ISSN 1392 – 1215 ELECTRONICS AND ELECTRICAL ENGINEERING 2007. No. 8(80)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 120 SYSTEM ENGINEERING, COMPUTER TECHNOLOGY
SISTEMŲ INŽINERIJA, KOMPIUTERINĖS TECHNOLOGIJOS

The Evaluation of Stocks of Components for Electronic Devices

V. Stupak

Kaunas Department of Police, Mykolas Romeris University
V. Putvinskio str. 70, LT – 44211 Kaunas ACP, Lithuania, tel.: +370 37 303645, *e – mail v.stupak@kpf.mruni.lt*

Introduction

At the analysis, evaluation and maintenance of reliability of electronic devices, consider, as a rule, that restoration of serviceability is performed in repair institution. Really, many real electronic systems and devices are exploited close to repair institution.

However are known various by scales and by purpose electronic systems and devices the restoration of serviceability of which close to a place of exploitation is not possible. So, not always there can be a repair institution at a place of exploitation of system or the device. Besides, restoration of serviceability can be possible only in large repair institution. Such repair institutions, as a rule, are remote from a place of exploitation.

Therefore, for maintenance of reliability of technical systems in exploitation, are provided certain stocks of necessary component. With this purpose, the control system of stocks of electronic systems and devices is planned [1].

The article suggests the method of an evaluation of quantitative structure of stocks a component of electronic devices. The periodic way of replenishment of stocks is considered. As an index of sufficiency, the probability of sufficiency of stocks is analyzed. The index of expenses describing the cost of stocks a component is considered. The evaluation of quantitative structure of stocks of a component is carried out in view of restrictions on values of index of sufficiency or an index of expenses.

The factors determining efficiency of functioning of stocks control system

The major factors influencing functioning of a stocks control system are as follows:

- the purposes of stocks control system;
- structure of stocks control system (consecutive system, hierarchical system, etc.);
- kind of stocks;
- index of expenses (cost, volume, weight of stocks, etc.);
- structure of stocks (stocks of one type, stocks of several types, etc.);
- strategy of replenishment of stocks;
- the index describing the process of replenishment of stocks;
- statistical characteristics of stocks and control process by stocks;
- place of storage of stocks.

Various combinations of listed and some other factors define a variety of models of management of stocks. Models that can be applied for management of stocks in the most various fields of activity are considered, for example, in [2 - 4].

At stocks control, tasks at the choice of rational structures of stocks control systems and structures of stocks can be solved. The development of methods and algorithms of calculation of quantitative structure of stocks is also important. This task, as a rule, is solved at preset values of all other parameters influencing the chosen index of efficiency.

In models of management, the influence of stocks on efficiency of exploitation of electronic devices can be taken with the help of index of sufficiency of stocks. In [5], the method of an establishment of requirements to a parameter of sufficiency of stocks of a component of electronic devices is developed. As an index of sufficiency, the probability of sufficiency of stocks is analyzed. Total expenses in exploitation of the electronic device for the period of replenishment are considered. The required level of probability of sufficiency of stocks of a component is defined by minimization of the given expenses.

In developing the methods of calculation of quantitative structure of stocks of the component the expenses should be taken into account as well. It allows choosing a rational set of stocks of a component. As a parameter of expenses, it is possible to consider cost, volume or weight of stocks a component [5]. Then, it is possible to regard two tasks (direct and return) as correct at the choice of rational quantitative structure of stocks of a component. It depends on that, there are restrictions on index of sufficiency or on index of expenses.

The direct task of calculation consist of definition of such stocks a component, that will provide values of index of sufficiency not below the required and the minimal value of index of expenses. The return task of calculation consists of definition of stocks, at which the greatest possible value of an index of sufficiency is provided, and values of an index of expenses do not exceed the established restrictions. The given tasks can be attributed to tasks of mathematical programming [6-8]. The formulated two tasks of calculation of stocks of a component also have much in common with tasks of optimum redundancy of technical devices [9].

Methods of solving of tasks of mathematical programming can be divided into two classes [6-8]. The first class – continuous methods, for example, a method of Lagrange multipliers. Continuous methods allow finding the approximately optimum continuous decision. Then, the best integer approximation is found. The second class – integer methods. For this class of methods, the result is estimated by one of the members of sequence of decisions.

