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FAULT TREE ANALYSIS OF RADIONAVIGATION SYSTEM'S MEASUREMENT CHANNEL

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Abstract: *In this paper the fault tree analysis of radionavigation system's measurement channel is proposed. It is done based on the error model describing the different error components during the measurement.*

Key words: *radionavigation system, measurement channel, fault tree analysis*

1. INTRODUCTION

The main goal of this consideration is to estimate the fault tree of measurement channel of radionavigation system based on the "state-space" model.

Let's consider the following measurement channel. This channel can be described by using state-space method [1]. It is also a linear discrete-time system with two equations describing the dynamics of the system (1.1) and the formation of the data accessible to the measurement (1.2):

$$\mathbf{x}(k+1) = \mathbf{\Phi}(k+1, k)\mathbf{x}(k) + \mathbf{G}(k+1, k)\mathbf{w}(k) \quad (1.1)$$

$$\mathbf{y}(k) = \mathbf{H}(k)\mathbf{x}(k) + \mathbf{F}(k)\mathbf{v}(k), \quad (1.2)$$

where: k – time index,
$\mathbf{w}(k)$- zero-mean white noise (process noise),
$\mathbf{x}(k)$- internal state,
$\mathbf{y}(k)$- observed signal,
$\mathbf{v}(k)$- additive noise in observed signal.

Also $\mathbf{\Phi}(k+1, k)$, $\mathbf{G}(k+1, k)$, $\mathbf{H}(k)$, $F(k)$ are matrices regarding to $\mathbf{x}(k)$, $\mathbf{w}(k)$, $\mathbf{y}(k)$, $\mathbf{v}(k)$.

In this case we consider the following model of the system:

2. PRESENTATION OF THE TASK

Fault tree analysis is used to show the minimum cut which consists of minimum cuts of component failures leading to failure of the entire system. In practice it is so important to solve for the following task: which failures and which matching of them leading to faulty state and what is the probability of it.

We will consider different failure modes of azimuth channel by using the following expression [1]:

$$\Delta\alpha = \delta\alpha + \upsilon_\alpha , \quad (2.1)$$

where: $\Delta\alpha$ - the measurement error;
$\delta\alpha$ - this is error associated with the presence of polarization errors, reflection from other objects- for example, aircrafts. This component has zero mean value and also has exponential correlation time.
υ_α - white noise in the measurement associated with the fluctuation noise in the receiver.

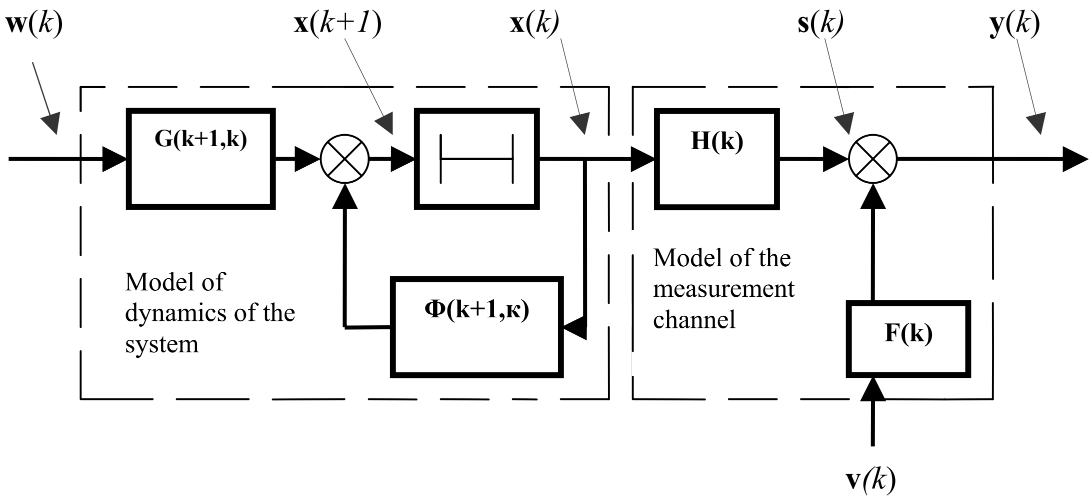

Fig. 1. Model of the dynamics of the system and model of measurement channel in "state-space" method

During our consideration we have to take into account the correlation time and the rates of different error components described in (2.1). Following the theory [2] we see that the correlation time for azimuth channel is: τ =10 *s* (β_α =0.1) and the standard deviation is σ_α =0.15º .

So, the rate associated with the process noise in this case is described as: $2\beta_\alpha\sigma_\alpha^2$
Then for the intensity (rate) we obtain: *0.0045* for the first component $\delta\alpha$. For the second one υ_α we take into account the standard deviation which is: $\sigma_{\nu\alpha}$ =0.125 º. Then the variance of this noise in the measurement is: $\sigma_{\nu\alpha}^2$ = 0.015625.

3. FAULT TREE CREATION

Based on the different error components described above we can create the fault tree of the system. We will use the "OR" gate due to the fact that we consider the system failure if one of the failures (regarding the errors in (2.1)) occurs. The TOP event will be "no correct measurement on the system output". The basic event will be described following the different error components in (2.1).

After completing the structure with different error components (basic events) of the fault tree we obtained the following (fig.2)

As it was mentioned above, the Fault tree analysis is used to show the minimum cut which consists of minimum cuts of component failures leading to failure of the entire system. Then we run the system analysis on the PC and obtained the summary with different parameters in terms of reliability/dependability (fig.3).

