Double-Channel Tracking Performance Study in Spaceflight Testing & Controlling

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Abstract. The characteristic of double-channels tracking are with simple equipment, and high reliability. So it is applied to wide range in spaceflight testing & controlling system. AGC, time constant and sub & sum channel phase, has enormous influence on the function of double-channel tracking. When AGC the signal was chose inappropriate, the amplitude of double-channels channel signal will be in distortion. The sub signal will be damaged when double-channels channel signal and the differential & sum channel phase are not the same. And the modulation degree of double-channels signal will be decreased. Through analysis the basis of AGC time constant and the influence that differential & sum channel phase on double-channels tracking performance. It gives the principle and experienced dates for choosing AGC time constant, and it also introduces the methods and features of phase correction.

Keywords: double channels, time constant, phase.

1. Introduction
In the tracking system of double-channels, demodulation devices receive the intermediate frequency and difference signal from information. It can be transferred into demodulation for telemeter and measuring of digital signal after amplifying when passing AGC signal and sampling A/D. In this system, because the tracking time difference circuit has no signal or even small, and the sum circuit has closed-loop AGC. So the sum circuit AGC voltage is used to normalize the difference signal gain, and make sample for A/D. And the tracking circuit closed loop can be completed after detection of angle phase discriminator, D/A outputting error voltage to servo system [1].

Within the testing and controlling system of double-channels tracking, the adjusting of error voltage and demodulating of telemetering dates use the automatic growing control module by simultaneously. As though the two functions require differences for constant of automatic gain control. So it should be considerable overall to choose AGC time constant to fulfill the both requirements when spaceflight testing and controlling [2]. Under the system of double-channels single mono-pulse, because the difference channel and the sub are mutually independent, it exists the delay of inequality and the normalization processing of different signal will be a synchronization. So the function of tracking is decreased, it can’t be tracked if under serious situations [3]. In the process of adjusting and tracking, using the phase result of the carrier wave circuit tracking and sum carrying signal to achieve the demodulation of different signals. So it must use correction to remove delay inequality of sum signals.
and difference signals to ensure the consistence of receiving frequency and tacking ability. According to the above two questions, this article provides current suitable setting methods by analyzing testing dates and testing and controlling experiences.

2. Analysis of AGC time constant effect

In the system of spaceflight testing and controlling, more changing of the distance between aircraft and testing station, more changing of the space loss. So long distance testing signal that testing station receiving also has big change. It can be normally over 50dB. But on the demodulation module (such as error voltage adjusting, long distance data adjusting and so on) allows the limited signal level fluctuation. To compete the the that fast declining signal on adjusting reception, the receiver normally uses AGC circuit to make gain control, in order to keep the constant of IF signal level which is sent to demodulation module. At the same time, AGC module can also overcome the influence of level changes caused by multiple effect, polarization attenuation, atmospheric absorption and other factors on the system, and its dynamic range is generally required to be 60-80db or higher [4].

Typical double-channels receiver module flow chart is as figure 1. When receiver receives intermediate frequency and different signal, it uses the homologous signal with different signal and AGC channel carrying wave to complete the adjusting of angle error of different signal.

Figure 1. Receive demodulation module.

Once AGC detection circuit get the signal amplitude detection, digital filter and AGC time constant control, the amount of digital AGC control should be gone through D/A transferring simulate output to control voltage in order to the middle frequency analog channel AGC amplifier circuit. To ensure that the input signal dynamic range of A/D acquisition intermediate frequency signal level is stable after completing the AGC loop operation.

Time constant is an important index in AGC module. The smaller of the time constant is, the shorter that the stable time of the output signal, the less change of input signal level. Under the premise of stable operation of AGC module, the time constant of telemetry data demodulation is required to be as small as possible, so that when the signal level drops rapidly due to multiple effect, polarization attenuation and other factors, the signal level sent to the telemetry data demodulation module is more stable, which is benefit of telemetry data demodulation. The effect of time constant on error voltage demodulation can be analyzed by simulation experiment. The signal source amplitude modulation signal is used to simulate the double-channel and differential signals. The modulation frequency is 1Hz, the decline rate of radio-frequency signal is simulated, and the modulation system is 90%. The decline degree of radio-frequency signal is simulated. Changing the time constant of the AGC module make its range decreasing gradually. And as you can see from the data statistics, when enlarge the time constant, the output of the AGC voltage accord will equipped with poor road signal range. Dealing with relatively smooth for differential signal, filter some deviation from the larger point. When time constant changes into1000ms and 1ms, AGC voltage change values as shown in figure 2.
The error voltage of angle tracking is coming from differential channel, besides it depends on the normalization processing of sum channel and AGC voltage. So the AGC module is synchronized control on sum channel and differential channel. The smaller the time constant is, the smoother the signal will be. It is advantageous to the telemetry signal demodulation, but may lead to differential signal distortion. Therefore, demodulation error voltage requires time constant large enough to ensure that the error voltage can reflect the target motion state. In a double-channel tracking device, the relationships between error voltage and time constant are obtained by changing the AGC time constant. As is shown in table 1.