Method of evaluation of quantitative structure of stocks of a component of electronic devices

Further, as in [5], we shall stop on the analysis of a case when stocks of a component are formed for a group of devices. Index of sufficiency of stocks will be considered as the probability of sufficiency $P_{S\Sigma}$ determined for the period of replenishment T_p. Calculation of stocks for a direct task of calculation is done on the basis of the following conditions:

$$P_{S\Sigma}(T_p) = \prod_{l=1}^{L} P_{1Sl} \ge P_{S\Sigma*} \ , \qquad (1)$$

$$C_S = \sum_{l=1}^{L} C_l n_l \to \min_{n_l} \ , \qquad (2)$$

where P_{1Sl} – probability of sufficiency of stocks of a component of type l; $P_{S\Sigma*}$ – the required value of an index $P_{S\Sigma}(T_p)$; C_S – cost of stocks of the components necessary for maintenance of exploitation N of electronic devices during T_p, N – quantity of devices for which stocks of a component are calculated; C_l – cost of components of type l, ($l = \overline{1, L}$); n_l – volume of stocks of a component of type l.

Definition of stocks of a component for a return task of calculation can be carried out on the basis of conditions:

$$P_{S\Sigma}(T_p) = \prod_{l=1}^{L} P_{1Sl} \to \max_{n_l} \ , \qquad (3)$$

$$C_S = \sum_{l=1}^{L} C_l n_l \le C_{S*} \ , \qquad (4)$$

where C_{S*} – the set restriction of a cost index of stocks of a component.

Probability of sufficiency P_{1Sl} is defined under formulas:

$$P_{1Sl} = \sum_{k=0}^{n_l} \frac{X_l^k}{k!} \exp(-X_l) \ , \qquad (5)$$

$$X_l = N T_p \lambda_{1l} m_l \ , \qquad (6)$$

where X_l – average of applications in repair institution on components of type l; λ_{1l} – failure rate of a component of type l; m_l – quantity of a component of type l in the electronic device.

Methods of the decision of a direct and return task practically coincide. Further, we shall stop on the decision of the given tasks by the example of a direct task of calculation.

Definition of quantitative structure of stocks of a component is carried out by a method of the steepest descent [7, 8]. For this purpose we shall use the developed computer program (fig. 1.). The algorithm of the program provides the actions considered below.

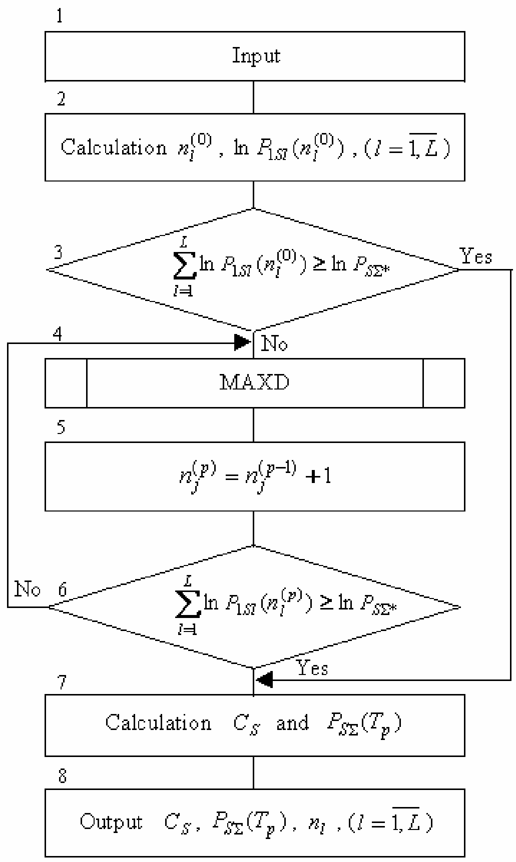

Fig. 1. The flowchart of algorithm of the program of calculation of stocks a component

- *Step 1.* The input of the initial data is carried out (operator 1).

