E3S Web of Conferences 139, 01080 (2019) https://doi.org/10.1051/e3sconf/201913901080
RSES 2019

The role of information in power management tasks

I.U. Rakhmonov[1,2*], *K.M.* Reymov[2], *Z.M.* Shayumova[1,3]

[1]Tashkent State Technical University named after Islam Karimov, 100095, Uzbekistan, Tashkent, University St. 2A
[2]Karakalpak State University, 230100, Uzbekistan, Nukus, Ch. Abdirov St.1
[3]Institute of Energy of the Academy of Sciences of the Republic of Uzbekistan,700100, Tashkent city, Republic of Uzbekistan

Abstract. The more complex the system designed to serve the person, the higher the requirements for its high-quality functioning and its reliability itself. Reliability monitoring should reach the level of the highest "survivability" if we consider systems such as "power systems", i.e. systems whose services mankind does not intend to refuse in the foreseeable future. The presence of naturally wearing elements and seed details actualizes the issue of developing a certain "reliability index" and, accordingly, the procedure for its calculation and current display. Below we will consider possible solutions to the problems posed by the example of the electric power system. Since we are talking about "information", first of all, on the basis of rigorous mathematical calculations, we will try to establish a connection between the measurement information and the so-called Shannon information. Summing up the above, we can outline the goals of research in the near future.

The advantage of the canonical, Shannon theory of information is its universality, independence from the specific semantic content of information. The amount of information, determined by Hartley and Shannon and associated with a change in the probability of the state of the object, usually ignores the coordination with the control tasks, with the achievement of certain goals [1].

In technical systems, the control task is to maintain some adjustable parameters (for example, the frequency and voltage of nodes in power systems) at the level of the required values, and the regulation itself is based on the so-called measurement information. The fundamental question is whether there is a connection between the canonical form of information and its measuring, parametric form. In our opinion, such a connection should be sought by analyzing the value characteristics of information.

The value of information entirely depends on its reception, i.e. from the consequences of its perception by the receptor (in particular, an automated controlled power system). The value of information was the subject of research by a number of scientists - A.A. Kharkevich, M.M.Bongard, R.L. Stratonovich, B.N. Petrov and others. The generality of their concept lies in a statistical approach to information, and the wording of M. M. Bongard should apparently be recognized as the most specific interpretation of the value for the conditions for the further use of information for management [2-4].

$$V = \log_2(P^{/} / P) \qquad (1)$$

where V is the value of information,
P and $P^{/}$- the probability of achieving the goal before and after receiving information.

If the entropy measure of information, determined by Hartley or Shannon (through probabilities P and P '), is an unambiguous and universal quantity, then this universality does not extend to the concept of the value of information (1), if only because the effect of goal achievement in various control systems can be different (incommensurable), and the analysis of the value of information without regard to its receptor becomes abstract [5-7].

In complex technical systems, to which energy systems (ES) should be attributed, the goal of control can be considered to be the achievement of a certain state that is optimal according to some previously justified criteria (in particular, economic). Note that for an ES at each instant of time, such an optimal state is unique. Any «removal» from the optimal state can be estimated by the corresponding damage (E), and «approaching» to the optimum (from «under the optimal» state) by the wins (*E*), which are similar in meaning and significance. In particular, damage and gain may well be purely economical. The distance from the optimum itself can be expressed in terms of deviations of the controlled parameters from their «optimal» (corresponding to the system optimum) values, i.e. through parametric (measuring) information [8-9].

Having determined the optimum of the system, i.e. outlining the purpose of control, we specified the use of parametric information (regulation parameters), the very meaning of the information and the method of its measurement, which is fully consistent with the approach [10]. Using now the concept of the system control effect, we find the relationship between the parametric information defined above and the Shannon

* Corresponding author: ilider1987@yandex.com

information, i.e. between "management" information and canonical information.

We will describe the state of the ES near the optimum by a certain linear economic characteristic, which is a function of a set of adjustable parameters π:

$$E = f(\pi_1^{'}, \pi_2^{'}, ...\pi_j^{'}, ..., \pi_m^{'}) = \alpha_1 \pi_1^{'} + \alpha_2 \pi_2^{'} + ... + \alpha_j \pi_j^{'} + ... \alpha_m \pi_m^{'} \quad , \quad (2)$$

Where: E - is the current (actual) value of the economic indicator of the ES;

$\pi_j^{'}$ - current (actual) values of the regulation parameters;

α_j - weighting factors (statistical, regression - in particular).

