**The laboratory work 3**

One of the basic requirements imposed to the ACS, is the accuracy of reproduction reference variable, which is determined by the shape of stationary control (*y (t)*) [5]. In this case, the established system error will be :

|  |  |
| --- | --- |
|  | (5.1) |

The steady value of errors in the ACS can determine , using the theorem of the limiting value of the original from the operational calculation.

If the functions ε ( t ) and έ ( t ) are the original and E (P) is the image of the function ε (t), then

|  |  |
| --- | --- |
|  | (5.2) |

Typically, ACS accuracy is determined for typical operating modes. The simplest of them are the modes [5]:

- at a constant value of external influence;

- when changing external influences at a constant speed;

- with a quadratically increasing change in external influence;

- with a harmonic effect.

*We find the value of the steady-state error in a closed self-propelled guns at a constant value of the external driving action g (t) = const = g0* .

Let the open loop transfer function be W (p). Then the transfer function of the closed system for the error will be equal to:

|  |  |
| --- | --- |
|  | (5.3) |

According to the theorem on the limit value of the original (5.2), the expression of the established error takes the form:

|  |  |
| --- | --- |
|  | ( 5 .4) |

For and where *M (P)* and *Q ( P )* do not contain the factor *P* , taking into account ( 5 .2) we get:

|  |  |
| --- | --- |
|  | ( 5 .5) |

This error value is called static error.

*Let the driving action change at a constant speed*

|  |  |
| --- | --- |
|  | ( 5 .6) |

According to formulas ( 5 .2) and ( 5 3), with considering the fact that in this case  we find:

|  |  |
| --- | --- |
|  | ( 5 .7) |

To eliminate the increase in the error in this case, the transfer function of the open circuit SAU - the W (p) should be zero pole. Then, as follows from formula ( 5 .7) yields ε mouth = V / K . This constant value is called speed error.

For example. Let   (one zero pole).

Then from ( 5 .7) we get :

|  |  |
| --- | --- |
|  |   |

If in this example the setting action is constant, then the steady-state error in the self-propelled gun will be zero :

|  |  |
| --- | --- |
|  |   |

So, a system having a zero pole in the transfer function of an open circuit *W (p)* will not have a static error and will give a constant value of the speed error.

Such a system is called an astatic system. In the transfer function of the open circuit *W (p)* , the presence of an integrating link is necessary .

Tracking systems and systems software controls should be designed as an astatic. System configurable to maintain a constant value of a controlled magnitude, can have and static errors.

The tracking system integrating link, creating *astatism* , is the executive engine. The angle of rotation of the shaft (or linear displacement) will be proportional to the integral of the input control signal (voltage).

As can be seen from the error formulas ( 5 .5) and ( 5. 7), to reduce the error value , it is necessary to increase the total gain K of the open circuit of the system. Therefore, the value of *K* is called the quality factor of the system.

It is possible to build self-propelled guns also with second - order and higher - order astatism, and not only with respect to the driving action, but also with respect to the disturbing effect. The condition of astatism in this case will be different and will be determined from the condition :

|  |  |
| --- | --- |
|  | ( 5 .8) |

*Accuracy with harmonic effects.* The steady- state error in this case is determined by the frequency characteristics of the closed system discussed earlier.

Let the input action change according to the law :

|  |  |
| --- | --- |
|  | ( 5 .9) |

In a linearized system in steady state, the error will also change according to a harmonic law :

|  |  |
| --- | --- |
|  | ( 5 .10) |

The accuracy of the ACS in this mode can be determined by the amplitude of the error, using the definition of the frequency response of a closed ACS by mistake :

|  |  |
| --- | --- |
|  | ( 5 .11) |

Typically, the system control is so designed that ε m was much less than the amplitude of the input signal g m . Therefore, the condition must be satisfied at the operating frequency ω p . Then the expression (2.11) can be replaced by an approximate :

|  |  |
| --- | --- |
|  | ( 5 .12) |

This formula allows you to calculate the amplitude of the error in the steady state, as well as to solve the problem of synthesis of self-propelled guns, providing a given accuracy in the steady state. For example, when constructing the desired LAF at the frequency of the control action (operating frequency - ω r ) for a given input amplitude - g m and the permissible error amplitude - ε m , the so-called control point with coordinates ω r and The Desired LAFC should go through this point (or slightly higher). Often when designing and testing systems of control are sinusoidal setpoint signal and in that case, when the requirements for system set for maximum speed and maximum acceleration input feedback. In this case , an equivalent sinusoidal signal can be determined .

If that speed and acceleration will be:

    

Hence,



From this calculated frequency ω p and the amplitude of gm sinusoidal reference variable corresponding to the desired maximum speed and acceleration, and namely:

   

These values are used for applying the coordinate reference points in the field of construction of desired LACHH open loop system control.

In this laboratory work, the steady-state errors of the system will be considered under constant, linearly increasing and quadratically increasing external influences.

**Program and work methods**

5 .2.1 In correspondence with its one construct circuit system , shown in Figure 5 .1. In the study system with astatism zeroth order to take *R (p) = K* and used in an external master exposure only *g = A, g = vt* (parameters selected from tables 5 .1), and at study astatic systems adopt *R (p) = K / p* and use *g = A, g = vt* as the external driving force ( select parameters from tables 5 .1) and  ( select parameters from table 5 .2) ,



Figure 5 .1 - System block diagram

where  - for the astatic system.

