Implementation of Dual-server Switching for Shipborne ACU Under Dynamic Tracking Condition

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***Abstract*—The antenna control unit(ACU) is one of the major constituent parts of shipborne antenna servo system. At present, the dual-server hot-backup technology has been applied to ACU, but the switching between the host and the backup would cause larger step change during the process of dynamic tracking and it could bring about the loss of tracked-target, which would result in the weakness of hot-backup function. To this point, this paper represents the working principle of auto-tracking loop and host-backup switching and analyses the reason of step change. Then an novel approach is presented to realized the smooth switching of ACU under dynamic tracking condition via memory tracking in order to accomplish the continuous output of speed command to antenna within switching period, by which the antenna could track the target stably. The results of experiments indicate that the maximal error voltage is less than 0.08V, which enhances the reliability of facility effectively.**

Keywords—antenna control unit(ACU), dynamic tracking, dual-server switch, step change, speed command

I. INTRODUCTION

ACU is one of the major constituent parts of shipborne antenna servo system and requires high level of facility reliability and working stability[1]. To improve the reliability of ACU, redundant design, especially hot-backup design, is one of the most effective methods. When the host breaks down, the backup will run in order to reduce the fault time of system[2-3]. At present, the dual-server hot-backup technology has been applied to ACU, but the switching between the host and the backup was allowed merely when the antenna was on standby. If switching conducted during the process of dynamic tracking, it would cause larger step change and bring about the loss of tracked-target, which would result in the weakness of hot-backup function. To this point, this paper analyses the reason of step change and presents an novel approach which can realize the smooth switching of ACU under dynamic tracking condition to ensure that the antenna could track the target stably.

II. WORKING PRINCIPLE OF TRACKING LOOP AND DUAL-SERVER SWITCHING OF ACU

A. Tracking Loop

Auto-tracking is one of major working mode of antenna servo system, especially main tracking. When the main tracking loop runs, the motion of tracked-target creates the error, antenna servo system gets these error-signals from the radar receiver or baseband and drives the antenna to move in order to reduce the error via digital processing and amplification to complete the auto-tracking. In the loop, the feed source and receiving devices are the feedback measurement and comparison links. At present, digital PID position regulator is adopted in shipboard equipment[4]. The signal flow diagram of error voltage is illustrated as *Fig. 1*.

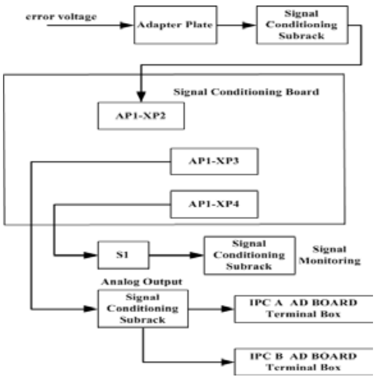


Fig. 1. The signal flow diagram of error voltage

As can be seen that the error signal passes through the signal conditioning unit and then is transmitted to A and B frames at the same time. Therefore, even if A-frame is online, B-frame can receive the same error voltage signal. As a result, the same error signal is equivalent to the same loop input of A and B frames, and it is the basis of switching between two frames under the condition of dynamic tracking.

B. Working Principle of Dual-server Switching

The host and the backup are defined as A-frame and B-frame and they can be switched via pressing the "A/B" key on control table. The switching signal transmits through the key control unit and the signal conditioning and switching unit to change the online state from A-frame to B-frame, as a result, it can ensure that only one frame of ACU, which can send data and commands outward, is online at the same time, meanwhile, both of them operate simultaneously and receive data. Two frames of ACU synchronize the data and state by adopting the real-time data transmission via network cable so that all data are equal to each other. When A-frame turns to the main tracking mode, the tracking loop of B-frame turns to the main tracking loop simultaneously, what ensures the consistency of both two frames. Because the port between ACU and drive device is query-based, only online host can reflect the status and data of drive device[4]. The constitution of main facility is shown as *Fig. 2*. The signal flow diagram is illustrated as *Fig. 3*.