We will consider the considered state sufficiently «close» to the optimal one, in which the ES functions most economically (with the economic indicator E_o):

$$E_o = f(\pi_1^o, \pi_2^o, ...\pi_j^o, ..., \pi_m^o) = \alpha_1 \pi_1^o + \\ + \alpha_2 \pi_2^o + ... + \alpha_j \pi_j^o + ... \alpha_m \pi_m^o \quad (3)$$

Here π_j^o - are the system parameters that determine its optimal state, we will call optimal.

The assumption of the proximity of the current state of the ES to the optimal E_o is necessary to comply with the linearity of the problem, i.e. invariance of coefficients α_j.

Consider a situation where all but one of the control parameters has their optimal value, and the j-th parameter has its current value that is different from the optimal one α_j. Denote the deviation of this parameter from the optimal by

$$\pi_j = \left| \pi_j^{'} - \pi_j^o \right| \quad (4)$$

Obviously, this will also lead to a deviation of the economic performance indicator of ES E_j from its optimal value:

$$E^{/}{}_j = E_j - E_o = \alpha_j = \left| \pi_j^{'} - \pi_j^o \right| = \alpha_j \pi_j \quad (5)$$

For brevity, we will call the $E_j^{/}$ effect of regulating the ES with respect to the parameter π_j. If the parameter π_j can be in n specific discrete states $P(\pi_{ji})$, then the resulting efficiency $E_{j\Sigma}$, as is known, can be calculated as the sum:

$$E_{j\Sigma} = \alpha_j \sum_{i=1}^{n} P(\pi_{ji}) \pi_{ji} \quad (6).$$

Analyzing the structure of expression (2), we come to the conclusion that the system-wide *(E_{ES})* regulation effect can be obtained by summing the regulation effects on individual components, i.e. it has the property of additivity:

$$E_{ES} = \sum_{j=1}^{m} \alpha_j \sum_{i=1}^{n} P(\pi_{ji}) \pi_{ji} \quad (7).$$

Since the sum (7) completely repeats the properties of the (6), for simplicity we return to the analysis of the *j*-th term. Note that in the transition from the case of a discrete change of a parameter π_j to its continuous change, expression (6) will change

$$E_{j\Sigma} = \alpha_j \int_o^{\pi_{j\max}} P(\pi_j) \pi_j d\pi_j \quad (8)$$

As follows from (5), E_j = 0 for the optimal value of the parameter π_j^o , i.e. with its very specific meaning, the probability of reaching which with targeted regulation $P(\pi_j^o) = 1$. Recall E_j that it can be interpreted as an optimization effect if an ES transfers from a suboptimal state to an optimal one, or as damage from nonoptimality if there is a reverse transition. The optimal state should be considered as completely ordered, whose entropy is equal to zero. The entropy of a disordered state, as is known, is associated with the probability of this state and for our example can be represented as follows:

$$H_j = \sum_{i=1}^{n} P(\pi_{ji}) \log_2 P(\pi_{ji}) \quad (9)$$

and for the continuous case

$$H_j = -\int_o^{\pi_{j\max}} P(\pi_j) \log_2 P(\pi_j) d\pi_{ji} \quad (10)$$

Recall the property of additivity of entropy, which allows the system to calculate the entropy as the sum of the enropies of its individual elements, which for our example gives

- in the discrete case

$$H_{ES} = -\sum_{j=1}^{m} \sum_{i=1}^{n} P(\pi_{ji}) \log_2 P(\pi_{ji}) \quad (11)$$

continuously

$$\mathrm{H}_{ES} = \sum_{j=1}^{m} \int_o^{\pi_{j\max}} P(\pi_j) \log_2 P(\pi_j) d\pi_j \quad (12)$$

The last formulas (9-12) are well-known expressions for Shannon's informational entropy, which is defined for a set of random variables. When the probability of the state changes from $P(\pi_j)$ to 1 (the system transitions from under the optimal state to the optimal one), the Shannon information change

$$I = O - \mathrm{H}_{ES} = \sum_{j=1}^{m} \int_o^{\pi_{j\max}} P(\pi_j) \log_2 P(\pi_j) d\pi_j \quad (13)$$

It is this information by Shannon that we use to transfer ES from under the optimal state to the optimal one and at the same time, the effect of the E_{ES} control is achieved. Naturally, practical regulation is carried out not according to Shannon information, but according to parametric (measuring), by minimizing the parameters π_j - see (5). Obviously, there is some correspondence between these two forms of information, which can be revealed through the effect of regulation (control).

