

# Explore the Influence of Temperature on the Operation of High Power Transmitter Based on Shangqiu Station

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**Keyword:** Solid-state transmitter; Blocking time; Statistical analysis

**Abstract:** The composition system of high-power solid-state transmitter is complex. The running time of the equipment is long and the running environment is poor. In this paper, the detailed data of each failure of Shangqiu station solid-state transmitter from 2009 to 2018 are analyzed. Statistical calculation of the time leading to the failure of the transmitter, the cause, and the transmission blocking time caused by the failure. The purpose is to demonstrate the influence of temperature on the operation of transmitter equipment. It is expected to improve the normal operation efficiency of the equipment through control improvement.

## 1. Introduction

### 1.1 Significance of this study

Following Germany, the United States, Japan and the United Kingdom, China is the fifth country in the world to master low-frequency time-code timing technology, filling the national gap. The transmitter is the carrier of time code signal transmission. The power and efficiency of transmitter directly affect the quality of transmitted signal. Up to now, the low-frequency transmitter has undergone four times of evolution. The first generation transmitter was the spark transmitter invented by Heinrich Hertz in 1886; the second generation transmitter was the equipment before the Second World War and is no longer in use; the third generation transmitter is the electronic tube transmitter, which has the advantage of high power compared with the previous two generations, but its disadvantage is that the efficiency is not high, and the third generation transmitter is generally used in high-power stations. The transmitter is a high-power electronic tube transmitter. Its advantages are high power, relatively simple circuit and low failure rate. However, its disadvantages are large size, heavy weight and high power consumption. The fourth generation transmitter is all solid-state transmitter. The fourth generation all-solid-state transmitter is the most efficient of all types of transmitters and represents the direction of future technology development.

Compared with the other four countries with low-frequency time service, the low-frequency time service system of our countries has a variety of shortcomings, especially in solid-state transmitters and supporting facilities, other countries are technologically leading us a lot. Long-wave transmitter belongs to the national strategic equipment, and advanced transmitter is the symbol of the comprehensive strength of the country. The transmitter used in low-frequency time code timing is the first and only high-power solid-state transmitter in China. Compared with the traditional transistor transmitter, it has a series of advantages, such as small size, low noise and high efficiency. However, as the first solid-state transmitter in China, it also has many defects and shortcomings. With the introduction and implementation of the "13th Five-Year Plan" timing project, a large number of solid-state transmitters have become the necessary facilities urgently needed. The improvement and perfection of the new generation of solid-state transmitters and supporting facilities have become more necessary. I am fortunate to have served in the operation and maintenance of our countries solid-state transmitter, and have a thorough understanding of the performance and problems of our countries s solid-state transmitter. The purpose of this paper is to put forward some good suggestions and opinions for the development and production of next generation domestic solid-state Transmitters Based on personal experience. Strive to make the new

solid-state launcher system more stable and reliable, and provide a better service platform for the production and development of the national economy.

## **1.2 Definition of statistical analysis of equipment faults**

It refers to the use of statistics to study the law of equipment failure. Through data collation, processing and comprehensive analysis of a large number of original data of equipment failure, the purpose is to reveal the regularity and trend characteristics of equipment failure [1]. True and accurate data and scientific and accurate statistical analysis are reliable basis for observing the trend of failure occurrence, exploring the causes of failure, formulating corresponding fault prevention measures and predicting future failure [2].

The object of analysis in this paper is Shangqiu low frequency time code broadcasting station. Because Shangqiu low frequency broadcasting station is mainly based on transmission time information, the length of downtime caused by equipment failure is defined as the length of interruption time. The fault statistical analysis methods used in this paper include: comprehensive statistical method, comprehensive analysis method, statistical analysis and data statistical analysis chart, etc.

The official broadcasting of Shangqiu station was on January 1, 2008. After a series of adjustments and improvements in 2008, the transmitter operated steadily in July of that year. There are many factors affecting the operation of transmitter, such as municipal power supply, air supply system, bad weather (heavy rainfall, thunderstorm, hail, strong wind, etc.), external temperature, humidity, improper manual operation, etc. In multivariate statistical analysis, the statistical law of multivariate random variables, namely multivariate random vectors, is studied [3].

