DETERMINATION OF THE OPERABILITY MARGIN OF ENGINEERING UNITS

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The analytic and search methods for determining the operability margin of engineering units have been described for a technological spread in the values of the element parameters, as well as for gradual failures of the elements.

The value of the operability margin of engineering units (EU) allows estimation of the usefulness of the units during their commercial fabrication or selection of the required control input during their operation.

Below a description is given of the analytic and search methods for estimating the operability margin of EU for known values of the parameters of the assembly elements, stipulated values of the output parameters, and the condition requiring that during the operation of the EU only gradual failures occur. The methods considered differ from known methods in their great simplicity and require less expenditures of time and hardware for their implementation for an identical reliability.

The operability margin L is estimated according to the magnitude of the distance from a nominal (working) point X_n to the closest boundary point $X^{(b)}$ of the operability domain (OD) G (see [1]). These conditions, G = M ∩ P. The domain M consists of the set of values of the parameters of the assembly elements - i.e., of the set of primary parameters $X = (x_1, x_2, ..., x_i, ..., x_n)$, for which the requirements governing the output parameters of the EU $Y = (y_1, y_2, ..., y_i, ..., y_m)$ are satisfied for simultaneous fulfillment of the m conditions

$$y_{j\,\min} \leqslant y_j = y_j(\overline{X}) \leqslant y_{j\,\max}, \quad (j = 1, \dots, m), \tag{1}$$

where $y_{j\min}$, $y_{j\max}$, y_j are the minimum, maximum, and current values of the j-th output parameters which determines the goal and purpose of the EU.

The domain P representing the set of admissible (limiting) values of the primary parameters of the EU is determined by the ensemble of inequalities

$$x_{i\,\min} \leqslant x_i \leqslant x_{i\,\max}, \quad i = 1, \dots, n, \tag{2}$$

where $x_{i\min}$, $x_{i\max}$, x_i are the minimum, maximum, and current values of the i-th primary parameter.

The values of $x_{i\max}$, $x_{i\min}$ may be stipulated, for example, by engineering constraints or by constraints on physical realizability.

In order to determine the operability margin L in the n-dimensional space of the primary parameters, we stipulate the metric: i.e., we define the function l for the vectors X_N, $X^{(b)}$. For example, we assume that

$$l = \left(\sum_{i=1}^{n} (\lambda_i (x_{iN} - x_i^{(b)}))^2\right)^{1/2}, \tag{3}$$

where x_{iN}, $X_i^{(b)}$ are the i-th coordinates of the vectors X_N, $X^{(b)}$; λ_i is a certain positive number (weight).

The quantity λ_i is the normalizing coefficient with respect to the i-th coordinate. Usually, it is assumed that $\lambda_i = 1/x_{i\max}$ or $\lambda_i = 1/(x_{i\max} - x_{i\min})$. Using λ_i, one may take account of the different dimensionality of the coordinates of the vectors X_N, $X^{(b)}$. If all λ_i are equal to one another, then expression (3) stipulates a Euclidean metric. In the particular case $\lambda_i = 1$, i = 1, ..., n.

The problem can be reduced to choosing the quantity $X^{(b)}$ which minimizes the value of l for known

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