Chapter 5: Broadcast of Beijing Time

It is the device for transmitting standard time and standard frequency signals in low frequency and high frequency bands in China. It is the traditional way of obtaining standard time in the field of national economy and national defense construction, and in the field of scientific and technological research. It consists of complex devices such as time service signal generation control, time service transmitting equipment and so on. It is the long and short wave time transmitting stations of the BPL and BPM National Time Service Systems at the National Time Service Center, Chinese Academy of Sciences.

1 Broadcast Control: Establish an Accurate Broadcast Standard

The national standard time is produced in Lintong, Xi'an, but the long and short wave time broadcast stations are in Pucheng, Weinan. These two places are about 70 kilometers apart, so there is a difficult problem that many time service systems face: the time broadcast station are not always located in the place where the standard time is produced. In the case of different location, the transmission of standard time signals through the cable is costly. It is necessary to transmit the standard time to the transmitting station through a remote time transfer method such as common view time comparison, fiber time transfer, and two-way satellite time transfer.

The transmission across space is unreliable, and even the most stable and reliable cables have the following problems. The first problem is the change of cable length. Thermal expansion and contraction will change the length of the cable, and then change the signal propagation delay, which leads to the deviation of the control of the signal transmission time. The second problem is the signal attenuation. With the increase of the signal propagation distance, the power of the signal is attenuated by the square of the distance, and the transmitted time signal will be so low that it will be submerged in the noise and cannot be recognized. The third and biggest problem is that the cable may be interrupted. The long distance transmission is complicated, and the abnormal conditions such as road repair and collision may cause the cable to be damaged, which will cause the transmitting station to be unable to receive the signal and the time service will have to be suspended.

It's easy to solve these problems. As long as the time is produced locally as the reference standard for the transmitting station, the local time can be deviated from the standard time by remote time comparison, and the local time and the standard time can be controlled within a certain range. The problem will be solved easily.

The establishment of the local time of the long and short wave transmitting station is completed by the time-frequency monitoring room. The full name of the time-frequency monitoring room is the monitoring and control room of time service broadcast.

Time-frequency monitoring room utilizes punctual equipment, time signal generator equipment, and monitoring equipment to provide standard time and standard frequency signals for the long and short wave time service broadcast stations. At the same time, it controls and monitors the time-frequency signals of the broadcast station to ensure time service broadcast quality.

The monitoring room is located in a small building built in the 1960s, next to a microwave tower that matches the standard time of Lintong.

Entering the building, down the stairs and then came to the basement, there are three atomic clocks. The atomic clock requires very high working environment, and the basement requires constant temperature and isolates the external noise and electromagnetic signals. Its operating state is transmitted through the camera to the working hall on the first floor. In order to ensure the safety of the equipment, the staff confirm and record the environment of the basement and the working state of the atomic clock regularly.

On the first floor, the monitoring and control work hall is the main place for staff. The hall is designed and decorated in accordance with EMC strictly. The walls of a row of equipment in the hall are arranged in categories of time comparison, signal generation, time service signal monitoring equipment, and all kinds of equipment indicator lights are particularly bright. The monitoring instruments constantly display the comparison, monitoring data. The staff methodically checks the working state of the equipment to ensure the normal reference time of the broadcast signal.

10.2478/9788366675988-005

Fig 5.1 Microwave comparison antenna in the monitoring rooms

The standard time UTC (NTSC), which controls BPL and BPM National Time Service Systems, is produced and maintained by the Key Laboratory of Time and Frequency Primary Standards, National Time Service Center. The time produced by the monitor room is called UTC (PU), which is the actual reference standard for the transmitting signal of the controlling and transmitting station. UTC (NTSC) and UTC (PU) are compared by two ways: microwave time transfer and Global Navigation Satellite System (GNSS) common-view time transfer. The clock difference is obtained.

The adoption of two time comparison methods is based on the consideration of reliability. Two-way microwave time transfer is the main way to use. Pucheng and Lintong have microwave signal transmitting station, which send microwave signals to each other and are compared by two-way time transmission. In order to ensure the reliability of comparison, GNSS is also used to carry out the common-view time comparison.

There are three cesium atomic clocks and these cesium atomic clocks work together in the monitoring room. The frequency signal of one atomic clock is selected as the source. The atomic clock signal is controlled using the comparison result with Lintong to generate the UTC (PU) time signal. In addition, in order to ensure the reliability of the time signal, another atomic clock signal is used to generate another time signal. This time signal is kept synchronized with the UTC (PU) in real time so that when the main link is abnormal, it is switched to the standby link in time. The deviation between UTC (PU) and UTC (NTSC) remains within 50 nanoseconds.