In order to prove the influence of temperature factors on transmitter system, this paper summarizes the causes of all faults and their interruption time from 2009 to 2018, excludes the factors other than temperature, and ensures the pertinence of data. In this paper, the total failure frequency of solid-state transmitter in Shangqiu station since 2009, as well as the failure frequency and blocking time of each item are analyzed and compared. The trend of fault development is shown through the broken line diagram. At the same time, by comparing and analyzing the length of fault interruption in different years and the same month, the influencing factors of temperature on the occurrence of equipment failure are analyzed, and the preventive measures are summarized.

## **2. Statistical analysis of equipment fault data**

This paper first summarizes, analyses and compares the failure frequency and interruption time from 2009 to 2018. The same method is used to analyze the data from 2017 to 2018 (since the end of December 2016, the station abolished the traditional fan air supply system in the transmitter room, changed to the air conditioning internal circulation system, and the working environment temperature of the transmitter is constant at 21 degrees Celsius after the improvement). When discussing multidimensional random vectors, we will also encounter the statistical law of other components under the condition that some of them take some values, which is called conditional distribution [4]. Using statistical methods, the frequency of failure blocking caused by different types of failure causes is listed, and the failure caused by non-temperature factors is eliminated. The specific data are presented in tabular form. On the basis of tabular statistical data, the trend of failure is visually displayed by using broken-line chart.

### **2.1 Analysis and comparison of annual failure rates**

High-power solid-state transmitter consists of tens of thousands of electronic components and multiple modules. Because it has been running continuously in high-power state (only one solid-state transmitter of Shangqiu low-frequency station), the probability of transmitter failure will change with the increase of its working years. Combined with the overall broadcast operation characteristics of the transmitter, the annual interruption time can better reflect the series characteristics of the transmitter's fault changes with the increase of years. According to the

data in Table 1, the total blocking time of transmitter failure from 2009 to 2018 is analyzed. The figure is shown in Table 1 below.

Table 1 Block time

Year (year)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Block Duration (hour)	84.68	100.68	106.05	112.42	123.14	131.1	203.93	135.32	47.03	59.35

From Table 1, it can be seen that the annual blocking time of transmitters from 2009 to 2018 has an obvious fluctuation time change, and reaches the maximum in 2015 when transmitters fail to block. For more intuitive analysis, according to the data in Table 1, the following broken-line graph is shown.

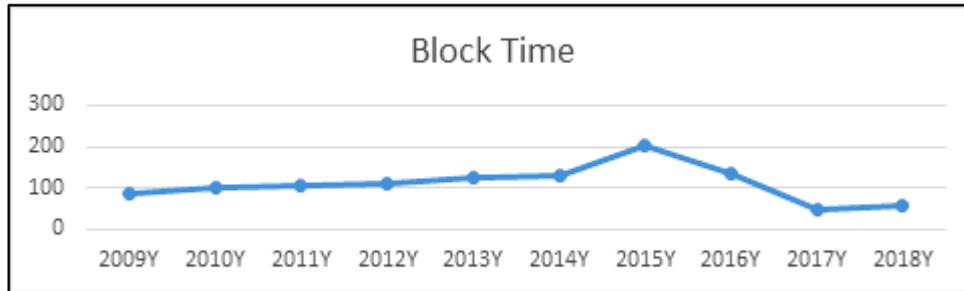


Figure 1 Annual interruption duration

It can be seen that with the increase of years, the downtime of transmitter due to failure increased gradually from 2009 to 2016. And it peaked in 2015. In order to ensure the stable operation of the transmitter, the transmitter stopped broadcasting between 2 and 4 p.m. in the high temperature weather from July to August 2016. With the improvement of cooling system in the computer room, the interruption time in 2017 is obviously reduced, but the interruption time in 2018 is still longer than that in 2017.

Conclusion: From Figure 1, it can be inferred that the overall transmission interruption time of transmitter is gradually increasing from 2009 to 2016, and the interruption time is obviously decreasing from 2017 to 2018 with the improvement of the air supply system in the engine room. It can be seen that the annual interruption time of the transmitter decreases with the decrease of the working environment temperature of the transmitter.

