Chapter VI

DISCUSSION

From the experiment, it is seen that the system cannot correctly track the sun because of some errors due to disturbances and nonlinear characteristics such as the backlash of a gear train. The disturbances can be classified in two categories, the internal and external disturbances. The internal disturbance is the effect of noise from a.c. power supply. The external disturbance is the wind effect.

The noise from the a.c. supply has an effect by the system itself on the correction of the control signal. This noise can be reduced to a certain degree by the very narrow bandwidth of the system. However, when a battery is used as a power supply, this effect can be completely eliminated. The effect of a gear backlash, which is practically impossible to eliminate entirely, yields the error angle of the tracked position. The average error angle of the system in one revolution is ± 1 degrees.

The wind acts as a disturbing torque to the driving torque of the motor. This effect results in slowing down of the speed of the moving parts and makes the error angle of the tracked position due to the combined effect of the gear backlash. If the torque generated by the wind at the moving part is greater than 100 oz.-in. which is the maximum torque of the motor, the motor and the gear will be damaged. The effect of the wind and gear backlash sometimes causes the system to oscillate. However, the tracked position of the system can automatically be corrected by the effect of feedback.

To reduce the wind effect, the design must be modified as follows :

1. Reduce the range of the moving part.

or 2. Use the motor with a higher speed and reduce to the desired speed by using gear trains. The driving torque will be increased. The disturbing torque from the wind will be reduced. The moving part can be designed with a higher load.

The combined effect of the load inertia and the gear backlash can also cause an error in the tracked position and oscillation of the system. However, a low speed and a large time constant of the motor can reduce this effect.

The system is designed to operate efficiently within the solar radiation range of 180-400 W/m^2. The minimum light intensity which the system can operate is 30 W/m^2 (by experiment). The position of the detectors need not be located at the ends of the lever. They can be located somewhere on the lever within the limit that the lever must have balanced load. Another photovoltaic cell used as is the phototransistor. However, the solar cell has more advantages :

1. it can generate its own voltage.
2. it has an unlimited life.
3. its characteristic is not sensitively changed with a change in the ambient temperature.

The zero-crossing detector and the adjustable-voltage-of-dead-zone are used to compensate the nonlinearity of the motor. The other method can be acheived by setting one cell at angle = 45^o and the other one at angle which is less than 45^o. This angle can be computed as follows :

$$\text{error voltage (V)} = \frac{\text{Dead zone voltage}}{\text{Gain}} .$$

$$= \frac{4 \cdot V}{8,000} .$$

$$= 0.0005 . \quad \text{Volt}$$

$$\text{From} \quad V = V_2 - V_1 .$$

$$= V_m(\cos\theta_2 - \cos\theta_1) .$$

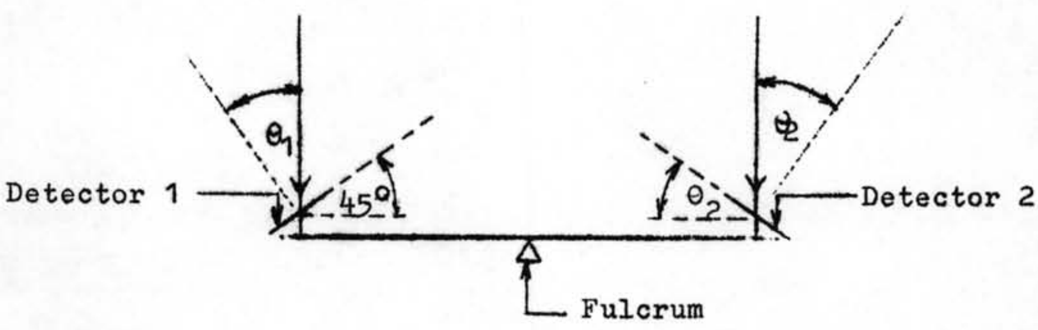

Figure 6.1. Detector Angles.

$$\theta_2 = \text{arc cos}\left[\frac{V}{V_m} + \cos\theta_1\right],$$

$$= \text{arc cos}\left[\frac{0.0005}{0.5} + \cos 45^{\circ}\right],$$

$$= \text{arc cos}\ (0.7081),$$

$$= 44.92^{\circ}.$$

Then, the other angle must be set at an angle of 44.92°.

In practice, it is very difficult to set this angle correctly. The deviated angle ($\Delta\theta$) yields a change in the dead zone voltage. The proof can be shown as follows :

From $$V = V_2 - V_1,$$

$$= V_m \cos(44.92^{\circ}+\Delta\theta) - V_m \cos(45^{\circ}),$$

$$= V_m\left[\cos(44.92^{\circ}+\Delta\theta) - \cos 45^{\circ}\right],$$

$$= 0.5\left[\cos 44.92^{\circ}\cos\Delta\theta - \sin 44.92^{\circ}\sin\Delta\theta - \cos 45^{\circ}\right],$$

$$= 0.35405\cos\Delta\theta - 0.35306\sin\Delta\theta - 0.35355.$$

Since $$\Delta V = V - \text{error voltage},$$

$$= 0.35405\cos\Delta\theta - 0.35306\sin\Delta\theta - 0.35405 - 0.0005,$$

$$= 0.35405\cos\Delta\theta - 0.35306\sin\Delta\theta - 0.35405,$$

$$= -0.35306 \times \frac{\pi}{180}\Delta\theta,$$

$$= -0.006162\Delta\theta.$$

Then, the dead zone voltage is changed to a new value.

$$\text{Change in dead zone voltage} = 8{,}000 \times \Delta V ,$$
$$= 8{,}000 \, (- 0.006162 \, \Delta\theta),$$
$$= - 49.3 \, \Delta\theta \quad \text{(approx.)} .$$

If this voltage is positive, the dead zone voltage will be greater than 4 volts and the system will track ahead the position of the sun. On the other hand if it is negative, the dead zone voltage will be less than 4 volts. Consequently,the system will track behind the position of the sun.

In a cloudy day, the detectors receive radiation not only directly from the sun, but also from the clouds. The detectors will not detect the right position of the sun. The system tracks in another direction. So, the system will operate unsatisfactory in the cloudy day.

Consider the response of the system. The analysis of the system on analog computer yields the following results :

1. Neglect the effect of gear backlash, the system responds to an input immediately after the input is applied.
2. With an increase in the gear backlash, the system takes some time before it follows the input. This time delay is increased with an increase in the gear backlash.