEA.
2. Failure Mode Effects and Criticality Analysis - FMECA.

## II. Reliability estimation

In accordance a requirements with international standards MIL-217, MIL-HDBK-217 and Telcordia[1,2] on the first phase is the construction of tree system and conducted reliability prediction[4]. This type of analysis is caused by the need to assess the costs of further maintenance of the system. Also system tree is the input data for subsequent stages of estimation the reliability and safety.

To estimate the reliability built a system tree, which is shown in Fig. 2.



| Ref.Des. | ID | Name | Qty | Opr. FR [10^-6] | Status |
|---|---|---|---|---|---|
| NR8215 | 1 | --- | 1 | 53.3203 | - - |
| Rack controller | 5 | --- | 1 | 3.6971 | + + |
| DD1 | 1 | STM32 | 1 | 0.1000 | + + |
| DD2 | 2 | ADM2682E | 1 | 0.0363 | + + |
| DD3 | 3 | SN65HVD230 | 1 | 0.0446 | + + |
| DD4 | 4 | M24M02-DR | 1 | 0.0372 | + + |
| DD5 | 13 | DS18B20 | 1 | 0.0347 | + + |
| C1-8 | 15 | CK | 8 | 0.1407 | + + |
| C9-10 | 16 | CH | 2 | 0.0200 | + + |
| ZQ1 | 17 | KX-CPPS | 1 | 0.0678 | + + |
| R1 | 18 | RLR | 1 | 3.303E-003 | + + |
| Front panel | 19 | --- | 1 | 3.2126 | + + |
| Power Amplifier | 6 | R&S*VU825 | 6 | 22.0607 | + + |

Fig. 2. System tree

Analysis of the system tree was made with the following input data:

- The environment of the system – laboratory
- The temperature of the environment - 20°C

As a result, the mean time between failures for:

- Digital exciter – $7{,}74 \cdot 10^5$ hours
- Central control unit – $3{,}79 \cdot 10^6$ hours
- Absorber – $1{,}66 \cdot 10^6$ hours
- Parallel in/out – $1{,}45 \cdot 10^6$ hours
- Rack controller – $2{,}7 \cdot 10^5$ hours
- Power amplifier – $2{,}71 \cdot 10^5$ hours
- Directional coupler – $1 \cdot 10^6$ hours
- Lightning protection – $2{,}5 \cdot 10^6$ hours
- Fans – $4{,}17 \cdot 10^4$ hours

The most critical is the mean time between failures of the fans.

Reliability block diagram(RBD) builds based on the system tree, and allows estimate the mean time between critical failures (MTBCF) or the mean time to critical failure. Reliability block diagram allows to consider means of fault tolerance, including redundancy. The function of changes the reliability in time is constructed based on the results of analysis, and also defined the mean time between critical failures. The function of changes the reliability in time is shown in Fig.3.

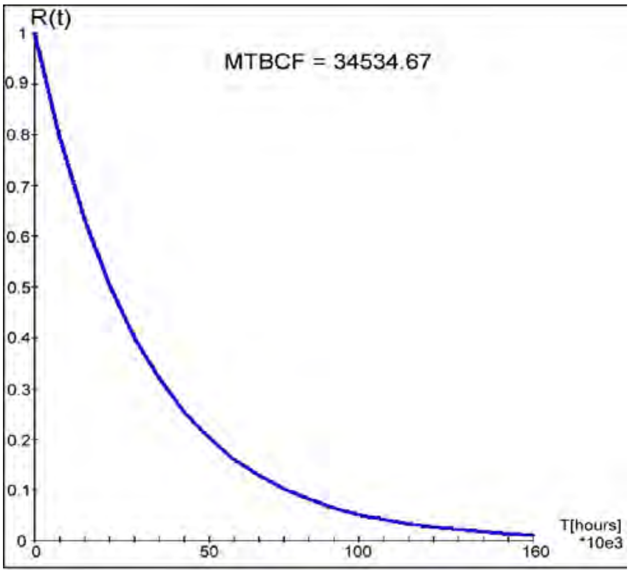



Fig. 3. The function of changes the reliability in time

The mean time between critical failures (MTBFC) is 34462,36 hours.

The next step estimation of reliability is building of a fault tree – FTA (Fault Tree Analysis). This type analysis allows to quantify estimate the probability of each failure, and also define a sequence or set of failures which will the lead to a critical failure.

Fault tree analysis was identified the next critical failures: “Failure of the directional coupler”, “Failure the absorber” i “Precipice «ground» the lightning protection”. Any of these events almost always is caused to overheat of system.

## III. Safety estimation

Failure Mode and Effects Analysis – FMEA allows to calculate safety parameters [5-7]. Risk Priority Number (RPN) calculates accordingly to Eq. 1:

$$RPN = S \cdot O \cdot D \qquad (1)$$

where: S – Severity (estimation of the severity of the potential consequences of failure), O – Occurrence (estimation of the probability that separate reason will cause system failure), D – Detection (estimation the probability of detection failure to management tools). RPN must not exceed 80 points, and for responsible systems of not more than 60. Results of FMEA showed that the most critical is the failure “Breakdown strip insulation” and “Deterioration heat transfer through the thermal grease” RPN for these failures is higher than 80 points. Failures be detected if replace thermal grease and strip insulation, and also control the maintenance works on the transmitter.

Failure Mode Effects and Criticality Analysis – FMECA allows to estimation of the degree seriousness of failure [7]. In this analysis, any of the failure by considering on the basis of two critical components – probability of occurrence and severity of the consequences of failure. Each of failure is assigned to a certain category.

## Conclusion

In this paper presents the results of estimation the reliability and safety of the FM transmitter R&S®NR8215 from using specialized software RAM Commander. Reliability analysis was calculated basic indexes of reliability, and defined failure which almost always is caused to catastrophic failure. Safety analysis detected failure that can lead to dangerous situations, and submitted recommendations for prevention.

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