## 2.2 Analysis of the frequency of faults in the same month of each year

Because statistics are the function of samples, and samples and populations are the same distribution, and independent of each other, the distribution of statistics is uniquely determined by the joint distribution of samples, that is, by the total sub-samples and their distribution [5]. Without changing the operating environment of the transmitter, the annual operating characteristic curve of the transmitter should be roughly similar. In order to more clearly analyze the impact of temperature on the transmitter, the failure frequency of the transmitter in different years and in the same month is calculated, and the frequency curve can well reflect the change of the failure rate of the transmitter with the change of weather temperature, which is the data characteristic. Through this feature, the intuitive influence of temperature on the transmitter can be better analyzed.

According to the statistical analysis of previous transmitter working logs, the failure frequencies of each month from 2009 to 2018 are shown in Table 2 below.

Table 2 Monthly failure frequency data of transmitters

Particular year frequency	2013-2018 Monthly Failure Frequency Data of Transmitters (Monthly)											
	1	2	3	4	5	6	7	8	9	10	11	12
2009	0	2	5	0	6	0	0	0	0	5	0	4
2010	1	1	0	5	5	7	2	3	1	3	4	7
2011	4	3	0	4	1	5	7	7	6	2	2	0
2012	3	4	0	3	1	8	10	6	4	0	4	0
2013	3	1	5	1	4	3	11	9	4	2	2	1
2014	1	1	1	2	3	2	13	3	2	3	5	1
2015	1	3	1	2	3	8	5	6	1	4	2	1
2016	6	4	0	3	1	7	1	14	2	2	4	0
2017	2	0	0	3	2	4	1	2	2	0	0	0
2018	3	2	3	2	6	2	1	2	0	0	0	4

From Table 2, it can be seen that the frequency of solid-state transmitter failures mostly concentrates between June and September, and peaks in July and August. In order to reflect this change more intuitively, considering that the man-made shutdown processing was adopted during the peak temperature in July-August 2016, the data of 2016 was not used for the time being. The monthly data of transmitter from 2009 to 2015 were reflected by the broken line graphics. The following Figure 2:

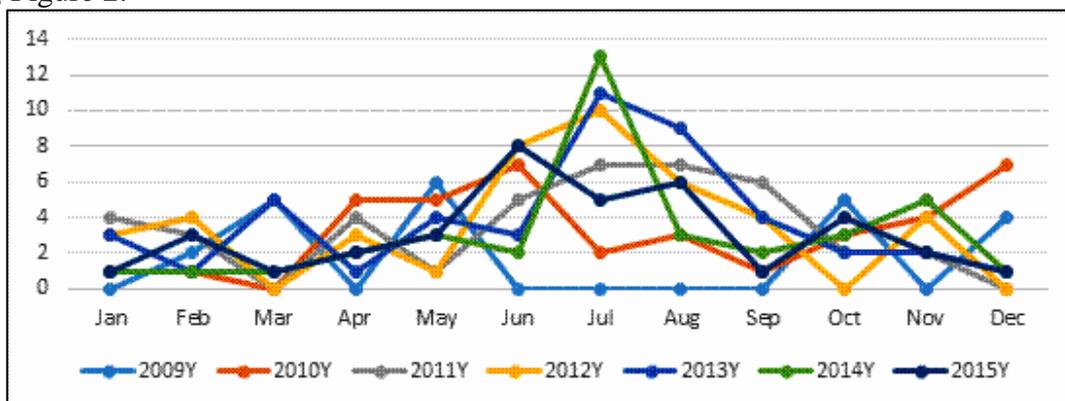


Figure 2 Contrast chart of failure frequency in different years and in the same month

Figure 2 shows more intuitively the change of failure rate with the change of seasons. After searching and analyzing the local annual meteorological data, it was found that the temperature of Yucheng county of Shangqiu city (Shangqiu station is located in Yucheng county of Shangqiu city, Henan Province) was the highest in August, and the highest outdoor temperature reached 38 degrees Celsius. Yucheng county of Shangqiu city had the highest temperature in July and the highest outdoor temperature reached 39 degrees Celsius in 2014. In August of 2015, Yucheng county of Shangqiu city had the highest temperature and the highest outdoor temperature reached 39 degrees Celsius. But in August 2015, the station adjusted the transmission time of the transmitter, and stopped the transmitter from 2 p.m. to 5 p.m. every day in August, which resulted in the decrease of equipment failure frequency in August 2015.

However, in 2016, for the needs of users, the transmitter did not take measures to shut down under high temperature environment in August, which resulted in a series of large-scale failures in August, the highest temperature in summer of 2016, which led to the concentrated occurrence of transmitter failure frequency.