UTC (PU) is a reference standard for the work of BPM short wave time broadcast station and BPL long wave time broadcast station.

The working clock of the time-frequency monitoring room provides the standard frequency standard time signal of 5

MHz、1pps (pulse per second) and the digital clock signal to the BPL long wave time broadcast station through a specially designed cable or optical fiber link. At the same time, the BPL broadcast signal (the antenna ground loop sampling signal) returned through the cable or fiber link would go to closed-loop monitoring and comparison. By comparing and calculating the difference between the long wave time service signal and the UTC (NTSC), the long wave time delay value is obtained and transmitted to the BPL room by the format of the signal, and BPL long wave time broadcast station corrects the signals and sends them out. The time control precision of UTC time signal is better than ±100 nanosecond.

The working clock in the monitoring room provides 5 MHz standard frequency signal, BPM time signal and time code signal to the BPM short wave time broadcast station through special cables. At the same time, the accuracy of BPM time signal is monitored by receiving BPM signal. The time control precision of UTC time signal is better than ±1 microsecond. The time control precision of UT1 time signal is better than ±100 microsecond, and the frequency accuracy is better than $\pm 1 \times 10^{-12}$.

The monitoring room has a high degree of automation, all the above comparison, calculation and other processes are completed by the computer, no manual participation. However, in order to detect possible failures in time and ensure safety, there are special personnel on duty.

2 Short Wave Time Service: Signal Global Coverage

The call sign of the short wave time broadcast station is BPM, using short wave broadcasting the standard time and standard frequency. Short wave refers to a radio band with a wavelength of 10—100 meters and a frequency of 3—30MHz.

(1)Features of short wave time service signal propagation

Like other short wave communications, the radio waves of the short wave time broadcast station are broadcasted in the way of ground wave and sky wave. The ground wave refers to the radio waves propagating on the near surface after radiation from the transmitting antenna, such as ground surface wave, ground direct wave, surface diffraction wave and so on. The sky wave refers to the radio waves emitted by transmitting antennas, which reaches the receiving point by the ionosphere reflection in the upper air. The ionosphere is a part of the upper atmosphere of the earth. It extends from 60 km to 1000 km, and the whole ionosphere is divided into four regions, from low to high respectively called D layer、E layer、F_1 layer and F_2 layer. Because the attenuation of ground waves increases rapidly with the increase of frequency, and the propagation distance of short wave ground waves is not more than tens of kilometers, sky wave propagation becomes the main way of short wave propagation.

Table 5-1 Frequency timing coverage

Frequency (MHz)	Coverage (kilometer)
2.5	Less than 500
5	Less than 500—1000
10	Less than 400—3000
15	Less than 1000—3000

The propagation of short wave sky wave mainly depends on ionospheric reflection propagation. Radio waves can be reflected many times through the ionosphere to a long distance. But during the process of propagation, there will be some “silent areas”, which could not be covered by the signals. Because the height and electron concentration of the ionosphere vary in different seasons and even 24 hours a day, and are also affected by sunspot activity. So the appropriate short wave frequency must be selected to improve the coverage of the time service signal.

The theory of wave propagation holds that when the radio waves are reflected by the ionosphere F_1 and F_2 layer, the communication distance between two points increases as the available frequency increases. In order to ensure the reliability of the propagation circuit (the receiving point receive time signal probability above 90%), short wave transmitted choice in 2.5 MHz, 5 MHz, 10 MHz and 15 MHZ. These several frequencies of 24 hours continuous transmit. At the same time, according

Fig 5.2 BPM short wave time broadcast station

to the antenna radiation pattern, the appropriate elevation angle is selected for short wave transmit, so the whole country will receive the time signal of the standard time standard frequency.

The biggest disadvantage of short wave time service is the interference between multipath. Due to the wide beam characteristics of the antenna, the ionosphere every layers(F_1, F_2) and their non-specular reflection and the effect of the inhomogeneous body in the ionosphere on the reflection of the radio waves make the shortwave propagation presents multipath transmission. So the radio waves arriving at the receiving point are not only along the large circle path transmission, as well as from the other side of the path to the other, the receiver of the field intensity as the sum of individual radiation field strength. Due to the height variation of the reflected ionosphere, the ionosphere electron density changes with time and natural conditions on the ionosphere disturbance, which makes the delay and attenuation of the multipath transmission taking on the corresponding random changes. The short wave multipath effect and Doppler frequency shift will result in the high transmission delay, the precision of frequency comparison is limited to $\pm 10^{-9}$, and the timing precision is limited to 500—1000 microseconds.

