GPS Time Server Clock Application in Power Plant & DCS Synchronization

With the rapid development of computer and network communication technology, thermal power plant automation system of digital and network era has arrived. This aspect for the data exchange between control and information systems, analysis and application provides a better platform, on the other hand for all kinds of labels on the accuracy of the real-time and historical data time also put forward higher requirements.

Using price inexpensive GPS clock to unification of the various system clock, has been the standard practice in use in the design of thermal power plants. Within the power plant distributed control system (DCS), auxiliary system programmable controller (PLC), ChangJi monitoring information system (SIS), power plant management information system (MIS) of the master clock by suitable GPS clock signal interface, get the standards of TOD (minutes) when (date) (month) (year), and then according to their respective clock synchronization mechanism, from inside the system clock deviation limit within the scope of the small enough, so as to achieve the coordination of clock synchronization.

1.GPS Time Server Clock and Output

1.1GPS Time Server:

Global positioning system (GPS) established in 1978 by a group of the United States department of defense started to launch satellites, a total of 24 in 6 geocentric orbit satellite plane, according to the time and place, the visible satellite number on earth has been spotted in 4 to 11.

GPS clock is a kind of accept the low power radio signals of GPS satellite launch, calculated the GPS time receiving device. To obtain accurate GPS time, GPS clock must receive at least four GPS satellite signal, compute their 3 d position. After have concluded that the specific location, GPS clock just accept to 1 GPS satellite signals can guarantee the clock's accuracy as well.

As standard clock of coal-fired power plant, our basic requirements for the GPS clock is: at least eight tracking satellites at the same time, with cold and hot start time as short as possible, with a backup battery, has high precision, flexible configuration of the clock output signal.

1.2GPSTime Code Output:

Currently, the main power plant used in GPS clock output signal has the following three types:

1.2.11 PPS/1PPM:

The format of time output a pulse signal or every minute per second. Obviously, the clock pulse output contains no specific time information.

1.2.2 IRIG-B :

IRIG (the United States the system - the Range Instrumentation Group) with A, B, D, E, G, H several coding standard (IRIGStandard200-98). In clock synchronization is most used in the application of IRIG - B code, a BC level shift code (DC), 1 KHZ sinusoidal carrier modulation code (AC) format. IRIG - B signal output frame per second (FPS), each frame is long for a second. A frame (PPS) 100, a total of 100 yards yuan each element width 10 ms, by different pulse width element to represent the binary 0, 1 and is marked (P)

1.2.3 RS-232/RS-422/RS-485:
The clock output through the EIA standard serial interface sends a string to ASCII representation of the date and time of message, output once per second. Time can be inserted into the message state of parity, clock, diagnostics, etc. The output current top format, below 17 bytes sent for a instance of standard time:

1.3 GPS Time Server in Coal Power Plant:

Coal-fired power plants with numerous with the GPS clock synchronization system or device, such as DCS, PLC, replication, SIS and MIS, RTU, fault wave record device, microcomputer protection device, etc. When determining the GPS clock should pay attention to the following:

These belong to thermal control system, electrical system, professional, such as decided by the DCS vendor GPS clock to achieve time synchronization (usually) at present, in front of the DCS contract negotiations, cooperation between should be professional, determine the requirements of the clock signal interface. (GPS clock can configure different quantity, type of output module commonly, if cannot determine in advance relevant requirements, the corresponding terms of the contract should be adjustable leeway.)

Use a set of GPS clock device, whether each system should be based on the system clock interface with ease, system's geographical location and other comprehensive consideration. Each major such as the requirements of the precision of GPS clock signal interface type or large, can be configured GPS clock, this can reduce the containment between professional, can make the system clock synchronization scheme 2 is easier to implement. In addition, when the system are far apart between (such as water treatment workshop, desulfurization workshop far away from the control tower), in order to reduce the clock signal in long distance transmission of electromagnetic interference, also can be in situ single GPS clock. Set up the GPS clock can also help reduce clock malfunction caused by impact.

IRIG B code, high reliability, interface specification, such as clock synchronization when the interface is optional, can be preferred. But note that the IRIG - B is the floorboard of the class B code, a coded modulation, do you have any specific CF and SBS, and divided into a variety of (such as IRIG - B000), so the clock receiving side should configure corresponding decoding card, otherwise unable to meet accurate clock synchronization.

(4) 1 PPS / 1 PPM pulse does not convey information TOD, but its synchronization precision, reason often used in SOE module clock synchronization. RS - 232 output time although use morer, but because of the top format, should pay special attention to in the design of confirm the clock signal and the receiver clock message format can be agreed.