After statistical analysis, the failure data of transmitter from 2017 to 2018 after improving the internal circulation system of air conditioning are summarized. The related data are shown in Table 3 below.

Table 3 Monthly failure frequency data of transmitter

Particular year	2015 Monthly Failure Frequency Data of Transmitter in 2017 and 2018											
	1	2	3	4	5	6	7	8	9	10	11	12
2015	1	3	1	2	3	8	5	6	1	4	2	1
2017	2	0	0	3	2	4	1	2	2	0	0	0
2018	3	2	3	2	6	2	1	2	0	0	0	4

It can be seen that with the decrease and stabilization of transmitter temperature (the working environment temperature is constant at 21 degrees Celsius), the overall failure rate of transmitter decreases greatly, and there is no previous breakdown phenomenon in summer high temperature season. For intuitive analysis, draw the following line chart.

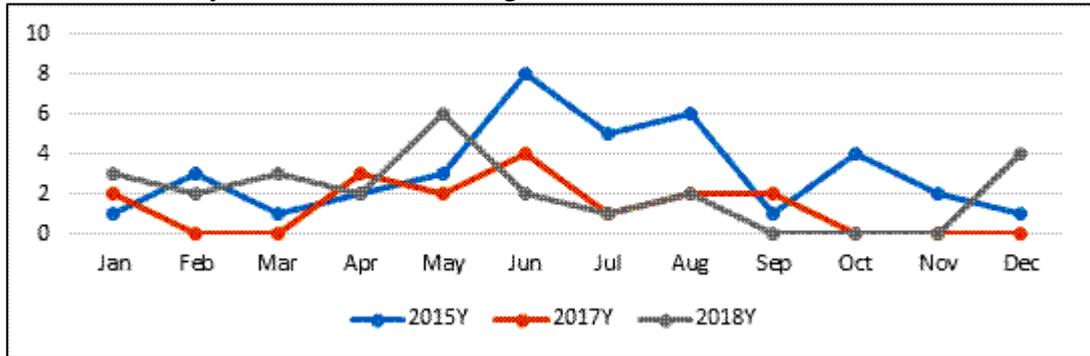


Figure 3 Contrast chart of transmitter failure frequency in the same month after changing cooling system

As can be seen from Figure 3 above, with the change of heat dissipation mode of solid-state transmitter, the frequency of faults significantly decreases from June to September. It can be seen that high temperature is indeed an important factor affecting the normal operation of high-power solid-state transmitter.

### 3. Conclusion analysis and improvement suggestions

Through the analysis of the failure data in the past 10 years, it can be seen that temperature is indeed a major factor affecting the stability of the transmitter. In the production and design of the new generation solid-state transmitter, measures should be taken to deal with this factor. For the traditional scheme of fan cooling, we must firmly refuse to adopt it. With the development of technology, there are many new energy-saving schemes that can be adopted in society [6]. Considering the different geographical locations of transmitters in the future, the following schemes can be adopted;

1. For the southern region with lower latitude, if the temperature is not lower than 5 degrees Celsius at the lowest time of the year, running water can be used to reduce the temperature. In other words, water-cooled radiators are installed on the power amplifier board or other parts of the transmitter which are easy to heat up. The radiators are cooled by circulating distilled water. This method has the following advantages;

(1) The operation and maintenance cost of fan cooling or air conditioning cooling is high, while the running water cooling only needs to spend a certain amount of money in the initial stage of equipment construction, and the subsequent maintenance cost is low.

(2) Low noise; water circulates in the radiator, without any other mechanical vibration, the sound is naturally very small.

(3) Energy saving; as long as a very small drive, water can be continuously circulating flow, compared with the traditional fan cooling or air conditioning cooling, its energy consumption is the smallest.

2. For areas with higher latitudes, because of the frost phenomena when the temperature is lowest in winter, especially in northern China, when the temperature is lowest, it will reach tens of degrees below zero. Therefore, this area can only take the way of industrial air conditioning plus

running water to cool down, when the temperature is higher than 5 degrees Celsius, using running water to cool down. When the outdoor temperature is below 5 degrees Celsius, air conditioning is adopted to cool down. The alternative use of the two methods can not only achieve the purpose of constant temperature of the equipment, but also save energy.

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