Although short wave time service has the above shortcomings, it covers wide range, time service and receiving equipment simple. At the same time, it is the earliest time service business, so it still have a very wide range of applications. There are some famous short wave time signal in the world, for example American WWVH, Russian RWM and Japanese JJY short wave time signal.

Table 5–2　The main short wave time broadcast station in the world

Call sign	Location	Carrier frequency (MHz)	Working time (UTC)	Broadcast procedure	Time signal
ATA	New Deli, India	5 10 15	$18^h—9^h$ all day $9^h—18^h$	Broadcasting the call sign and reporting hour and minute on minute 0, 15, 30 and the first 20 seconds of minute 45.	Second: 5 cycles of 1kHz Minute: 100 cycles of 1kHz
BPM	Xi'an, China	2.5 5 10 15	all day	Broadcasting the call sign on minute 29 and second 20 of minute 59.	Second: UTC (5 cycles of 1kHz) UT1 (100 cycles of 1kHz) Minute: UTC (300 cycles of 1kHz) UT1 (300 cycles of 1kHz)
BSF	Taipei, China	5 10	all day	Broadcasting the call sign and reporting hour and minute on minute 0, 10, 20, 30, 40 and 50. It is omitted from Minute 35 to 40.	Second: 5 cycles of 1kHz in the first 5 minutes of every 10 minutes, 5ms pulse in the last 5 minutes Minute: 300 cycles of 1kHz in the first 5 minutes of every 10 minutes, 300ms pulse in the last 5 minutes
HLA	Seoul, South Korea	5	$01^h—08^h$ from Monday to Friday except for the holidays	Voice report after second 52 per minute	Second: 9 cycles of 1.8kHz, except for second 29 and minute 59 Minute: 1440 cycles of 1.8kHz Hour: 1200 cycles of 1.5kHz
RID	Irkuzk, Russia	5.004 10.004 15.004	all day	It is omitted on second 56–59 of minute 4, 9, 14, 19, 24, 29, 34, 39, 44, 49, 54, 59 of per hour.	Second: 100ms with AIX type Minute: 500ms with AIX type
RWM	Moscow, Russia	4.996 9.996 14.996	all day	from 10 to 20 minutes from 40 to 50 minutes other time	Second: 100ms with AIX type Minute: 500ms with AIX type DXXXW
VNG	New south wales, Australia	2.5 5.0 8.638 12.984 16.0	all day all day all day all day $22^h—10^h$	Broadcasting the Morse code or voice call sign at minute 5, 30, 45, 60, second 55–second 58 per minute 5 milliseconds, omitted on second 59, second 20–second 46 with BCD code report day / year, time, minute.	Second: 50 cycles of 1kHz Minute: 500 cycles of 1kHz
WWVH	The island of Kauai in the state of Hawaii, USA	2.5 5.0 10.0 15.0	all day	During minutes 59 and 0, minutes 29 and 30, broadcast call sign.	Second: 6 cycles of 1.2kHz Minute: 600 cycles of 1.2kHz Hour: 1200 cycles of 1.5kHz
WWV	Fort Collins, Colorado, USA	2.5 5.0 10.0 15.0 20.0	all day	During minutes 0 and 1, minutes 30 and 31, broadcast call sign. There is a time notice before the whole minutes, omitted on second 29, second 59.	Second: 5 cycles of 1kHz Minute: 800 cycles of 1kHz Hour: 1200 cycles of 1kHz
YVTO	Caracas, Venezuela	5	all day	The call sigh is broadcasted during second 40 and second 50, but this is omitted second 30 per minute. There are voice reports hour, minute and second during second 52 and second 57.	Second: 100 cycles of 1kHz Minute: 500 cycles of 1kHz

(2) Composition of BPM short wave time service system

BPM short wave time service system is composed of time-frequency monitoring room and BPM short wave time broadcast station. Time-frequency monitoring room is compared with the National Time Service Center to produce the time base UTC (PU) for BPM broadcast control.

BPM short wave time broadcast station is the main component of short wave time service system. The main task is to generate frequency signal which short wave needs, and the time signals of the time-frequency monitoring room convert into binary codes . According to the time-frequency signal of the time-frequency monitor room, the short wave time service signal is transmitted. The key equipment of the short wave time broadcast station is placed in the transmitter room, and there are transmitting antennas outside. The short wave monitoring room is configured to monitor the accuracy of short wave signals.

The transmitter room of BPM short wave time broadcast station is made up of independent transmitter room and short wave monitoring room. The transmitter and antenna switch are placed in the transmitter room. There are 7 transmitters in the BPM transmitter room, five of which are 10 kilowatt transmitters. These five 10kW transmitters, two of which are pulse-width modulation whose last stage are vacuum tubes and the remaining three are all-solid-state transmitters. These transmitters can operate reliably at arbitrary frequencies of 5 MHz、10 MHz or 15MHz. The remaining two of seven are1.5 kW transmitters and they operate with the frequency of 2.5MHz.