(5) in thermal power plants has interconnection control and information system, but because of the system clock synchronization protocol may vary, so still need to access the GPS clock signal respectively. Even through the bridge connected to the unit DCS and utility DCS, if the clock synchronization signal with large time delay in the network, also should consider separately with GPS clock synchronization.

2、Siemens TELEPERMXP Time Synronization:

Here to Siemens TXP system as an example, take a look at how DCS internal clock in time synchronization.

TXP power bus is based on CSMA/CD Ethernet, on the bus has two master clock: real-time transmitter (RTT) and a AS620 and CP1430 communication/clock card. Under normal circumstances, RTT as the master clock TXP system, when the reason about 40 s, as backup clock CP1430 will automatically be alternative (actually can be configured on ES680 2 blocks) CP1430 as backup master clock)

RTT is free to run (freer unning), can also be used with external GPS clock by TTY interface (20 ma current loop) synchronization. With the GPS clock synchronous serial message (32 bytes long, 9600 baud, a start bit, 8 data bits, 2 stop bits) and second/minute pulse two kind of way.

RTT is generated in the network layer and send the master clock pair of message, every 10 s power plant bus to send it again. Most time RTT is sending message waiting 1 ms. Such as within 1 ms to messages sent to a bus, then cancel this time send message: process is interrupted, such as message sent immediately to generate a current time message. Clock message has a multicast address and special frame head, dated from 1984.01.01 to the number of days in the day, for from the day 00:00:00, 000 h to the current value of ms, resolution of 10 ms.

OM650 get time message from power plant on the bus. Within the OM650, using the Unix function will be time to send it to the bus terminal SU, OT, etc. Usually consists of a PU as a time server, login other OM650 equipment for customers.

AS620 AP after the start, by calling the function block "synchronization", clock synchronization with CP1430 automatically. Then CP1430 every 6 s and AP pair.

The precision of the TXP clock is as follows:

From the above TXP clock synchronous clock accuracy in time, you can see that TXP system in each clock USES is master-slave hierarchical synchronously, namely the clock with higher levels clock synchronization, the more the higher level of clock its precision is higher.

3. Time Server Clock and Time Deviation:

3.1 Time deviation:

As is known to all, the computer's clock is generally using quartz crystal oscillator. Crystal vibration body continuously produce a certain frequency of the clock pulse, counter these pulses are cumulative time value. As a result of the clock oscillator pulse by environmental temperature, uniform load capacitance, drive level and crystal aging instability factors, so the clock itself inevitably there are errors. For example, a precision of + 20 PPM clock, its error is per hour (1 * 60 * 60 * 1000 ms) * (20/10.6) = 72 ms, a day of accumulated error of 1.73 s; If the work environment temperature rating from 25 ℃ to 45 ℃, you will also increase the additional error of plus or minus 25 PPM. Visible, if a clock synchronization via regular calibration of DCS, the error of the freedom to run for a period of time after can reach the level of system application is unable to endure.

With the development of the crystals manufacturing technology, at present in the application of the high-precision clock, for all kinds of high stability crystal vibration body available for selection, such as TCXO (temperature compensation crystals), VCXO (voltage-controlled crystal vibration), OCXO (constant temperature crystals), etc.

3.2 Time Server Synchronization Deviation:

If the clock synchronization method similar to the TXP is analyzed, it is not difficult to find that the clock synchronization process of DCS in top-down absolutely pair error that is made up of three parts:

3.2.1 GPS clock with satellite launch the UTC () when the world coordinate error

This part of the error is decided by the precision of GPS clock. The output 1 PPS, for pulse front along the on time, accuracy between dozens of ns and 1 mu s commonly; The IRIG B code and the RS - 232 serial output, such as with the Chinese academy of sciences at the national center for timing clock products as an example, the synchronization accuracy with the reference element frontier or relative to the initial 1 PPS frontier deviation meter, 0.3 mu s and 0.2 ms respectively.

3.2.2 Synchronization Deviation between DCS Master Clock and GPS Clock

Master clock on DCS network and GPS clock synchronization by way of "hard connection". Usually by DCS clock synchronization card accepted within a site GPS standard time coding, the hardware clock output. For example, as in the receiver of the RS - 232 output ASCII byte sent delay compensation, or to the IRIG B code USES the code element carrier cycle count or high frequency decoding card pin, the master clock with the GPS clock synchronization precision can reach high accuracy.

