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AUTOMATIC CONTROL OF VIDICON SENSITIVITY IN THE TELEVISION SENSOR OF AEROSPACE CONTROL SYSTEMS

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Abstract

In the present work a flow chart of vidicon sensitivity automatic control in TV-sensor is proposed, which provides to achieve the maximal possible accuracy in identification of bright point objects. The major system parameters are defined which ensure system stability and speed.

In television coordinators determining the coordinates of bright point objects, the useful information is contained only in the videosignal they produce. The other signals are noise signals preventing to achieve maximum accuracy in determining the objects' coordinates. In application TV cameras, with a view to more precisely transmit brightness relations, vidicon sensitivity is regulated based

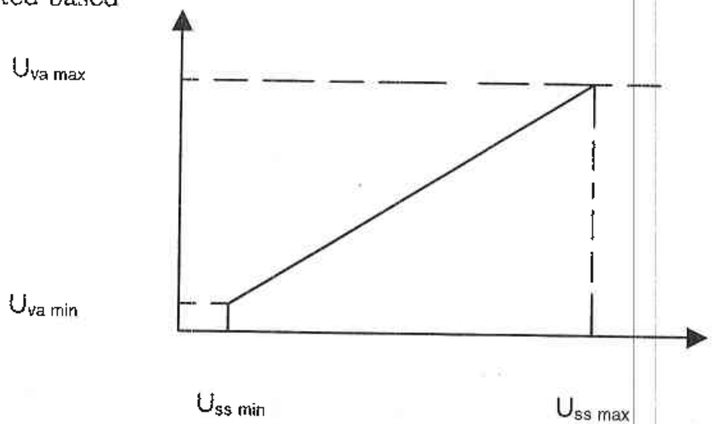

Fig. 1

on the average illumination of the vidicon target. In this case, the signals of the brightest objects are restricted, i.e. with this type of automatic control of vidicon sensitivity (ACS), the useful-signal to noise-signal ratio decreases.

Therefore, it would be more reasonable if vidicon ACS in television coordinators was based not on the average target illumination, but on the maximal amplitude of the videosignal in each frame. Vidicon sensitivity in the working area is a linear function of the signal slice voltage U_{ss} as shown in Fig.1 [1]. Therefore, the maximal amplitude of the videosignal from the bright spot object may be preserved by changing U_{ss} depending on the vidicon's illumination E, as shown in Fig.2.

The ACS system may be synthesized after the flow chart shown in Fig.3, where 1 is the optical system projecting the object images on the vidicon target. The videosignal obtained at the output of vidicon 2 is amplified by videoamplifier 3 and and is fed to coordinator 4, where the coordinates of the bright point object are determined. From 3, the videosignal is fed to the peak detector 5, whose charge time constant is very small, as a result of which the output voltage reaches its maximum within a shorter time interval than the duration of the videosignal from the point object.

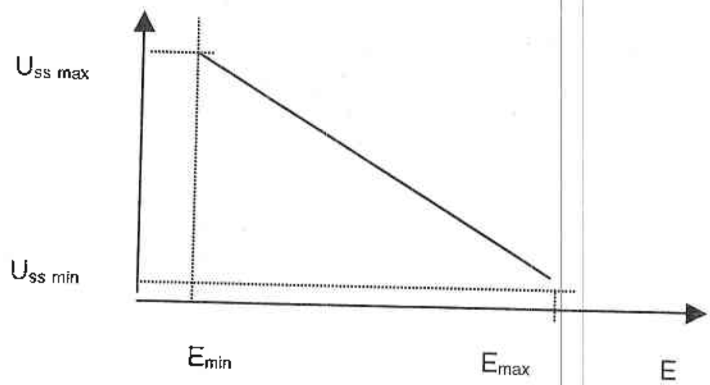

Fig. 2

Since the discharge time constant of peak detector T_{pd} is big enough, its voltage U_{pd} does not change essentially within one frame T_{fr}. This voltage is amplified in the direct-current amplifier 6 by the amplifying coefficient K_a

and is then averaged in the low-frequency filter 7, whose time constant T_f is big enough ($T_f >> T_{fr}$).

In the considered flow chart, the amplitude of the output voltage of the peak detector in a stable mode will be:

(1) $$U_{pd} = U_{vid} K_{va} K_d.$$

The voltage amplitude of the signal slice will be:

(2) $$U_{ss} = U_{ss\,max} - U_{vid} K_{va} K_a K_d = U_{ss\,max} - U_{va} K_a K_d.$$

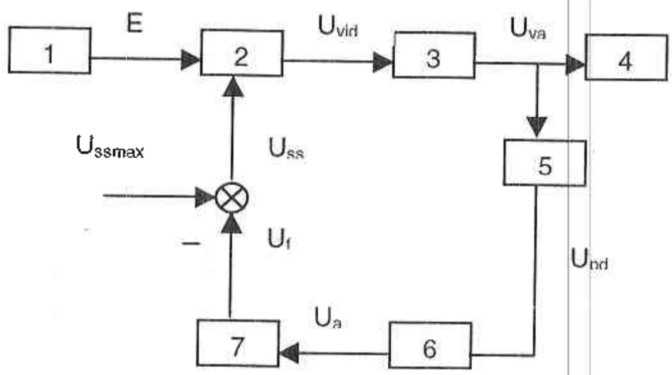

Fig. 3

From equality (2), the maximal amplifying coefficient of the direct-current amplifier in the ACS may be determined:

(3) $$K_{a\,max} = (U_{ss\,max} - U_{ss\,min}) / K_d U_{va\,min}.$$

In the cases where K_a is bigger than the coefficient obtained from formula (3), the ACS system will be unstable. Then, its oscillations could be removed provided only the time constant obtained from formula (15) is very big (2 - $3T_{fr}$). In this case, the system becomes so inert that it can not respond to possible rapid changes in the object's luminosity (e.g., changes within time interval 3 - $5T_{fr}$).

