Design of Beidou timing module

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Abstract. The Beidou timing module receives the Beidou Satellite Information, calculates the time and positioning information, transmits the time and timing information through various external interfaces, and has the function of short message forwarding. This paper presents a system design scheme for the Beidou time-keeping module, which uses adaptive filter switching technology to achieve accurate and stable time-keeping results, by automatically switching synchronous clock source (Beidou, IRIG-B (DC), internal high-stability crystal Oscillator) to complete time service, Beidou module with seamless switching, short-circuit protection, fault detection and diagnosis, health management and other functions.

1. Introduction
The navigation system can provide very accurate time information and has excellent long-term stability and accuracy[1], but due to the ionosphere influence, troposphere influence and multipath effect, the time information of satellite has short-term jitter[2][3][4], the local constant temperature crystal oscillator is not affected by various factors in the propagation process, and has strong short-term stability but poor long-term stability. Therefore, the timing equipment combines the advantages of two frequency sources, generates time information that is good for both short-term and long-term stability[5].

The serial time code IRIG-B is widely used in aerospace and industrial control fields because of its many advantages, while the DC time code B has higher synchronization precision in short distance transmission. In the research of time synchronization technology based on GPS, the existing problem is that the precision and stability are not very good. Some papers put forward to use Direct Digital Frequency Synthesis to achieve high precision clock output, at present, the general method is to get the phase difference between 1PPS of Crystal Oscillator and 1PPS of GPS receiver by phase detector, and to Control Crystal Oscillator by D / A circuit into analog signal[6].

In view of the above research background, this paper puts forward a reasonable system design scheme, including the use of adaptive filter switching technology to achieve accurate and stable Beidou positioning and timing results, the multiple check technique is used to verify the clock source (Beidou and B Code) to ensure that the clock source used for timing is accurate and reliable.

2. Hardware design

2.1. The composition of Beidou module
The Beidou module is designed separately, which is composed of Beidou main board card, Beidou Antenna and cable. Beidou main board card is composed of Beidou Unit, Integrated Navigation Processing Unit, Main Control Processing Unit, time-frequency Signal Processing Unit, NTP unit, PTP unit, power unit and interface unit. The schematic block diagram of the Beidou module is shown...
in figure 1.

The Beidou Antenna receives the beidou-2 satellite signal and sends it to the Beidou unit through cables. The Beidou Element is located and timed according to the B1 / B3 frequency point signal. The positioning and timing data are sent to the integrated navigation processing unit to complete the integrated navigation, and then the processed data of the integrated navigation unit are sent to the main control processing unit, which outputs the protocol data through the interface unit, at the same time, the short message communication function of RDSS is completed in response to the short message transceiver protocol of Beidou serial port.

The time-service data of the Beidou unit is fed into the time-frequency signal processing unit through the serial port, and the time-frequency signal processing unit manages and switches the three clock sources of Beidou time, b code and constant temperature crystal oscillator, ensure the accuracy and stability of local time. The time information is sent to the Master Control Processing Unit, and then the master control processing unit outputs through the interface unit to complete the time service. The second signal is output through the second pulse interface, and the second signal of 11 different interface standards is obtained.

The main engine Power Supply Unit Receives External 12V DC power supply, produces different internal voltage values, and has the function of short circuit protection to the input power supply.

The Interface Unit completes the level conversion and impedance matching of all interface signals.

2.2. Beidou module design

2.2.1. Beidou module selection

2.2.1.1. Beidou unit
The Beidou unit adopts a receiver developed by Jiangsu Automation Research Institute. On the basis of the technology of DF31B Beidou communication equipment, the design idea of chip and integration
is adopted, it realizes the miniaturization and low power consumption of the Beidou unit and meets the technical requirements of the Beidou module. The schematic block diagram is shown in figure 2.