The short wave monitoring room is the control and monitoring center of the BPM short wave time broadcast station, which is composed of the broadcast control equipment and monitoring equipment. The broadcast control equipment distributes and amplifies the 5 MHz standard frequency and 1 KHz time signal by the broadcast control equipment sended to the working clock room. The short wave monitoring room is equipped with on-line monitoring oscilloscope and other monitoring equipment to monitor the output waveform and amplitude modulation of each working transmitter.

Table 5-3 BPM short wave time broadcast station broadcast frequency and timetable

Broadcast frequency (MHz)	Broadcast time
2.5	9:00—15:00
5	0:00—24:00
10	0:00—24:00
15	9:00—17:00

BPM short wave time broadcast stations are continuously distributed at 2.5 MHz, 5 MHz, 10 MHz, 15 MHz 24 hours a day.

Knowledge Link

Modulation Modulation is the process of changing some parameters of carrier signal according to the change rule of modulation signal. Generally, the nonlinearity of electronic devices is used to realize it. Modulation plays an important role in radio communication. By modulation, the spectrum of the modulated signal can be moved to the desired position so that the modulated signal is converted into an adjusted signal suitable for channel transmission. The common modulation includes amplitude modulation, frequency modulation and phase modulation.

(3)Transmission precision of BPM time service by short wave radio

The time-frequency signal broadcasted by BPM can reach the following precision:

The accuracy of carrier frequency signal is better than $\pm 1 \times 10^{-12}$.

The timing accuracy of UTC time signal broadcast is better than 50 microseconds (antenna end).

The difference between UT1 broadcast time and UT1 prediction time is less than 300 microseconds.

When the user receives the short wave time signal, the following criteria are used to improve the reception accuracy:

When receiving the BPM shortwave time signal, the user should select a receiver with high sensitivity, good selectivity, stable frequency phase stability, strong anti-interference ability and a directional antenna.

Pay attention to the electromagnetic environment of the receiver in use, and the receiver should be well grounded.

The user should receive the carrier frequency of the BPM time signal according to the reference of the BPM carrier frequency.

Users should try to avoid the sunrise and sunset and ionosphere interference when receiving the BPM short wave, and choose to receive at the same time every day as possible.

After observing the received waveform on the oscilloscope for a few minutes, the user determines the most stable transmission conditions and selects the most consistent part of the timing waveform.

Table 5–4 BPM user carrier frequency selection reference

solar activity	the upper solar year		the lower solar year	
Beijing Time / Distance (kilometer)	9:00—17:00	17:00—9:00	9:00—17:00	17:00—9:00
Less than 500	5 10 15	5 10 2.5	5 10	5 2.5
500—1000	10 15 5	10 5 2.5	10 5	5 2.5 10
1000—2000	15 10 5	10 5	10 15 5	10 5 2.5
2000—3000	15 10	10 5	15 10 5	10 5
More than 3000	15 10	10	15 10	10

3 Long Wave Time Service: Precision with One Millionth of a Second

The call sign of China's long wave time service station is BPL. Its working frequency is 100 KHz and the format of transmission signal is carrier frequency phase coded pulse group. The starting point of the signal of is controlled by UTC (PU). It is the broadcasting base time, is produced by the time-frequency monitoring room, and kept in synchronous with UTC (NTSC). The users received the BPL time service signal by a special receiver. The receiver outputs a second pulse synchronized with the time service station. So the users can get the UTC information synchronized with the time service station by the pulse.

(1) Propagation characteristics of long wave time service signal

The long wave refers to a radio band with a wavelength of 1—10km and a frequency of 30—300 kHz. Long wave time service station is the ground radio station that broadcasts standard time and standard frequency signal using long wave.

Since that the accuracy of short wave time service is only in the order of milliseconds, it cannot satisfy China's national economic construction and national defense modernization needs, necessarily needing to look for a new frequency band and new form of wave propagation to improve the time service accuracy. The new frequency band is low frequency (30—300 kHz, also known as long wave). The radio waves of these frequencies have long wavelength, low antenna radiation efficiency and high background levels of atmospheric noise. In order to get a higher SNR, a large transmitting system is required. At the same time, the range of the frequency band is narrow, the information capacity is small and the transmission speed is low, will be greatly restricted in the engineering application. However, the wave propagation characteristics of this band also have unique advantages, such as the strong ability of the permeable layer and seawater, and the long transmission distance; the signal transmission loss is small, and the signal strength, transmission speed and phase are relatively stable. The radio waves of this band are especially suitable for reliable transmission high precision information over long distances.

