SATER Modem Used in Microwave Time Transfer

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Abstract—**The paper introduces the microwave time transfer system between timekeeping laboratory in Lintong and time & frequency control laboratory in Pucheng of National Time Service Center. The distance between timekeeping laboratory and time & frequency control laboratory is about 71 km. The microwave time transfer system was reconstructed in 2007, in order to transfer time signal more precisely, the digital channel was added to the system which adopted SATRE Modem to modulate and demodulate 1pps signal. The time comparing data of the digital microwave time transfer system is measured by a counter, the data is sampled once an hour in about one month. Then the wrong data was processed by using some math methods before it is analyzed. By comparing the analyzed result of analog channel with digital channel, the conclusion was put forward at the end of the paper，including the reason that the microwave digital channel is more precise than analog channel and what cause its instability.**

I. INTRODUCTION

The microwave system is constructed between the NTSC (National Time Service Center) timekeeping laboratory in Lintong and the time & frequency control laboratory in Pucheng in 1980s for the construction of long-wave time service department in Pucheng. There are two main reasons [1].

Firstly, in order to monitor the broadcast time, the work clock of long-wave time service department is needed to be compared with the time base of timekeeping laboratory in real-time. Microwave transfer is of stability and high precision, which meet the requirement of high precise time transfer.

Secondly, in order that the atomic clock and signal is not disturbed by the strong electromagnetic field of broadcast station, the clock house of Time base should be far away from the broadcast station. The distance between timekeeping laboratory and time & frequency control laboratory is about 71km, and there is no obstacle on the transfer way. It is just suitable to microwave transfer.

It is proved to be very successful due to well operation for more than 20 years. But with the passage of time, the device aging lead to the performance declining, so the microwave time transfer system was renewed in 2007, the analog channel is renewed digitally, at same time, the digital channel was added to the system which adopted SATRE Modem to modulate and demodulate 1pps signal. The microwave time transfer system component is showed as Fig.1.

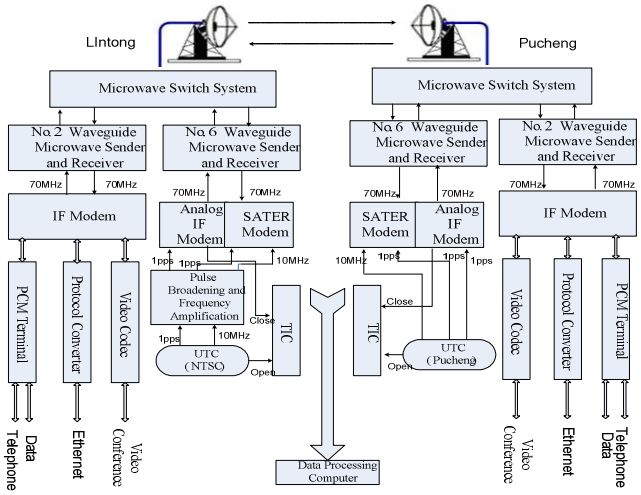

Fig.1 microwave time transfer system component

II. THE DATA COLLECTION, PROCESSING AND ANALYSIS

The data is collected and stored through dedicated software. We select the data from August 27th, 2008 to September 21st, 2008.

Firstly, the date is converted to MJD.

Secondly, the leap point of data array is corrected.

Thirdly, the linear error of system is corrected through linear fitting.

Fourthly, the gross error is rejected by using 3σ law [2].

Finally, the blank point is filled through Cubic spline interpolation [3].

The arranged data is showed as Table.1.

TABLE.1 ARRANGED DATA OF MICROWAVE TIME TRANSFER SYSTEM

MJD	UTC(N)-UTC(P) digital channel	UTC(N)-UTC(P) analog channel
54705.000	0	0
54705.042	0.14	-0.035
54705.083	1.17	0.735
54705.125	0.53	2.238
54705.167	0.59	1.592
54705.208	-0.2	2.797
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According to the arranged data, draw the polyline scattergraph. As Fig.2 shown.

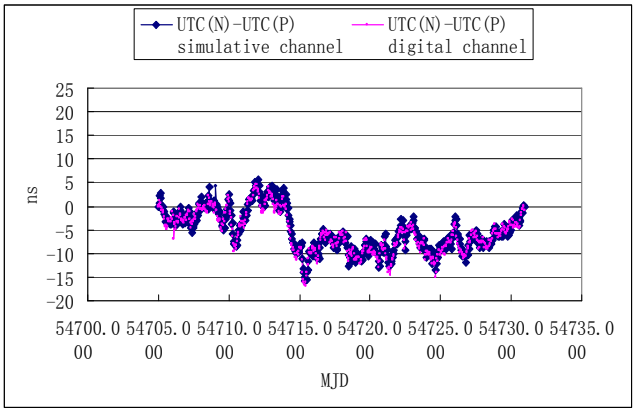

Fig.2 microwave digital and analog channel data polyline scattergraph

According to the Fig.2, we find analog channel data and digital channel data is similar, so we think that the data is real and can be used. We used Stable32 to analysis the data with 1 hour interval and get result, as Table.2 shown.

TABLE.2 COMPARING DIGITAL CHANNEL WITH ANALOG CHANNEL

Indicators	Analog	Digital
RMS	5.44ns	4.27ns
AVAR($\tau = 1H$)	3.35E-13	2.63E-13
TVAR($\tau = 1H$)	0.69ns	0.54ns

In the Table.2, the RMS reflect the comparing precision, the AVAR reflect the frequency stability[4], and the TVAR reflect the synchronization precision[5]. It can be seen that the digital channel is better than analog channel.

According to the arranged data, draw the microwave two-way polyline scattergraph. As Fig.3 shown.

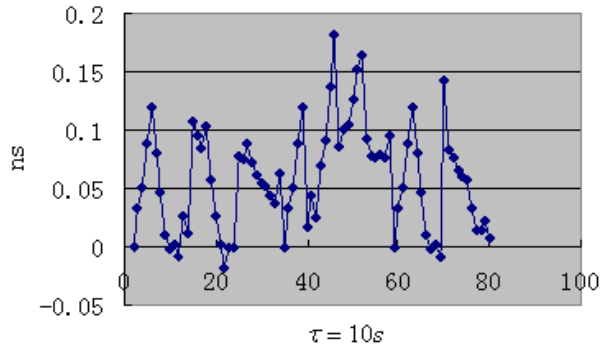

Fig.3 microwave two-way polyline scattergraph

We used Stable32 to analysis the one-way data and two-way data with 10 seconds interval and get result, as Table.3 shown.

TABLE.3 COMPARING MICROWAVE TWO-WAY AND ONE-WAY

Indicators	One-way	Two-way
RMS	0.100ns	0.045ns
AVAR ($\tau = 10s$)	5.41E-12	3.94E-12
TVAR ($\tau = 10s$)	0.03ns	0.02ns

It can be seen that the two-way operation is better than one-way operation.

III. CONCLUSIONS

The analysis result of microwave digital channel and analog channel show that digital channel has higher stability and precision. In the digital channel, two-way method is better than one-way method.

According to the microwave time transfer system component, the single difference between the digital channel and the analog channel is the IF part. The digital channel use SATRE Modem in which the Pseudo-code spread-spectrum technology is used to modulate signal. The analog channel use TV IF Modem in which the sub-carrier modulation method is used. It can clearly be seen the different modulation method lead to different comparing precision, frequency stability and the degree of synchronization.

Microwave links are sensitive to atmospheric conditions (rain, snow, antenna, vibration, etc) and multi-path effects. So two-way operation to null-out phase fluctuations is required. This means a feedback system and a continuously operating channel[6].

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