

Study on a New Time Transfer Method by Digital Satellite TV Signal Broadcasting

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Abstract— This paper is dedicated to studying on the new method of digital satellite TV time transfer service by DVB-S protocol. We present a new way that takes the advantage of pilot carrier information and symbol information to provide time transfer service. Because of the synchronization characteristics of symbol frame, we can insert time code information in the blank position of the pilot carrier information periodically. In the mean time, a kind of simplified data encoding method to show the complete time code message was introduced.

I. INTRODUCTION

The study on time frequency signal transfer by TV system focused on 70s ~ 80s last century.^{[1][2]} The ground transmission application research used by active insert and the time comparison used by TV broadcast satellite are mainly two methods. Under microwave link, the precision of passive time-synchronous is $\pm 1\mu\text{s}$, and the active precision is 100ns.

In the middle of 80s, active television time frequency broadcast test system was researched. It delivers the standard time to the user by the microwave network of television system, and the precision of timing service approach several microsecond. The precision of frequency adjustment have reached to $n \times 10^{-12}$ sec. However, some questions about analog Television broadcast time service are following:^[3]

- Standard time signal often breaks off.

- The time generated by CCTV standard clock should be synchronous with Nation Time Service Center standard.
- The precision of time service just stayed on millisecond order.
- Leap second and error code. The broadcast standard time is UTC, it needs to be adjusted every other year according to the international stipulation.

Time service uses analog satellite TV system to insert standard time frequency signal, time encode, satellite ephemeris and the other information among some row synchronous impulse in the period of field blanking, and transmit them to user nationwide by satellite with TV program. At the same time of receiving TV program, the time code can be extracted from TV signals to display receiving moment: hour, minute, second with designed extractor, and extracted satellite ephemeris, calculated the delay time from transmission point to receiving point of standard second impulse, it can be used to correct the standard second impulse and receive to acquire the standard time.^{[6][7]}

The analog TV technique is being replaced gradually by the digital TV developing in recently years. Therefore, traditional analog satellite TV time service technology should be replaced by digital satellite TV time service.

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It is introduced the traditional Television technology principle in Chapter 2 of this paper; Chapter 3 describes digital satellite Television standard and technology; chapter 4 gives out a method to insert time information among digital Television satellite signals.

II. SATELLITE TV TIME SERVICE

A. Satellite time service technology

The satellite position on the GEO should be given accurately in usual high precision satellite TV time service. First, more than 3 cities should be chosen that have long distance between each other and also have satellite TV broadcast station, and the time broadcast control system should be built separately in these cities. Time broadcast control system includes standard time frequency source, TV time frequency signal coder and TV time-frequency signal mixer. One of these time broadcast control stations broadcasts standard time signal as the main station whose time-frequency source is one of cesium atom clock, rubidium clock or hydrogen atom clock, and time code is related to time-frequency source. Others TV station takes rubidium clock or hydrogen atom clock as the local time-frequency source^[4].

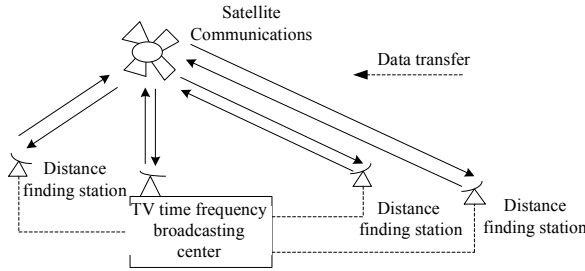


Figure 1. Satellite standard time service system

Local time is synchronized with standard time used double transmission method by satellite. Time broadcast control system may be built in satellite ground station or the broadcast center of TV station. If it was built in TV station, generally speaking, there are some distances between satellite ground broadcast station and TV station, so when transmitting time is calculated, it should be considered the delay time between that tow stations.

In Fig2, atom standard frequency source is in main station, which is the atom clock and controlled by National Time Service Center time, substation keeps the same steps with main station. Time generator is digital multiplexer which is generated by the TV signal mode which is analog or digital. The mixing signal is broadcasted by the transmitter of satellite ground station.

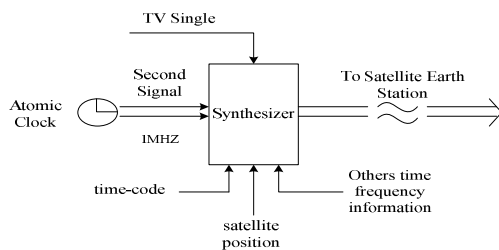


Figure 2. Time frequency signal emission

B. Analog TV satellite time service

The template is used to format your paper and style the text. All margins, the traditional television satellite time service technology, which uses standard time frequency signal, time code, satellite ephemeris and other information inserted analog satellite TV signal where field blanking is periodic between some rows synchronous impulse, then those information is transmitted with TV program to users by television satellite. This information is being extracted while TV program is being received to show the receiving time (hour/minute/second) by time code. By calculating transmitting time of standard second impulse between sending and receiving time via satellite with satellite ephemeris, then a standard second information corrected by transmitting time can be got.

China analog Television satellite time service technology is taking the 16th and 329th row at the period of Television signal field blanking as the time and frequency broadcast row. CCTV has inserted 1MHz standard frequency, 1pps, hour, minute, second time code in the 16th row of CCTV1 and CCTV2 program, 1MHz standard frequency in the 329th row, the signal format as Fig.3 shown^[5].