Considering the property of the additive effect of system regulation noted above and the well-known property of additive entropy, we consider the correspondence (== -is the sign of correspondence) of the effect and information using the example of one (*j*-th) parameter:

$E_{j\Sigma} == I_j$ or

$$\alpha_j \int\limits_{o}^{\pi_{j\max}} P(\pi_j)\pi_j d\pi_j == \int\limits_{o}^{\pi_{j\max}} P(\pi_j)\log_2 P(\pi_j) d\pi_j \quad (14)$$

To simplify the analysis, we differentiate the right and left sides of the expression (14):

$$\alpha_j P(\pi_j)\pi_j == P(\pi_j)\log_2 P(\pi_j) \quad (15)$$

Comparing the right and left sides of expressions (14,15) with respect to probability factors, we can conclude that they are affinely similar, i.e.

$$\frac{P(\pi_j)}{P(\pi_j)\log_2 P(\pi_j)} = idem \quad (16)$$

The factor αj of the left-hand side of expression (14) can be considered as a scale factor providing a geometric similarity. The only element in (14) that does not have a similar one is the regulation parameter π_j. This means that, up to a certain constant (*C*), the parametric (measuring) information, on the basis of which targeted optimization control in the ES is carried out, corresponds to the information according to Shannon:

$$C\pi_j = I_j \quad (17)$$

We can note the validity of relations (14) and (17) for the boundary conditions. Let the ES with respect to parameter *j* be brought to the optimum state. Moreover $\pi_j = 0, \quad P(\pi_j) = 1, \quad \log_2 = P(\pi_j) = 0, \quad I_j = 0$, the right and left sides of expressions (14) and (17) are identically equal to zero. This means that in the optimum state there is no (and not needed!) information for further control. Consider another example - a certain parameter π_ν does not affect the formation of the economic effect of management, i.e. its coefficient $\alpha_\nu = 0$ or we are dealing with useless information. In this case, the definition of the goal has not been formulated with respect to this parameter, therefore, from the point of view of the ES control, the parameter π_ν value can be any. It is known that the probability of any parameter value is always equal $I(P(\pi_j) = 1$, $\log_2 1 = 0$ and there is no regulation information for control $I_\nu = 0, \quad C\pi_j = 0, \quad t.i. \quad C = 0$ for this parameter should be performed.

The presence on the left side of expressions (14) and (17) of a physically measurable parameter is logical in the sense that a transition from abstract, conical information to concrete, physically measurable is necessary. An important conclusion that follows from the above is that such a «bridge» between the conical form of information (according to Shannon) and its measurable, parametric form exists for pre-agreed conditions and lies in some constant *C*.

Thus, when fixing the method of measuring and using information (for control purposes) and when determining the control goal as achieving a certain (optimal) state of a controlled object, Shannon information corresponds to measuring, parametric information (or vice versa) up to a constant.

Fixing the method of using information logically leads to the question of the effect of its use, of its value from a management perspective. If information on Shannon is a factor for determining the bandwidth of information transmission channels in the automated control system, then the determining factor in the organization of the management itself is its value. In this regard, it is legitimate to talk about the development of the informational aspects of management, about the construction of management systems adequate to the processed information. In theoretical terms, the justification of «informational» management methods and the development of an informational management theory are required.

References

1. V.Sokolov, E&T, **2**, 46-52 (1982).
2. V.Sokolov, E&T, **2**, 41-49 (1985).
3. V.Venikov, Electricity, **1**, 1-5 (1986).
4. L.Koptsev, A.Koptsev, Ind. Ener., **1**, 18-23 (2011).
5. A.Grinev, Ind. Ener., **3**, 19-22 (2012).
6. L.Kazarinova, T.Barbasova, O.Kolesnikova, A.Zakharova, CTME, **14**, 5–11 (2014).
7. M.Bazaar, K.Shetty, NPTA, **583** (1982).
8. I.Rakhmonov *Technical science and innovation*: Vol. 2018 Iss. 1 , Article 10. (2018)
9. F.Hoshimov, .Rahmonov, AJTNS, **3-4**, 52-55 (2015).
10. F.Khoshimov, I.Rakhmonov , *Technical science and innovation*: Vol. 2018 : Iss. 1 , Article 9. (2018)