Long wave radio waves are mainly transmitted by ground and sky waves. Because the energy spread and is absorbed by the ground, the intensity of the ground wave attenuate with the increase of propagation distance. The speed and frequency of attenuation are related to the electrical characteristic parameters (dielectric constant and the earth conductivity) of the path. Long wave time service signal covers a large area. The topography and geomorphology are complex within its coverage area, so the measurement of earth conductivity is difficult. On the basis of national census, the scientific and technical workers of National Time Service Center put forward the concept of "equivalent conductivity". Which means the electrical parameters can be described by the equivalent conductivity when it changed little with the propagation path. Due to the stability of ground wave field strength and phase, high precision can be obtained by using the ground wave time service.

The development of navigation technology, as well as the integration of navigation and communication services, has put forward special requirements for the time service signal which is different from other radio engineering. The signal format adopted by the time service system involves the required bandwidth of the signal, the signal-to-noise ratio and the anti-interference capability, etc. of the receiver. It is closely related to the main performance of time service system and the design of specific equipment in the system. This signal format is the pulse phase coded transmitted system.

Long wave time service system is same with the long wave navigation system (LORAN—C and Changhe), whose working frequency is 100kHz. Long wave radio waves are long and the signal amplitude and phase are stable, so the timing precision of long wave signal is on the order of microsecond, and the frequency correction accuracy is on the order of 10^{-12}. At present, the world's important long wave time service systems are: the MSF in Britain (transmitting frequency is 60 kHz, transmission power is 25KW), the LORAN—C chain of American (transmitting frequency is 100 kHz, carrier power up to 1800KW), the Changhe chain (transmitting frequency is 100 kHz), the BPL long wave time service system of our country.

The BPL long wave time service system broadcast pulse code signal. The center frequency of the signal is 100 kHz and the group repetition interval is 60 milliseconds. The peak effective power of transmitter pulse is about 2000KW and the effective power of antenna radiation pulse is more than 1000KW. The coverage radius of ground wave signal is about 1000km meanwhile the coverage radius of the combination of the sky wave and the ground wave is about 3000km. The BPL Long wave time service signal radius can cover China's land and offshore waters. The precision of the ground wave signal time service is better than 1 microsecond, and the precision of the sky wave signal time service is better than 2.8 microsecond. So the precision of radio time service on land-based radio in China precision has reached the international advanced level.

(2) Composition of BPL national time service system

BPL National Time Service System includes four parts: time-frequency monitoring room, transmitter system, transmitting antenna and monitoring system.

The UTC (NTSC), the time and frequency reference of National Time Service Center, is compared with UTC (PU) through microwave two-way and GPS common view time comparison. The UTC (PU) is the time reference of long wave transmission.

Since the current signal of the transmitting antenna unable to be monitored directly, after the BPL time signal is radiated by the transmitter antenna, a sampling signal of antenna current is generated in the bottom of the transmitting antenna circuit with current loop coupling. Then the sampling signal is feedback to the timing control device of monitoring unit. The real-time calibration of the phase of transmitting signal is realized.

The transmitting room consists of the broadcast monitoring, transmitter system and the power system. The transmitter is XN-BPLT all solid state transmitter whose timing control circuit adopts the brand-new integrated circuit and computer, and adopts the international common EUROFIX digital modulation technology, in order to realize the function of transmitting the BPL timing code and other data. The control cabinet of the XN-BPLT all solid state transmitter adds the function: One is presetting digital clock face, the other one is generating and outputting 1 second pulse signal.

The XN-BPLT all solid state transmitter is composed with transmitter control equipment and transmitter host. The transmitter control equipment mainly includes: operation control unit (TOPCO), remote control unit/state monitoring unit (RCU/SMU), LORAN timing unit (LTU), pulse control unit (PCU), signal distribution unit (SDA), coding formation unit, etc. Among them, remote control unit, ROLAN timing unit, pulse control unit and coding formation units are the main-backup structures. The transmitter hosts include: 64 half cycle power generator (HCG), coupling/output network, switching network (RF switch), antenna matching network and antenna switch. The coupling/output network is main-backup structure.

LORAN timing unit (LTU) is the core of transmitter control equipment, completing tasks such as frequency division, pulse grouping, phase encoding, closed-loop adjustment of transmission system and timing.