Step 2. Initial stocks of component and corresponding values of probabilities of sufficiency of the given stocks are defined (operator 2). Initial stocks of a component represent the minimal integer values $n_l = n_l^{(0)}, (l = \overline{1, L})$ under which:

$$\ln P_{1Sl}(n_l^{(0)}) \ge \ln P_{S\Sigma*} \, . \qquad (7)$$

Transition from considered probabilities to their logarithms is done due to convenience of calculations.

Step 3. The check of a condition is carried out (operator 3):

$$\sum_{l=1}^{L} \ln P_{1Sl}(n_l^{(0)}) \ge \ln P_{S\Sigma*} \, . \qquad (8)$$

At performance of an inequality (8), management is passed to the operator 7. The quantitative structure of stocks of a component is as follows: $n_1^{(0)}$, $n_2^{(0)}$, . . . , $n_L^{(0)}$.

Otherwise, if the inequality (8) is impossible, there is a transition to a number of consecutive steps for change of quantitative structure of stocks of a component.

Step 4. Define (operator 4) at each of steps, with the help of subroutine MAXD, type of components, the stock of which should be increased.

At p a step, j type of a component to which the maximal value corresponds $\Delta_j^{(p)}$ is originally defined:

$$\Delta_j^{(p)} = (\ln P_{1Sj}(n_j^{(p-1)} + 1) - \ln P_{1Sj}(n_j^{(p-1)}))\big/C_j \, . \quad (9)$$

Then, only for this type of a component, there is an increase by unit of stock $n_j^{(p-1)}$ available for previous $(p-1)$ step.

Step 5. At p a step (operator 5) a stock for j type of a component is increased:

$$n_j^{(p)} = n_j^{(p-1)} + 1 \, . \quad (10)$$

Step 6. The check (operator 6) of the following condition is carried out:

$$\sum_{l=1}^{L} \ln P_{1Sl}(n_l^{(p)}) \ge \ln P_{S\Sigma*} \, . \quad (11)$$

At validity of an inequality (11), management is passed to the operator 7. The quantitative structure of stocks of a component is as follows: $n_1^{(p)}$, $n_2^{(p)}$, . . . , $n_L^{(p)}$.

Otherwise, if the inequality (11) is impossible, consecutive steps of change of quantitative structure of stocks are continued. The last step is the one, where the inequality (11) is valid for the first time.

Step 7. The cost C_S for the found quantitative structure of stocks of a component (operator 7) is calculated according to (2). The probability of sufficiency $P_{S\Sigma}(T_p)$ is defined under the formula:

$$P_{S\Sigma}(T_p) = \exp\left\{\sum_{l=1}^{L} \ln P_{1Sl}(n_l^{(p)})\right\} . \quad (12)$$

Step 8. An output of the initial data (operator 8), together with the values C_S, $P_{S\Sigma}(T_p)$, received as a result of calculation, and quantitative structure of stocks of a component n_l, ($l = \overline{1, L}$), is carried out.

For calculation of the logarithm of probability of sufficiency of stocks of a component l type $\ln P_{1Sl}$, ($l = \overline{1, L}$), function LPS (subroutine) is used. The operator 2 (fig. 1) stipulates the operation of definition $\ln P_{1Sl}$. The flowchart of algorithm of function LPS (subroutine) is provided in fig. 2.

At $X_l \le 40$, the probability P_{1Sl} is calculated (operator 12) under the formula (5). In a case $X_l > 40$, the size of P_{1Sl} is accepted as equal to corresponding value function of distribution of the normal law.

At $X_l > 40$, numerical integration is performed by Simpson's method. In this case the area of values of a variable is broken into 500 equal intervals.