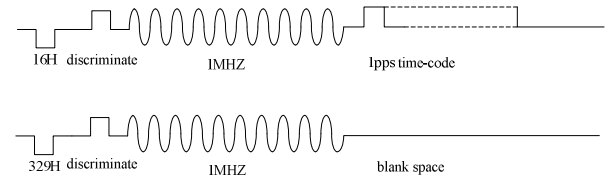


Figure 3. The format of the inserted time-code

III. THE METHOD BASED ON DTV SATELLITE SIGNAL

Different from in the analog satellite TV system, it is difficult to apply time service based on DTV Satellite Signal without any change in the DVB^[7] system. The DVB-S second version shows some characteristics that make it be available.

A. Digital TV time service based on DVB system

1) DVB-S2 system

The DVB-S2 standard is the upgrade version of DVB-S standard^[8], which almost has the same concept with DVB-S. Moreover, it has a lot of improvement. DVB-S2^[9] modulation system is shown as following:

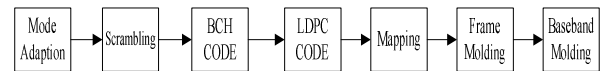


Figure 4. DVB-S2 modulation system block diagram

2) DVB-S2 frame structure and method of frame synchronization:

Figure 4 shows that DVB-S2 frame is including frame head, payload and pilot. 26 bits SOF (start of frame) and 64 bits PLSC (physical layer signaling code) compose frame head. Payload is separated into S slots and each slot has 90 signs. Payload is inserted each 16 slots by one pilot including 36

signs if it is needed. The modulation of payload has 4 modes QPSK, 8PSK, 16APSK and 32APSK which are using concatenated codes, outer coder is LDPC and inner coder is BCH. Tow length of a frame: 64000bits and 16200 bits.

Frame synchronization is depended on the following characteristic of the frame head analysis. The modulation mode of frame head is (pi/2) BPSK, constellation mapping and then separated into I, Q :

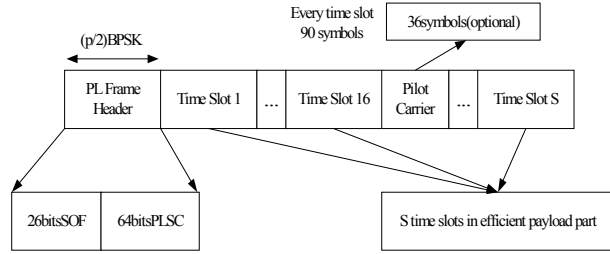


Figure 5. the frame structure

$$I_{2i-1} = Q_{2i-1} = (1/\sqrt{2})(1 - 2y_{2i-1}) \quad (1)$$

$$I_{2i} = -Q_{2i-1} = -(1/\sqrt{2})(1 - 2y_{2i})(i = 1, 2, \dots, 45) \quad (2)$$

Which, y_k is binary code of frame head input

$$Z_k = I_k + jQ_k (k = 1, 2, \dots, 90)$$

B. Time code insertion method

DVB-S2 frame is including frame head, payload and pilot. Payload modulation is QPSK, and is inserted each 16 slots by one pilot including 36 signs, each pilot is 72 bits, the information of clock may be inserted in the pilot. The encoding method is familiar with the insertion TPS into DVB-T frame.

The information of pilot is free carrier wave without time code and 1PPS information, also free carrier wave with 1PPS information, modulated by time code without 1PPS information in this pilot. The modulate information is as following:

The first bit in this pilot is symbol which is the beginning of zero sign. Each pilot has 36 signs from NO.0 to NO.35, including currently time (second, minute, hour, day). Code information is adjusted with modulation mode. Under QPSK, second information form 00 to 59 is separated into 2 parts, one is second and the other is decade second, denoted by the sign respectively. Second occupies 4 signs from 1 to 4, and decade second occupies 3 signs from 5 to 7. Minute information form 00 to 59 is separated into 2 parts, one is minute and the other is decade minute. Minute occupies 4 signs from 9 to 12, and decade minute occupies 3 signs from 13 to 15. Hour information form 00 to 23 is also separated into 2 parts, one is hour and the other is decade hour. Hour occupies 4 signs from

17 to 20, and decade hour occupies 2 signs from 21 to 22. Day information calculation sums days from 1st Jan to today. Day information form 000 to 365 (leap year is 366) is separated into 3 parts, one is day, the second is decade day and the last one is hundred day. Day occupies 4 signs from 24 to 27, decade day occupies 4 signs from 28 to 31, and hundred day occupies 2 signs form 32 to 33. And the last 2 free signs is the symbol separating the next time space.

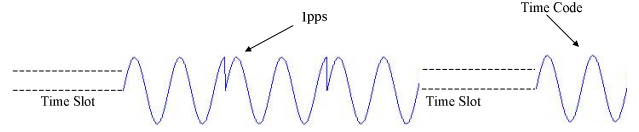


Figure 6. Insertion of Time and Frequency

IV. CONCLUSION

The key method of time service using digital satellite TV signal is that time-frequency be inserted without any change in digital TV system, and the periodic pilot insertion is very important to this timing service. This paper proposes a probable method using the periodic idle pilots in the broadcasting signals of DVB-S second version to make time service by DTV satellite signal become a reality.

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