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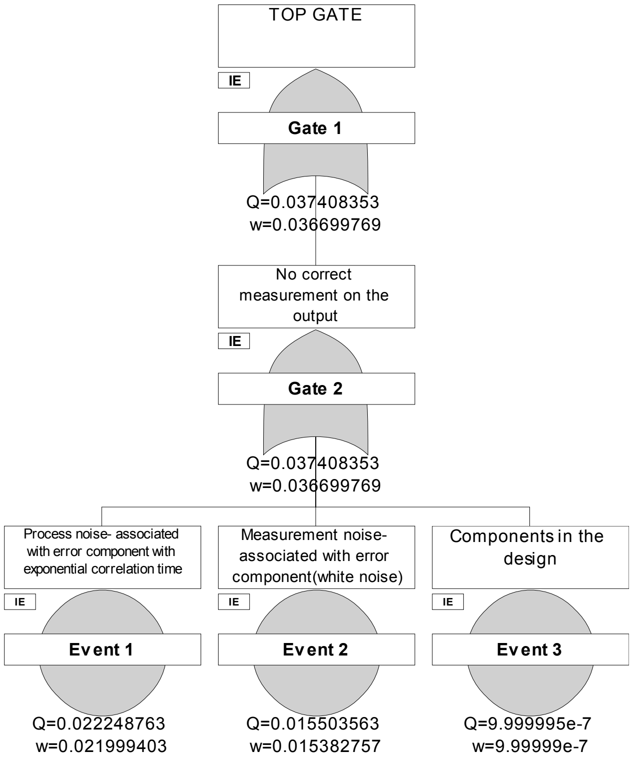

Fig. 2. Fault tree structure

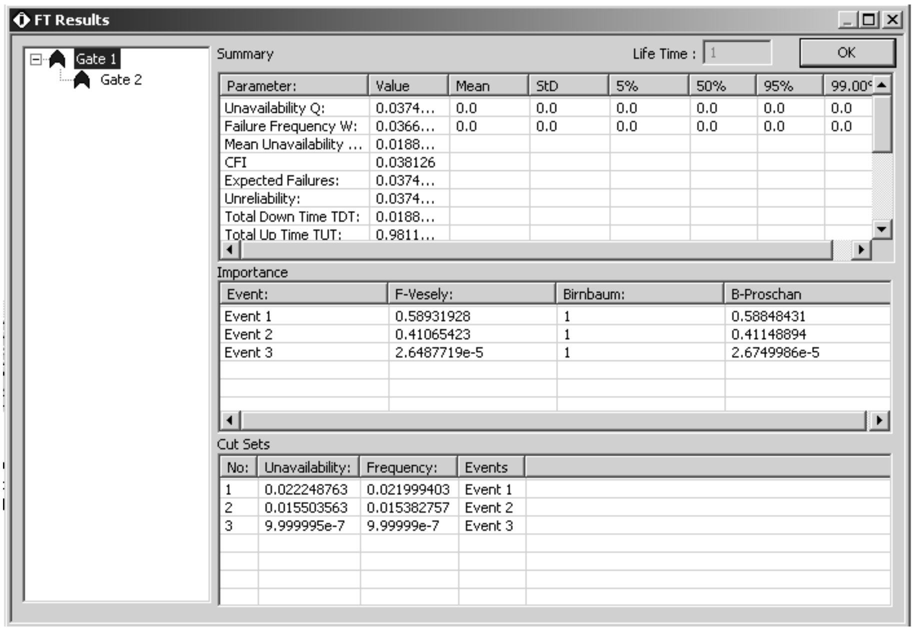

Fig. 3. Fault tree results

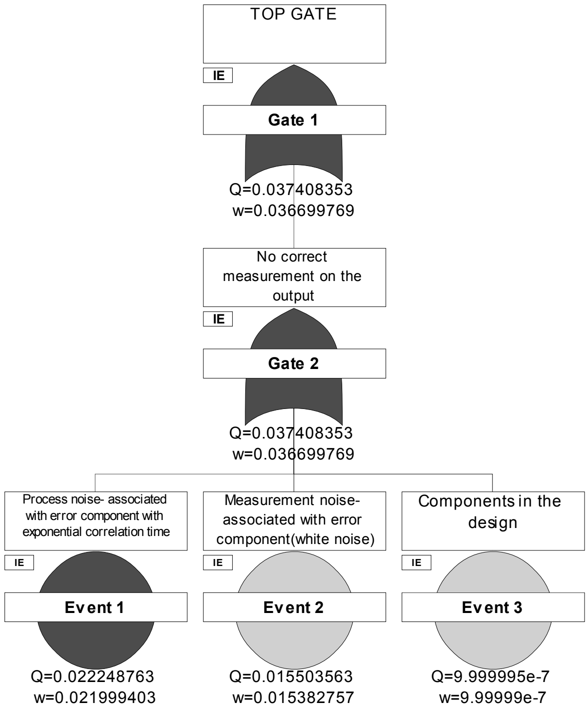

Fig. 4. Creation of minimum cut

After that we tried to find the minimum cut to see the components with high probability of failure occurrence (fig.4) [3].

4. CONCLUSIONS

4.1. a model of radionavigation system's measurement channel has been created in "state-space".

4.2. different failure modes are considered regarding the measurement error in the channel

4.3. a fault tree associated with the models in point (4.2) of the channel is created.

4.4. a reliability parameters summary of the system is shown.

4.5. the critical path in the system is investigated to show the components with high failure probability.

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АНАЛИЗ НА ДЪРВОТО НА ОТКАЗИТЕ НА КАНАЛ ЗА ИЗМЕРВАНЕ В РАДИОНАВИГАЦИОННА СИСТЕМА

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Резюме: *В този доклад е предложен анализ на дървото на отказите на канал за измерване в радионавигационна система. Това е направено на базата на модел на грешката на измерване в канала включваща различни нейни компоненти.*

Ключови думи: *радионавигационна система, канал за измерване, дървото на отказите.*