The Boolean type signal is chosen as the switching signal. When the signal which is transmitted into key-control board is "1", the switching operation runs. Antenna-control software is developed by Borland Delphi[5]. At present, the code for switching is shown as follow:

```
procedure ABSwitchDeal;

begin
if(ABSwitchCommand<>ABSwitchLastCommand)then

    begin   AcuSetStandbyMode;

      end;

end;
```

It is obvious that the online host automatically switches to the standby mode in order to realize the dual-server switching. At this time, the speed command output is 0, until the switching is completed and the new host starts to send the speed command outward. In consequence, once the conversion time exceeds the time of drive device to maintain the speed command, the speed command received by the drive device will change to 0. If the antenna is under the condition of tracking, it will cause a large step, resulting in the antenna unable to track normally.

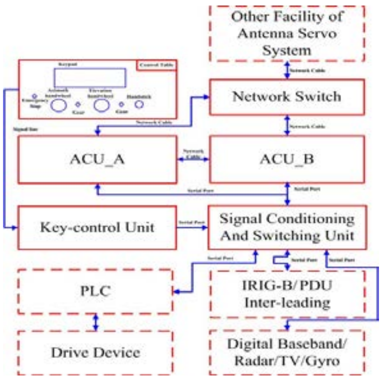


Fig. 2. The constitution of main facility. The contents with squares of full line are ACU facility and the other are corresponding facility.

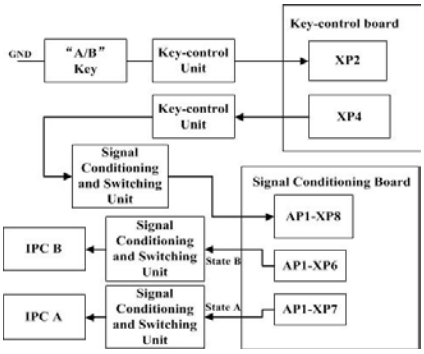


Fig. 3. The signal flow diagram of dual-server switching.

III. Realization Method of Smooth Switching under Dynamic Condition

A. Problem Analysis

As things are at the moment, the frequency of sending speed command of this ACU is 40Hz. The speed command receiving strategy adopted by the drive device is to keep the received speed command in a transmission cycle, that is, 25ms, and then the drive device receives the next frame speed command sent by ACU. While normal tracking, the speed command voltage of each frame does not change much, what is reflected in the movement of the antenna. However, when the processing time of switching process exceeds 25ms, the speed command will suddenly change to 0, and the antenna cannot operate normally. The longer the time is, the greater impact on the antenna movement is.

B. Memory Tracking

Memory tracking is an effective mechanism to keep the antenna running normally[6]. When the target signal is lost, memory tracking method is utilized to keep the antenna moving at the current speed for 5 seconds in order to keep tracking the target.

In view of the above problems, memory tracking method can be applied here. When switching between the host and the backup, the online host enters the memory tracking mode until the new host starts to work, enters the main tracking mode, and sends a new speed command to the driver. Code can be rewritten as follow:

```
procedure ABSwitchDeal;

begin      if(ABSwitchCommand<>ABSwitchLastCommand)
then

   begin  if MainTrkLock  then

       begin   if MemoryFlag  then

          begin

           MemoryFlag := True;

           if MemoryTime < 40 then

           MemoryTime := MemoryTime + 1

          AcuSetStandbyMode;

           end

         end

     end

end
```

In the code, the memory time is set to last 40 cycles, i.e. 1s, during which the antenna keeps its original speed and continues to move. When the antenna moves at a low speed, the memory tracking method has little effect on the target's retargeting. But when the antenna moves at a high elevation and a high speed, the speed change of each frame of the antenna will increase, and the accuracy of the memory tracking will decrease. In this case, the difference method can also be applied for smoothing.

C. Difference Method

Difference method [7] is that in the process of memory tracking, ACU calculates the digital-guide speed according to the digital-guide value, and does the first-order differential processing, which is converted into the voltage value and superimposed into the speed command of memory tracking, so that the speed command received by the drive device is similar to the main tracking state.

IV. EXPERIMENTAL VERIFICATION

In order to verify the availability of this modification, an antenna is used for experimental verification, where ACU operates and measure angle computer (MAC) records data status.

A. Experiment for Original Code

Without code modification, the target simulator is used to simulate the tracking target, and the appropriate time is chosen to switch the two sets of ACU. It is found that the error voltage has a larger value and there is an obvious step phenomenon. Select the partial record of the MAC data as shown in TABLE I.