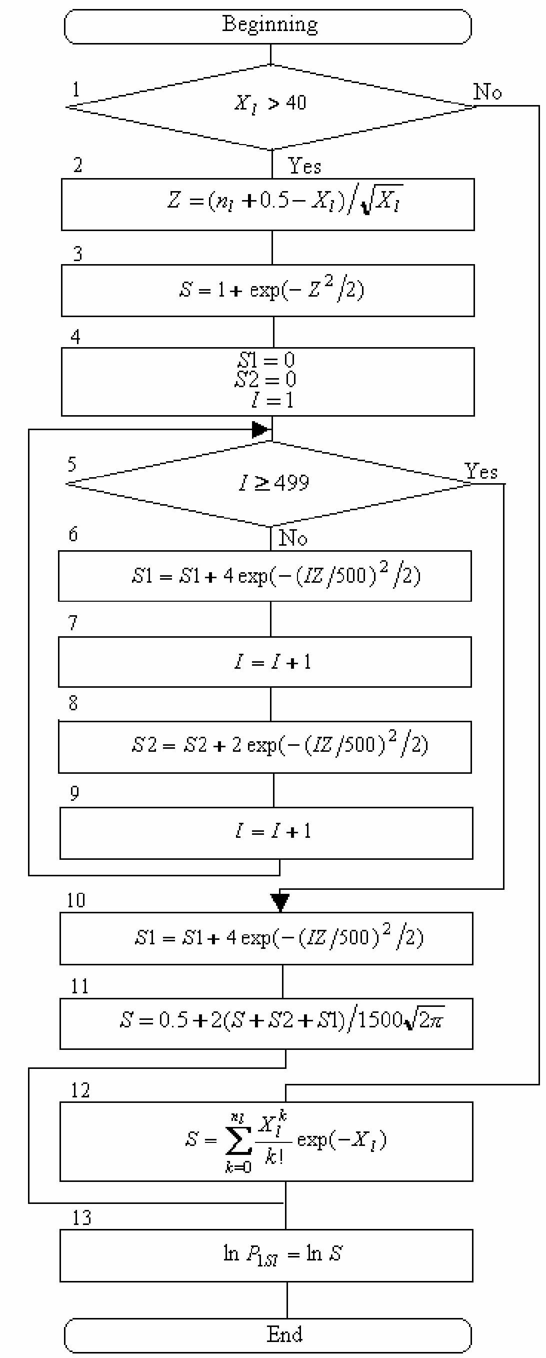

Fig. 2. The flowchart of algorithm of function LPS (subroutine)

The example of calculation of stocks of a component of the electronic device with the use of the considered computer program is provided in Table 1. Calculation is executed according to formulas (1) and (2) for the case, when $N = 50$; $T_p = 24$ *months*; $L = 4$; $P_{S\Sigma*} = 0.95$.

Table 1. Results of calculation of stocks of a component n_l depending on m_l, λ_{1l} and C_l

l	m_l	$\lambda_{1l} \cdot 10^6$, 1/ hour	C_l	n_l
1	1	1.019	320.84	1
2	2	5.000	42.43	4
3	1	14.815	100.25	5
4	2	19.907	250.84	8

Conclusions

1. The restorable electronic devices are being discussed. The system of maintenance with necessary components, used for repair of group of devices, is analyzed. The method of the evaluation of quantitative structure of stocks of a component is offered.
2. With the purpose of a choice during calculation of stocks of a rational set the component, the index of expenses is taken into account. As index of expenses, cost of stocks of a component is considered. At the restrictions of index of expenses, the direct task of calculation of quantitative structure of stocks is solved. At restrictions of index of sufficiency, the return task is solved.
3. The periodic way of replenishment of stocks is considered. As an index of sufficiency, the probability of sufficiency of stocks $P_{S\Sigma}$ is analyzed.
4. At the evaluation of quantitative structure of stocks of the component, the developed computer program is applied (fig. 1, 2). Required values of quantitative structure of stocks of a component of the electronic device n_l, depending on m_l, λ_{1l} and C_l at set N, T_p, L and $P_{S\Sigma *}$, are submitted in Table 1.

References

1. **Balaišis P., Eidukas D.** Elektroninių įtaisų eksploatacija. – Kaunas: Technologija, 2002. – 262 p.
2. **Porteus E. L.** Foundations of stochastic inventory theory. – Stanford University Press, 2002. – 320 p.
3. **Yao D. D., Zheng S.** Dynamic control of quality in production – inventory systems: coordination and optimization. – Springer, 2002. – 232 p.
4. **Buckley J. J., Feuring T., Hayashi Y.** Solving fuzzy problems in operations research: inventory control// The ninth IEEE International Conference on Fuzzy Systems, 7–10 May, 2000. – IEEE, 2000. – Vol. 1 – P. 352 – 357.
5. **Stupak V.** Analysis of component supply system for electronic devices// Electronics and Electrical Engineering. – Kaunas: Technologija, 2006. – No. 8(72) – P. 83 – 86.
6. **Nash S. G., Sofer A.** Linear and nonlinear programming. – McGraw – Hill, 1995. – 692 p.
7. **Bertsekas D. P.** Nonlinear programming, 2nd edition – Athena Scientific, 1999. – 780 p.
8. **Bazaraa M. S., Sherali H. D., Shetty C. M.** Nonlinear programming: theory and algorithms, 3rd edition. – John Wiley & Sons, 2006. – 872 p
9. **Handbook** of reliability engineering/ edited by Igor A. Ushakov, Robert A. Harrison. – New York: John Wiley & Sons, 1994. – 663 p.