If the regulation characteristic of the television sensor (vidicon and video amplifier), shown in Fig.4 is assumed linear, that it can be written in the following way:

$$K = K_{min} + \alpha (U_{ss} - U_{ss\,min}), \tag{4}$$

where: K - the transmission coefficient of the television sensor;
α – the steepness of the control characteristics, and

$$\alpha = tg\,\varphi = (K_{max} - K_{min}) / (U_{ss\,max} - U_{ss\,min}). \tag{5}$$

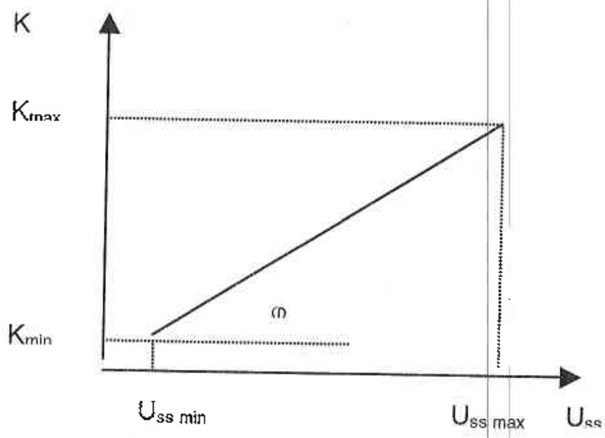

Fig. 4

Usually, the transmission band of the television sensor is much greater that the transmission band of the ACS. Therefore, it may be assumed that the amplitude U_{va} varies simultaneously with the change of the sensor amplifying coefficient, which is determined by U_{ss}, whose operating range is: $U_{ss\,min} < U_{ss} < U_{ss\,max}$.

In practice, in preliminary calculation, the following parameters should be assessed: the transmission coefficient of the television sensor, the range within which it should change, and the steepness of the control characteristics. Here, the following initial data is used: the possible change of illumination of the vidicon target by the bright point object (it should not exceed the illumination's work range, indicated in the vidicon certificate) and the range of voltage variation of the signal slice (also indicated in the vidicon certificate).

The output amplitude of the video amplifier will be:

(5) $$U_{va} = KE,$$

where E is the target illumination in lx. Therefore, the maximal and the minimal value of the transmission coefficient, accounting for the work of the ACS, will be:

(7) $$K_{max} = U_{va\ min} / E_{min},$$
(8) $$K_{min} = U_{va\ max} / E_{max}.$$

This coefficient will change within the range:

(9) $$\Delta K = K_{max} - K_{min} = (U_{va\ min}E_{max} - U_{va\ max}E_{min}) / E_{max}E_{min}$$

Provided the frame frequency is great enough, so that the ACS regulation time T_{reg} is much greater than the frame time, i.e. $T_{reg} >> T_{fr}$ [2], with changing the object's brightness, the voltage of the signal slice will be expressed as follows:

(10) $$U_{ss}(t) = U_{ss\ max} - K_aKEe^{-t/tpdd}(1 - e^{-tf}).$$

Since in television sensors the frame time is preset, the discharge time constants of peak detector and filter may be represented in the following way:

(11) $$t_{pdd} = aT_{fr}\ , \qquad t_f = bT_{fr},$$

where a and b are arbitrary positive constants.

From (10) and (11), the voltage variation of the signal slice corresponding to an illumination change of ΔE will be:

(12) $$\Delta U_{ss}(n) = K_aK\Delta Ee^{-n/a}(1 - e^{-n/B}) > 0,$$

where n = 1,2,3... is the number of frames upon change of illumination by ΔE.

The values of a and b are chosen by a compromise. The greater the value of a and the smaller the value of b, the more rapidly will U_{ss} achieve its stable value. With very great values of a the reactivity of the ACS system decreases, and with very small values of a, it becomes unstable, whereas within one frame, the following inequality is fulfilled:

(13) $$\Delta U_{ss} < K_d K_a \Delta U_{va}.$$

From (6) and (12) it follows that the following conditions must be satisfied:

(14) $$a < - 1/ \ln K_d,$$

(15) $$b > 1/ \ln(1 - K_d e^{1/a}).$$

So that the ACS system might preserve its stability and sufficient adaptivity.

Conclusion

1. A flow chart of the automatic control system of vidicon sensitivity at maximal illumination of the target is proposed. The system may be used in television coordinators to determine the coordinates of various space objects.

2. An analysis is made and the major system parameters are defined: transmission coefficient and time constants.

References

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2. Г р и в и ц к и Б. Х. Автоматические системы радиотехнических устройств, Госэнергоиздат, 1962.

АВТОМАТИЧНО РЕГУЛИРАНЕ НА ЧУВСТВИТЕЛНОСТТА НА ВИДИКОНА В ТЕЛЕВИЗИОНЕН ДАТЧИК НА АВИОКОСМИЧЕСКИ СИСТЕМИ ЗА УПРАВЛЕНИЕ

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Резюме

В настоящата работа е предложена блокова схема на система за автоматично регулиране чувствителността на видикона в телевизионен датчик, която позволява достигане на максимална възможна точност при определяне на координатите на ярки точкови обекти. Определени са основните параметри на системата, които осигуряват нейната устойчивост и бързодействие.