TABLE I. MAC RECORDING DATA AFTER OPERATION OF ORIGINAL CODE

Time	***Earth Azimuth (°)***	***Earth Elevation (°)***	***Azimuth error voltage (V)***	***Elevation error voltage(V)***	***ACU state***	***ADU state***
20:36:00.700	21.107	6.81	0	-0.031	Main tracking	normal
20:36:00.800	21.101	6.795	0.005	-0.03	Standby	0
20:36:00.900	21.109	6.758	-0.059	0.064	Standby	0
20:36:01.000	21.115	6.732	-0.169	0.238	Standby	0
20:36:01.100	21.12	6.698	-0.283	0.415	Standby	0
20:36:01.200	21.127	6.67	-0.409	0.61	Standby	0
20:36:01.300	21.129	6.639	-0.54	0.807	Main tracking	normal

As can be seen in TABLE I. that the shortest switching time is 450ms, and the longest switching time is 550ms, that is, the 18~22 sending cycle, which is much longer than the speed holding time of the drive device. *Fig. 4* and *Fig. 5* can be obtained by analyzing the switching process in the tracking experiment.

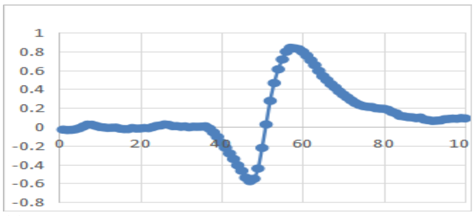
It can be seen from the figures that the error voltage has changed greatly. After the switching, the antenna will continue to deviate at a certain angle due to the inertia, and there is an overshoot phenomenon. Its azimuth and elevation angles change about 0.1 ° and 0.12 °, respectively, which is smaller than the half beam width of the S-band antenna, so the target is not lost. However, from the step size of the error voltage, it is obvious that it approaches the half beam width of C-band, and even exceeds the half beam width of X-band antenna.

TABLE II. MAC RECORDING DATA AFTER OPERATION OF CHANGED CODE

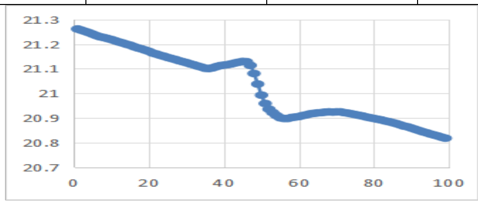
Time	***Earth Azimuth (°)***	***Earth Elevation (°)***	***Azimuth error voltage (V)***	***Elevation error voltage(V)***	***ACU state***	***ADU state***
08:38:22.500	21.103	6.81	0	-0.035	Main tracking	normal
08:38:22.600	21.091	6.803	0.005	-0.036	Memory	normal
08:38:22.700	21.08	6.794	-0.005	-0.022	Memory	normal
08:38:22.800	21.072	6.783	-0.017	-0.014	Memory	normal
08:38:22.900	21.068	6.771	-0.033	-0.005	Memory	normal
08:38:23.000	21.065	6.757	-0.057	0.005	Memory	normal
08:38:23.100	21.061	6.741	-0.072	0.02	Main tracking	normal

B. Experiment for Changed Code

Back up the original program, and memory tracking command is adopted instead of the original standby command. The target simulator is utilized to play back the last tracking experiment. At the end of the same tracking period, when switching conducted, it can be found that the step basically disappears and the error voltage changes in the normal range. Select the partial record of the MAC data as shown in TABLE II. Analysis of record data can be shown in *Fig. 6* and *Fig. 7*.

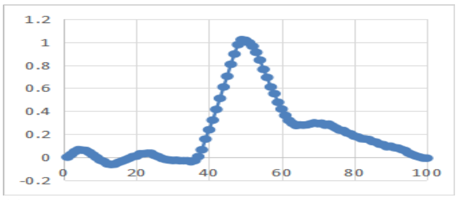


(a)

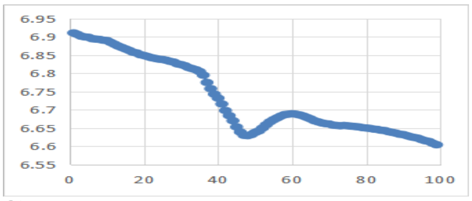


(b)

Fig. 4. When the original program is running, the voltage diagram of azimuth error and the diagram of azimuth angle change in the process of switching between two sets of ACU. The interval between each point of abscissa is 50ms, and the 36th to 45th points are the switching process. (a) represents the error voltage diagram, in which the ordinate represents the azimuth error voltage (V); and (b) represents the azimuth angle change diagram, in which the ordinate represents the azimuth earth angle (°).