Fig 5.3 The XN-BPLT all solid state transmitter

Fig 5.4 the control equipment of BPL long wave time service broadcast

Fig 5.5 the power supply and distribution system of BPL long wave time service station

Transmitter is the core of long wave time service. LORAN timing control equipment uses UTC (PU) as a reference, generates the basic timing signal T0 of transmitter and the trigger pulse sequence synchronized with T0. The trigger pulse sequence triggers the transmitter host to produce the BPL pulse sequence with carrier frequency of 100kHz. This BPL pulse sequence is fed to the transmitting antenna by a preset power after passing through the half-cycle power generator/coupling network and the antenna matching network. At this point, it becomes the BPL timing signal and is radiated by the antenna. A sampling signal of antenna current is generated in the bottom of the transmitting antenna circuit with current loop coupling. Then the sample signal is feedback to the timing control device of monitoring unit that monitors the phase of the standard zero crossing of it. The standard zero crossing is locked in T0 through the circuit to compensate for the delay change of the transmitting channel caused by various reasons, so as to maintain the synchronization of T0 and UTC (NTSC).

(3) Transmitting antenna of BPL long wave time service system

Transmitting antenna is an important part of ground facilities of BPL long wave time service system. It can convert the powerful pulse current fed in by the transmitter into electromagnetic fields and is applied to the service area in the form of ground wave and sky wave which carry the precise time information given by transmitter. Then the waves are received and used by time users.

BPL long wave time service system transmitting antenna supports an antenna barrier (top load) with certain sag using four 206 meters high iron towers. An inverted cone consisting of eight lower leads is uniform hung around the antenna barrier, which is the radiation body of the antenna. A good grounding network is laid on the antenna site.

The antenna top load is suspended by the high tower and lower leads at a certain height to meet the antenna's effective height and antenna electrical target requirements. The top load improves the capacitance distribution of antenna, thus improve the effective height of antenna structure.

The antenna has a good grounded counterpoise because the ground plane cannot approximate to a completely pure conductive plane. The grounded counterpoise is formed by connecting copper wires in the radial direction in underground of the antenna site. The electric field generated by the antenna will penetrate the earth and excite current. Thereby the ohmic losses were reduced and the efficiency and the electrical indicators of the antenna were improved.

Fig 5.6 the ground counterpoise of the antenna of BPL long wave time service system

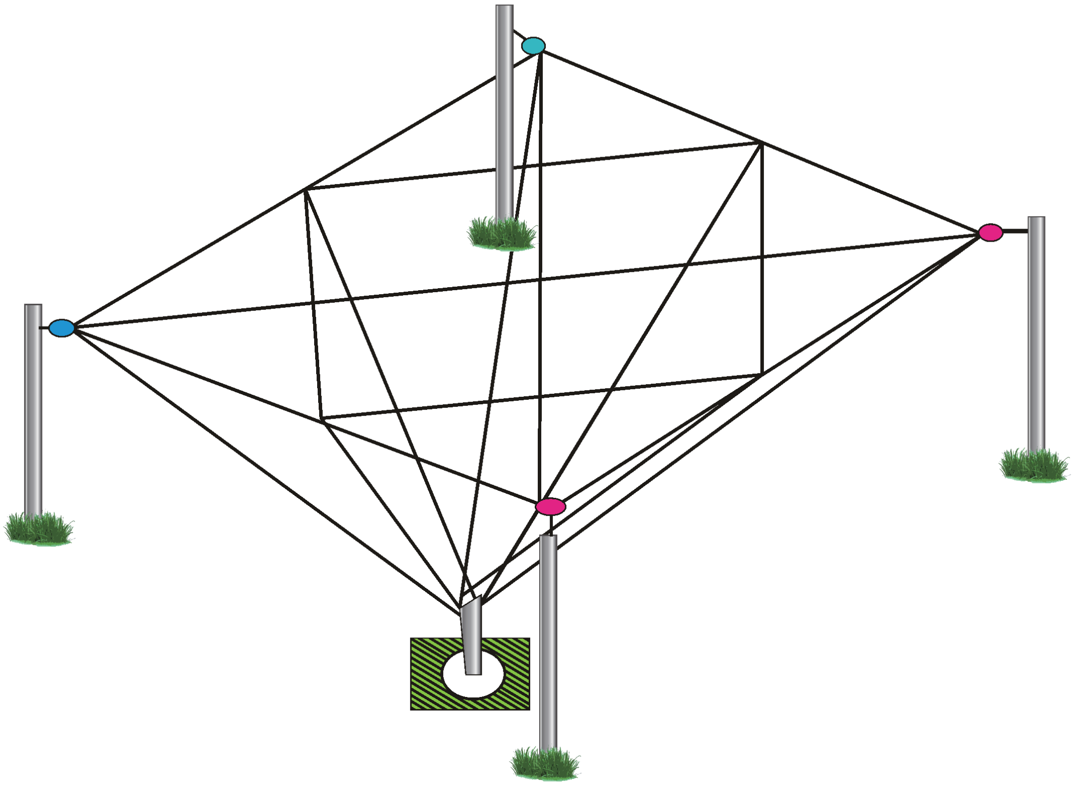

Fig 5.7 perspective view of the antenna of BPL long wave time service system

In addition, there are four winch rooms at the four corners of the antenna, which can be used to tighten up the antenna top load wire network and put down the antenna wire network for maintenance.