5.2.2 Carry out a study of a system with a zero order of astatism when exposed to a constant signal. For this need with the help package MATLAB- Simulink collect circuit pattern, both shown in Figure 5 .2. The constant signal generator is the *Constant* block from the *Sources* library , the parameter of which is the constant signal *g = A.* The role of *R (p) = K is* played by the *Gain* amplifier from the *Math* library*. The transfer function* is realized with the help of block *Transfer Fcn* library *Continuous* , with the help of parameters which in the model are written K1, T1, T2. The output is a *Scope* oscilloscope from the *Sinks* library . To view simultaneously two signals and their comparison to its input simultaneously provide the two signal: *g = A* (with output oscillator signal *Constant* ); *y (t)* (from the system output ). This allows you to make the *Mux* block (the black quadrangle in the figure) from the *Signals & Systems* library .



Figure 5 .2 - Model diagram on MATLAB- Simulink

for a system with a zero order of astatism when feeding

on the input signal *g = A*

5.2.3 Changing K = 1, 5, 10, to receive the transition process and to determine the limit values established error for each K.

5.2.4 Collect similarly pp . 5 .2. circuit model for a system with zero order astatism when applying for entry Ramp signal *g = v · t ,* both shown in Figure 5 .3. To obtain the input action *g = v · t , the Integrator* block from the *Continuous* library is connected in series with the constant signal generator *.*



Figure 5 .3 - Model diagram on MATLAB- Simulink

for a system with a zero order of astatism when feeding

on the input signal *g = v · t*

5.2.5 Also for three values of K = 1, 5, 10 to receive the transient processes and to determine the limit values established error for each K.

5 .2.6 Investigation of systems with first- order astatism . For such systems, *R (p) = K / p* , and therefore the *Integrator* block from the *Continuous* library is connected sequentially to the *Gain* amplifier *.* The model diagram is shown in Figure 5 .4. A quadratically increasing input actioncan be obtained if two integrators are connected in series with the generator of the acting signals . The transfer function parameters for the respective options are shown in Table 5 .2. and the parameters of the acting signals in tables 5 .1. and 5 .2.



Figure 5 .4 - circuit pattern on MATLAB- Simulink for systems with astatism when applying on the input signal  (as an example is shown in Scheme transfer function 

5.2.7 Based on the data obtained, analyze the influence of parameters on the accuracy of the system.

Table 5 .1 - Variants of the parameters of systems with a zero order of astatism

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  Option |  K1 |  T1 |  T2 |  TO | Typical Input Impacts  |
| *g = A* | *g = vt* | *g* = at2/2 |
| 1 | 1 | 0 | 3 | 1, 5, 10  | 1 | t | 0.2 t 2  |
| 2 | 1.5 | 0 | 2.5 | 1, 5, 10  | 4 |   2t | 0.25 t 2  |
| 3 | 1.5 | 0 | 0.5 | 1, 5, 10  | 2 | t | 0.3 t 2  |
| 4 | 2 | 0 | 1 | 1, 5, 10  | 2 |   2t      | 0.45 t 2  |
| 5 | 3 | 0 | 1 | 1, 5, 10  | 1 | 2t | 0.4 t 2  |
| 6 | 2.5 | 0.5 | 5 | 1, 5, 10  | 1 | 0.5t | 0.35 t 2  |
| 7 | 2.5 | 2.5 | 3 | 1, 5, 10  | 2 | 4t | 0.3 t 2  |
| 8 | 8 | 0.5 | 3 | 1, 5, 10  | 2 | t | 0.2 t 2  |
| 9 | 5 | 0.1 | 2 | 1, 5, 10  | 1 | 2t | 0.2 t 2  |
| 10 | 3 | 1 | 2 | 1, 5, 10  | 1 | t | 0.25 t 2  |
| 11 | 1.5 | 1 | 0.7 | 1, 5, 10  | 2 | 3t | 0.25 t 2  |
| 12 | 2 | 1 | 0.6 | 1, 5, 10  | 2 | 2t | 0.5 t 2  |
| 13 | 3 | 2 | 2 | 1, 5, 10  | 2 | 2t | 0.45 t 2  |
| 14 | 4 | 2 | 3 | 1, 5, 10  | 1 | 0.5t | 0.2 t 2  |
| 15 | 5 | 1 | 0.5 | 1, 5, 10  | 2 | 2t | 0.3 t 2  |

Table 5 .2 - Options for the study of astatic systems

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Option | *W 0 (p)* | *g*  | Option | *W 0 (p)* | *g*  |
| 1 |   | 0.2 *t* 2 | 8 |  | 0.25 *t* 2 |
| 2 |  | 0.5 *t* 2 | 9 |  | 0.2 *t* 2 |
| 3 |  | 0.2 *t* 2 | 10 |  | 0.5 *t* 2 |
| 4 |  | 0.4 *t* 2 | 11 |  | 0.3 *t* 2 |
| 5 |  | 0.3 *t* 2 | 12 |  | 0.45 *t* 2 |
| 6 |  | 0.45 *t* 2 | 13 |  | 0.4 *t* 2 |
| 7 |  | 0.25 *t* 2 | 14 |  | 0.5 *t* 2 |