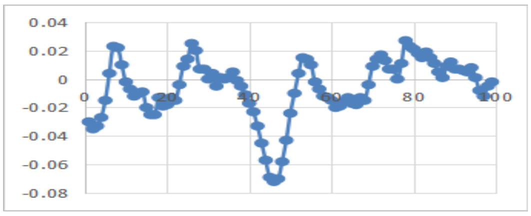
(a)



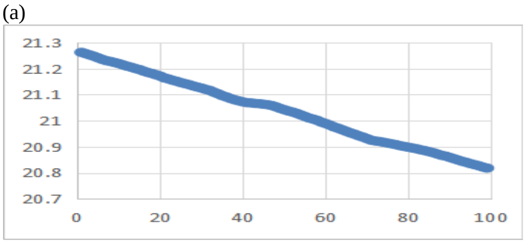
(b)

Fig. 5. When the original program is running, the voltage diagram of elevation error and the diagram of elevation angle change in the process of switching between two sets of ACU. The interval between each point of abscissa is 50ms, and the 36th to 45th points are the switching process. (a) represents the error voltage diagram, in which the ordinate represents the elevation error voltage (V); and (b) represents the elevation angle change diagram, in which the ordinate represents the elevation earth angle (°).

Comparing *Fig. 4* to *Fig. 7*, it can be illustrated that the change of azimuth and elevation error voltage in *Fig. 6* (a) and *Fig. 7* (a) is significantly smaller than that in *Fig. 4* (a) and *Fig. 5* (a). The maximum error voltage change is not more than 0.08v, basically the same as the normal change. And the angle changes smoothly, in addition, the amplitude is within the half beam width of C-band and X-band antennas, what proves its good stability.

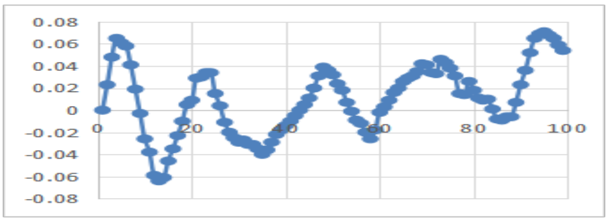


(a)

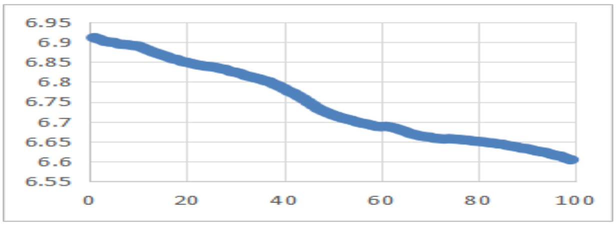


(b)

Fig. 6. When the new program is running, the voltage diagram of azimuth error and the diagram of azimuth angle change in the process of switching between two sets of ACU. The interval between each point of abscissa is 50ms, and the 36th to 45th points are the switching process. (a) represents the error voltage diagram, in which the ordinate represents the azimuth error voltage (V); and (b) represents the azimuth angle change diagram, in which the ordinate represents the azimuth earth angle (°).



(a)



(b)

Fig. 7. When the new program is running, the voltage diagram of elevation error and the diagram of elevation angle change in the process of switching between two sets of ACU. The interval between each point of abscissa is 50ms, and the 36th to 45th points are the switching process. (a) represents the error voltage diagram, in which the ordinate represents the elevation error voltage (V); and (b) represents the elevation angle change diagram, in which the ordinate represents the elevation earth angle (°).

V. Conclusions

In this paper, aiming at the problem that the current switching of dual-server ACU can only be carried out in standby mode, and the large step of antenna is caused by switching the online opportunities of the host and the backup in the tracking process, it is analyzed that the reason for the step is that the switching process takes up a long period of time, which will cause the speed command sent by ACU to the drive device to become zero, and an improved measure is proposed, that is, replacing the original program with the memory tracking mode. The experimental results show that this change can effectively avoid the large step of the antenna, and its error voltage variation is not more than 0.08v. It can meet the tracking requirements of S, C and X bands, and greatly improve the stability of dynamic tracking.

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