| time constant /ms | error voltage/v |
|-------------------|-----------------|
| 1                 | -1.78--1.81     |
| 10                | -1.78--1.82     |
| 100               | -1.77--1.86     |
| 1000              | -1.70--1.96     |

The experimental data shows that when the AGC constant is 1/f, which f is the fading rate of RF signal. It can meet the requirements of double-channel tracking on sum and differential signal without affecting the demodulation of telemetry data. In order to counter the effect of signal fading rapidly on the reception demodulation, AGC circuit is usually used for gain control. Time constant is usually the AGC ms magnitude. While the RF signal fading rate reaches more than kHz magnitude, if the receiver only AGC voltage than the maximum weighted combiner, the change of weighting coefficient will lag behind the change of the signal, a synthetic signal distortion, which can affect the receiving demodulation performance. Therefore the without-tracked AM should be checked from AGC in the intermediate frequency signal. After treatment and plus with AGC voltage, it can realize the gaining control with signal fading rapidly.

3. Analysis of sub& sum different channels
To realize the normalization the signal amplitude in phase and sum different channels. The controlled voltage by AGC, is also provided by the same channel intermediate frequency receiving module in the receiving demodulation module of angles and tracking unit. It can’t be achieved the normalization of the signal amplitude in phase and sum different channels if there exists delay in the channel. It can cause the decreasing of tracking performance [5]. We have get the data by testing the influence of voltage output in diagonal error of phase and sum different channels and opposite angles. Pls see the below 2nd sheet:
Table 2. Correspondence between error voltage and $\Delta \Phi$.

| $\Delta \Phi$ (°) | error voltage/v | $\Delta \Phi$ (°) | error voltage/v |
|-----------------|-----------------|-----------------|-----------------|
| 0               | -2.00~+2.00     | 30              | -1.72~+1.71     |
| 60              | -0.99~+1.00     | 90              | +0.00~0.01      |
| 120             | +1.00~1.00      | 180             | +1.99~2.00      |
| 150             | +1.70~1.71      |                 |                 |

In a typical system of double-channel monoplane with mono-pulse angle measurement, the different signal makes the azimuth error voltage and pitch error voltage on the same carrier in an orthogonal way by ORTHO. Ideally, azimuth error voltage and pitch error voltage should be orthogonal to each other if sharing with the same channel. As is shown in formula 1:

$$U = K[\cos \Phi + \sin \Phi]$$  \hspace{1cm} (1)

But in fact, the actual position and pitch error voltage should be as the formula 2 & 3. it is due to the difference between cable of phase and sum different channel and the shifting of circuit.

$$U_A = K_A \cos(\Phi + \Delta \Phi)$$  \hspace{1cm} (2)

$$U_E = K_E \sin(\Phi + \Delta \Phi)$$  \hspace{1cm} (3)

To test the phase value and sub & sum channels of one receiver. The phase change of sub & sum channel cable is approximately linear and proportional to the frequency. Therefore, the phase difference of sub & sum channel can compensate the delay caused by signal transmission of sub & sum channel through a phase correction unit which can realize the normalization of carrier phase of sub & sum signal.

Through the digital phase shifter, the phase correction unit can correct the local oscillator signal channel, and the carrier phase correction differential signal can be obtained accurately. The zero value and slope correction unit provide a way to adjust the system's claim and slope differences.

Firstly we should control the digital phase shifter within the phase (range 0-360°) and move the phase with definite phase interval when making phase correction. We should record the testing position of the pitch error voltage detection. At the same time, we need to do the vertical axis error voltage, capacity of the horizontal axis of carrier phase correction Angle error voltage curve fitting, automatic discriminant out a maximum Angle error, their phase is the phase of the maximum Angle error correction, the value into phase correction unit digital phase shifter, can accurate implementation and difference carrier phase correction. After the phase correction, the azimuth and pitch branches should be calibrated to strictly correct to make the differences between the error voltage slope of azimuth and pitch angle. In the procession of phase correction, according to the Angle error directional sensitivity coefficient, the control unit automatically judge after finding a maximum angle error of judging receive signal, and automatically calculate the azimuth and pitching angle error voltage slope correction, and placing the slope correction unit, after completing slope correction, making the angle error voltage output is to meet the requirements of the system-the sensitivity of angle error detection.

4. Summary

The double-channels tracking system is mostly used in aerospace in order to overcome the influence of receiving normal demodulation from high dynamic aircraft. So we add the AGC control technology. However, the time constant setting of AGC cannot meet the needs of tracking and demodulation. At the same time, it brought inconsistent problem for sub & sum channel phase. In conclusion, in terms of the above problems, i get the result that AGC time constant is relevant with the signal fading through
theoretical analysis, combined with the experimental data. To provide the reference for time constant of AGC I put forward the method by designing phase correction units to solve the relative influence on tracking after researching orientation and the principle of azimuth and pitch error generation.

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