The structure of the BPL long wave antenna is shown in figure 5-7. The antenna is 193 meters high. The side length of top load square is 401.41 meters long and the side length of the iron tower square is 425.5 meters. The field area of the antenna field is about 20 hectares. The assembly point of the lower leads is located at the center of the antenna field, and is 6.6 meters high.

There is a story behind the design and construction of BPL long wave antenna.

In the second half of 1972, the "3262 project" headquarters proposed the antenna design task. At that time, referring to the American LORAN-C antenna, they specified "single tower umbrella antenna". Because of the frequency of the long wave at 100 kHz and the wavelength of 3000 meters, if the antenna was designed according to a quarter of the wavelength, the antenna would have a geometric height of 800 meters. If the top load was loaded on the antenna to increase the antenna's effective height, the antenna will be 300 meters high yet. At the top of the antenna, there should be 9 top loads and 6 cage wires, and the diameter of the cage should be 90 meters. Such large cages were difficult to achieve in structure. In addition, the tower of the umbrella tower antenna is an antenna radiator, it must be insulated from the ground. The base insulator was subjected to hundreds of tons of mechanical pressure and more than 100kv of high frequency voltage on electricity. At that time, no such insulator could be made in China. The height of the tower, the design of the steel structure, the connection of the cable, the quality and the wind load of the cable insulator components, all had brought the design restrictions.

In 1974, the "3262 project" headquarters staff got the information: some of the umbrella tower antennas of LORAN-C navigation system of America had been damaged or even collapsed. Except for some metal components, most of them were related to the antenna cable insulators. So they had begun to use multiple tower antenna instead of umbrella tower antenna, and had built one and put it into use. But our technicians had only a profile picture of the LORAN-C navigation system, and no other details.

According to the data of simple introduction, the engineers and technicians of the long wave time service station carried out the analysis and design according to the basic principle of antenna design. They designed the simulation transmitter of 1/100 and 1/12 of the size of the transmitter and carried out the alignment tests. Through the analysis and comparison of the experimental data, the finalization size and electrical parameters of the antenna were determined. From June 1975 to November 1975, the "3262 project" headquarters staff and designers together formed a test team. They conducted multiple model tests repeatedly and obtained a large number of experimental data and first-hand information. Through theoretical analysis and calculation, the geometrical size and the electrical index scheme of the antenna satisfying the overall technical requirements were finally determined.

The "3262 project" headquarters staff organized national experts to seriously discuss the umbrella tower antenna and the four-tower inverted cone antenna scheme. The experts analyzed the experimental data and theoretical analysis report and considered the domestic strength at that time. Finally they agreed to adopt the scheme of the four-tower inverted cone antenna and the electrical index of the scheme.

The antenna is characterized in that the height of iron tower is low (about 200 meters), and the iron tower is only used as a support and can be grounded, so the base insulator is not needed. The cable insulator is relatively simple, easier to carry out in engineer and can withstand greater tensile force. At the same time, the antenna has uniform characteristic impedance and a small electric resistance slope. As a result, the antenna has a wider bandwidth and a lower high-frequency voltage.

It has been more than 30 years since the antenna was built in 1980. The towering iron tower, with its red and white safety colors, is dazzling in the sunshine. It has become a geographical symbol of the location of the time service department.

(4) BPL national time service precision

The precision of our country's BPL long wave time service has reached the international advanced level. BPL long wave time service of our country is one of the most powerful countries in the world in the long wave domain, as detailed in table 5-5.