3.2.3 Time Difference of DCS master clocksa and slave clocksDCS

Master clock with the site from the clock synchronization through the network, during which there is a clock message sending time delay, delay, delay processing. Displays in: (1) on the master clock end to generate and send time message, protocol processing, the operating system kernel call overhead of synchronous request, time will time message sent to the network communication interface, etc.; (2) in time before the message on the Internet, but also have to wait for network (Ethernet), free will resend encounter conflicts; (3) the time after the message on the Internet, to a certain period of time through DCS network media delivered to the child clock in from the master clock (electromagnetic wave propagation speed for two-thirds of the speed of light in the fiber for DCS LAN, propagation delay to hundreds of ns, negligible); (4) in the network communication interface from a clock time is confirmed after the message, receive message, record packet arrival time from the clock, interrupt requests, calculation and correction, etc. Also need time. The time delay more or less the DCS between master-slave clock, and from the clock error of time synchronization.

Of course, different network types of DCS, the clock synchronization algorithm and the communication protocol, can make the network synchronization precision of the pair each are not identical, the above analysis is based on general principles. In fact, with people's unremitting study of the network clock synchronization technology, a variety of complex, but high efficiency, high precision clock synchronization protocols and algorithms have appeared and get practical application. Applied widely on the Internet, for example, the NTP (Network Time Protocol, NTP) in DCS LAN has been able to provide the pair Precision of + / - 1 ms (such as GE's ICS distributed control system), and IEEE1588 PTP (Standard Precision Time Protocol) can make the real-time control of Ethernet, from the microsecond synchronous clock.

4.Time Clock’s precision and SOE Design

Although the amount of normal switch DCS scan rate has reached 1 ms, but to meet the requirements of the SOE resolution of 1 ms or less, for a long time, people are always follows the design method, the all SOE points under a controller, the event trigger switch signal to hardwire access SOE module, its reason lies in the different controller its clock there is a certain error. On this point, Siemens in describing the TXP system scattered FUNB module configuration of engineering practice, due to the clock can't sync cannot do 1 mssoe resolution, even more has been clock difference nearly ms, SOE event log order upside down.

So, how do you both can satisfy the requirement of engineering for SOE scattered design (such as set up public after DCS, the unit of SOE and utility of SOE should separate, or wish to enter the MFT of the controller, ETS without tripping signal via the output back to SOE module can be used in SOE, etc.), and not too much lower SOE resolution? Through the analysis of the DCS products is not hard to find, usually adopt to the controller or the SOE module clock directly with external GPS synchronous clock signal. In ABB Symphony, for example, SOE Server Node (usually in common DCS online) punctual main module (INTKM01) accept IRIG - B time code, and clock synchronization signal generated by the RS - 485 link to each controller quill (HCU) SOE time

synchronization module (LPD250A), its on-board hardware timer clock can external 1 PPM sync pulse, automatic reset once per minute. Again, such as, MAX1000 + PLUS distributed processing units (DPU4E) with IRIG - B synchronous, make DPU DI points can be used as SOE, at the same time with 1 PPM or RS - 485, IRIG - B hard wiring the clock "synchronization", avoids the DCS clock synchronization via the network the accuracy of the poor also, keep the deviation between the controlled clock in small range, so the SOE scattered point design is feasible.

Thus, in the engineering design should be combined with the characteristics of the DCS to determine SOE design scheme. Not to switch volume scanning rate of 1 ms or 1 ms controller (or SOE module) clock relative error is equal to 1 ms SOE resolution, which simply disperses SOE points throughout the system. At the same time also should see, SOE points "decentralized" compared with "concentration", although the resolution is reduced, but as long as the clock relative error is very small (such as with 1 ms off an order of magnitude), or completely to meet the need of actual power plant accident analysis.

5.Conclusion:

5.1 at present, the coal-fired power plant each control system is no longer a separate information island, a large number of real-time data need to be in different places on the stamp, and then sent to the SIS and MIS, used in various applications. Therefore, should be carefully considered in the design of various system clock synchronization scheme and to achieve clock synchronization precision.

5.2 in DCS design should pay attention to not only understand the system master, from the clock's absolute time setting accuracy, the relative error between the more should pay attention to the clock. Because if you want to scatter SOE point design at the same time not too much to reduce the incident resolution, its key lies in each clock deviation should be as small as possible.

5.3 have every reason to believe that, with the continuous development of the network clock synchronization technology, through the network to high precision system clock synchronization will become very common.