![Receiver Block Diagram](image)

Figure 2. Receiver Block Diagram

The satellite signal is transmitted to the receiving antenna through space, and is sampled in the receiving channel by a band-pass filter, a low noise amplifier, a down converter and a central amplifier to the AD to form a digital signal. In the baseband signal processing unit, the sampled satellite signal is searched and captured, the carrier loop is captured and tracked, the satellite signal is de-amplified, and the data synchronization, frame synchronization and data demodulation are completed. In the baseband signal processing unit, the storage and presetting of carrier and code phase, lock-out recapture, signal-to-noise ratio statistics, pseudo-range, carrier phase and Doppler are also accomplished, the navigation and positioning calculation, timing calculation and timing signal output are carried out for the demodulated navigation message, and the protocol navigation data are exported through the navigation information processing unit.

2.2.1.2. Integrated navigation processing unit
The Navigation Processing Unit adopts the integrated navigation module developed by Jiangsu Automation Research Institute. Integrating gyroscopes, accelerometers and Barometers, together with the velocity and position information output by the beidou-2 receiver, the real-time attitude, velocity and position information of the carrier can be quickly solved, and the integrated navigation function can be realized, it also has the function of dead reckoning without satellite signal.

2.2.1.3. Time-frequency signal processing unit
The time-frequency signal processing unit adopts FPGA chip. Crystal Oscillator is the production of ROCK company. DA uses Ti's DAC8560. The block diagram of the time-frequency signal processing unit is shown in figure 3.

2.2.1.4. NTP Unit
The NTP unit is designed using two mcu, each of which achieves one NTP timing output. NTP Network Time Protocol Ntpv4, in line with the RFC5905 Standard, NTP Network Time Level 1 exchange accuracy ≤10ms.

2.2.1.5. PTP Unit
PTP precision network timing function, accuracy ≤10 S. It can meet the requirement of PTP precision network timing information accuracy ≤100us when receiving / transmitting time information through E1 in secondary exchange.
2.2.2. Interface design
The interface unit mainly realizes the mutual conversion between TTL level and RS232 level, the mutual conversion between TTL level and RS422 level, the mutual conversion between TTL level and RS485 level, and uses the serial port / Ethernet conversion module and the coupler to realize a universal interface, the interface of management network is realized by using dedicated PHY interface chip and Coupler, the network interface signal of NTP unit is output by Coupler, and the 5V and 3.3V produced by the power supply unit of host computer are output by half voltage to health management sub-card, the temperature sensor and EEPROM devices are arranged and connected to the health management sub-card with an I2C interface. The interface unit is realized as shown in figure 4.

3. Key technology
(1) An adaptive filter switching technology is used to realize the accuracy and stability of Beidou unit positioning and timing results
When the dynamic is small, the Kalman filter algorithm is used to solve the problem. When the dynamic is large, the least square algorithm is used to solve the problem, select the median as the current second timing correction value, to ensure the accuracy and stability of the positioning timing results.

(2) The clock source (Beidou and B Code) is verified by multiple check techniques to ensure the accuracy and reliability of the clock source used for time service
When the Beidou Time Service is valid, the Beidou second signal and the second signal generated by the local constant temperature crystal oscillator are used for phase discrimination processing. When the Beidou time service is invalid and the B Code input is valid, the B Code Second Signal and the second signal generated by the local constant temperature crystal oscillator are used to process the phase discrimination, the closed-loop control of the crystal oscillator with adaptive algorithm ensures the accuracy and stability of the timing results.

(3) The technology of seamless switching when the reference source of time service changes
In order to avoid the jitter of the timing result caused by the switching of the time service signal source, an adaptive filtering algorithm is adopted because the accuracy of different second signals is different, in the closed-loop control, the filter bandwidth and frequency correction parameters are adjusted according to the phase discrimination results to realize the seamless switching when the reference source changes.

(4) Simplified design
Adopting mature standardized unit, the chip with high integration and small size package is designed to meet the design requirements of miniaturization, low power consumption and low heat dissipation.

4. Conclusion
In this paper, the system design process of the Beidou timing module is presented according to the high precision requirement of the Beidou navigation system. The module adopts the adaptive filter switching technology to realize the positioning and timing results of the Beidou Unit, automatic switching of synchronous clock source (Beidou, IRIG-B (DC), internal high-stability crystal oscillator), and through a variety of external interfaces to complete the transmission of time-keeping information, while the Beidou short message forwarding function, the module system design is reasonable, it has a good application prospect.

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