Submitted for publication 2007 09 28

V. Stupak. The Evaluation of Stocks of Components for Electronic Devices // Electronics and Electrical Engineering. – Kaunas: Technologija, 2007. – No. 8(80) – P. 19–22.

Electronic devices, which are exposed to restoration during exploitation, are discussed. The system of maintenance with necessary components, used for repair of group of devices, is analyzed. The method of the evaluation of quantitative structure of stocks of a component is offered. At calculation of stocks, the index of expenses is taken into account. It allows choosing a rational set of a component. Two tasks of calculation of stocks are analyzed. The first task is solved with the restrictions of an index of expenses. At the restrictions of an index of sufficiency, the second task is solved. The periodic way of replenishment of stocks is considered. As an index of sufficiency, the probability of sufficiency of stocks is analyzed. As an index of expenses, cost of stocks of a component is considered. At the evaluation of stocks, the developed computer program is used. The example of calculation of stocks of a component is provided in the table. Ill. 2, bibl. 9 (in English; summaries in English, Russian and Lithuanian).

В. Ступак. Оценка запасов компонент электронных устройств // Электроника и электротехника. – Каунас: Технология, 2007. – № 8(80) – С. 19–22.

Рассматриваются электронные устройства, которые в процессе эксплуатации подвергаются восстановительным работам. Анализируется система обеспечения необходимыми компонентами, используемыми для проведения ремонта группы устройств. Предлагается метод оценки количественного состава запасов компонент. При расчёте запасов учитывается показатель затрат. Это позволяет выбрать рациональный набор компонент. Анализируются две задачи по расчёту запасов. Первая задача решается при ограничениях на показатель затрат. При ограничениях на показатель достаточности решается вторая задача. Рассматривается периодический способ пополнения запасов. В качестве показателя достаточности анализируется вероятность достаточности запасов. В качестве показателя затрат рассматривается стоимость запасов компонент. При оценке запасов используется разработанная компьютерная программа. Пример расчёта запасов компонент приведён в таблице. Ил. 2, библ. 9 (на английском языке; рефераты на английском, русском и литовском яз.).

V. Stupak. Elektroninių įtaisų komponentų atsargų apskaičiavimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2007. – Nr. 8(80) – P. 19–22.

Nagrinėjami elektroniniai įtaisai, kurie eksploatacijos metu yra taisomi. Analizuojama įtaisų grupės aprūpinimo reikalingais remonto darbams atlikti komponentais sistema. Siūlomas įtaisų komponentų atsargų apskaičiavimo metodas. Panaudojimas rodiklio, apibūdinančio išlaidas, leidžia parinkti racionalią komponentų visumą. Analizuojami du atsargų apskaičiavimo uždaviniai. Pirmas uždavinys sprendžiamas tuo atveju, kada nustatyti reikalavimai rodikliui, apibūdinančiam išlaidas. Kada nustatyti reikalavimai rodikliui, apibūdinančiam atsargų pakankamumą, sprendžiamas antras uždavinys. Nagrinėjamas periodinis atsargų papildymo būdas. Kaip komponentų atsargų pakankamumą apibūdinantis rodiklis analizuojama atsargų pakankamumo tikimybė. Kaip išlaidas apibūdinantis rodiklis nagrinėjama suminė komponentų atsargų kaina. Apskaičiuojant komponentų atsargas naudojama sudaryta kompiuterinė programa. Komponentų atsargų apskaičiavimo pavyzdys pateiktas lentelėje. Il. 2, bibl. 9 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).