Table 5-5 distribution of stations chains of global long wave navigation and time service

Serial number	Chain name	Group repetition interval (microsecond)	Location
1	Gulf of Alaska chain	7960	America
2	Southeast U.S. chain	7980	America
3	North central U.S. chain	8290	America
4	South central U.S. chain	9610	America
5	Great Lakes chain	8970	America
6	U.S. west coast chain	9940	America
7	Northeast U.S. chain	9960	America
8	North pacific chain	9990	America
9	Canadian east coast chain	5930	Canada
10	Canadian west coast chain	5990	Canada
11	Newfoundland east coast chain	7270	Canada
12	Saudi Arabian North chain	8990	Saudi Arabia
13	Saudi Arabian South chain	7170	Saudi Arabia
14	LESSAY chain	6731	France
15	Chinese North sea chain	7430	China
16	Chinese East sea chain	8390	China
17	Chinese South sea chain	6780	China
18	Chinese BPL long wave time service	6000	China
19	Russian west chain	8000	Russia
20	Russian Japanese chain	7950	Russia/Japan
21	Russian American the Bering sea chain	5980	Russia/America
22	Russian Japanese South Korea chain	9930	Russia/Japan /South Korea
23	Japanese South Korea chain	8930	Japan/South Korea
24	EJDE chain	9007	Western Europe
25	BOE chain	7001	Western Europe
26	SYLT chain	7499	Western Europe

4 BPL and BPM Monitoring: the Self-assessment of the System

After the time service signal is broadcasted, users in the coverage area can use the signal. Because time is a basic parameter of modern society, time has been widely used in more and more occasions. Correspondingly, the impact of time error will be inestimable.

There are many ways to guarantee the quality of BPL and BPM broadcasting signals.

The above mentioned transmitting guarantee is on the one hand and on the other hand, it is to monitor the signal sent to the air. It can be said that the monitoring of air signal is the last safeguard.

The time service broadcasting quality monitoring setting of BPM short wave broadcasting station is divided into two parts: near-field monitoring and far-field monitoring. The near-field monitoring is located in the monitor and control room of the time service broadcast system, which mainly monitors the blocking rate and modulation amplitude of each frequency signal of BPM broadcasting. The far-field monitoring is located in monitoring station of Lintong in Shaanxi province, which monitors the field intensity, frequency, bandwidth, scattering emission and the comparison of UT1 and UTC. The data of time comparison is stored in the database after batch processing and then is published by Time and Frequency Bulletin.

The standard time and frequency signal broadcasting by the long wave time service station (BPL) is in close relationship with the environment. There is not only the interaction between the signal and the propagation environment, but also the regulation function of the time service system. Which make the intensity of signal, the precision of timing and the accuracy of frequency and so on to achieve a stable state of design.

As with other open system, long-wave time service system has a system of constant self-adjusting and adaption. In electronics, the adaptive or self-adjusting function of the system is called feedback control or closed-loop control. The long-wave timing system has three feedback control loops. The first feedback loop is between the antenna and transmitter timing control unit. The transmitter emits a BPL timing service signal by the antenna, then an antenna current sampling signal generated by cyclic current coupling loop in the bottom of the antenna. Finally, the signal is fed back to the transmitter timing control unit and is compared with input frequency and time. So the transmitter feedback control is completed. The second feedback loop is between the antenna and the clock room. The antenna current sampling signal is fed back to the clock room of broadcast monitoring and controlling, then compared with UTC (PU) after the signal transmission delay is deduced. It ensures that the precision of the long wave is kept in the control precision range. The third feedback loop is the monitoring of air signals. The long wave monitoring station receives and monitors the signals. Then, it feeds the result back to the launch system, and the launch system adjusts and optimizes the emission parameters according to the monitoring results.

The long wave time service monitoring station equipped with long wave receiver, receives the BPL signal and output four signals: amplitude, waveform, phase and second pulse. These signals and the baseline second pulse signal from the time base source UTC (NTSC) enter the long wave monitor together. After a series of preset processing, the signals enter the comparison system by the serial port with the form of data. The comparison system handles the incoming data, classifies, analysis , draws, stores and outputs. The monitoring data of this station can provide the transmitting waveform information, amplitude and phase stability information in time and provide the benchmark data of field intensity and time difference. The monitoring station measures the signal peak power of the broadcasting antenna and the blocking rate of timing service transmitting, but also measures the signal peak power ratio of the third cycle and the second cycle. The ratio is published monthly in the Time and Frequency Bulletin for user reference.

Knowledge Link

Feedback control Sending the output signal back to the input side to enhance or reduce the effect of the input signal is called feedback. The control system established according to the feedback principle is called the feedback control system.

The feedback control system consists of hybrid circuit, control device, object, sampling circuit and feedback network. The feedback that causes the input signal to weaken is called negative feedback and the feedback that increased input signals is called positive feedback. In the self-regulating and automatic control system, the generation of deviation signal and the adjustment of control quantity are realized by negative feedback. The negative feedback can control the deviation, overcome the influence of various disturbances, and achieve the purpose of automatic control.

The precision of BPL long wave time service is in order of microseconds, mainly comes from the correction error of time delay in path.