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Characteristic Analysis of DS18B20 Temperature Sensor in the High-voltage Transmission Lines' Dynamic Capacity Increase

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ABSTRACT

Dynamic capacity increase in high voltage electric power transmission line is currently the most economical method for solving electric power transmission bottleneck nowadays. DS18B20 temperature sensor is applied to the dynamic capacity increase of high voltage transmission lines to measure the conductor temperature and ambient temperature. The paper is focused on the experiment of DS18B20 both in the laboratory and outside. From the result of the lab temperature measurement data analysis, using 4 DS18B20's is the most suitable plan, considering both accuracy and economical efficiency. In the experiment outside, we get four groups of conductor (uncharged) temperature and four groups of ambient temperature. The data proved that DS18B20 has good stability, and small measurement error. It is suitable for measuring the temperature of conductor and ambient in dynamic capacity increase, and helpful to improve the accuracy of the calculation of capacity increasing.

Keywords: DS18B20 Temperature Sensor; Measurement Error; Dynamic Capacity Increase; Data Analysis

1. Introduction

In recent years, with the development of China's sustained and rapid, power consumption will also continue to increase. In economically developed areas, due to the partial slow speed of grid construction, the bottleneck problem of the power system transmission capacity of transmission lines has become increasingly prominent. However, because of the limited line level of thermal stability, transient stability level and the level of dynamic stability, about a quarter of the transmission line transmission capacity was significantly lower than the level of foreign. In order to improve the transmission capacity of transmission lines, the comment measures are UHV technology, flexible AC transmission technology, the series compensation technology, dynamic reactive power compensation with the rod back and compact transmission, heat-resistant wires of large cross-section and other technologies,etc.[1]. Among various researches, increasing the heat capacity of transmission line has been carefully studied by most electrical departments and has been proven to be an effective and the most economical way to enhance the current capacity of transmission lines.

The current capacity of transmission line is depend on its heat-balanced equation. The line's current capacity is related to various factors like sunlight intensity, wind velocity and direction, characteristics of line (such as diameter, aging and AC resistance , etc.) and ambient temperature. The maximum current capacity of transmission line is changing with the line's temperature. However, the maximum current capacity can only be calculated by the conductor temperature model. It can't be monitored online. It is important to get conductor temperature exactly by online monitoring. The error of conductor temperature is mainly from two aspects. One is measurement error, sensor error and sensor acquisition device error; the other is the algorithm error, reduce from the regularity of distribution of the sample to. Therefore, this paper is focused on analyzing the validation and precision of DS18B20 temperature sensor which we decided to use on measuring temperature, by doing experiments in laboratory and outside.

2. Temperature Sensor Experiments

2.1. Laboratory Experiments

1) Experimental equipments

DS18B20 temperature sensor: measuring range-55℃

-125℃, accuracy±0.5℃; two standard mercury thermometer: measuring range-5℃-150℃, accuracy±0.1℃, it is the standard value; GDWJS-250 alternating wet heat test box: temperature range -40℃-150℃,temperature volatility≤±0.5℃, temperature uniformity≤±2℃.[2]

2) Experimental methods

In the laboratory, eight DS18B20's and a mercury thermometer are put into an alternating wet heat test box, and the data collection equipments are put outside the box. According to the measuring range of each temperature sensor, We choose 0℃,20℃,30℃,40℃,60℃ and 80℃ as test points. When it reaches to the test temperature and stipulated time, we record the temperature of mercury thermometer and data collection equipments in each test points for four or five times, every minutes. We use SPSS software to process data, and do the Levene-test and t-test to the sample[3].

2.2. Field Experiments

1) Experimental equipments

We Beijing Key Laboratory of High Voltage & EMC designed the temperature measurement device. As it is showed in **Figure 1**, there are four sensors in the device. Sensor 1 is for measuring the temperature of transmission line. Sensor 2 is for measuring the reference wire. Sensor 3 and 4 are for ambient temperature.

2) Experimental methods

In the experiment of measuring real transmission line, we hang the four temperature measuring devices on wire between two towers, which span is 187.8 meters, **Figure 2** shows how the devices are hanged on the wire, we record a data every 5 minutes, testing for 24 hours. We use SPSS software and Excel to process data, and do Time series analysis and Paired-samples T-test to the sample.

3. Analysis on Experimental Data of Temperature Sensor

3.1. Analysis on Experimental Data of Laboratory Experiments

Because of different measuring points and the differences among temperature measurements, it is difficult to analysis overall. We unify the experiment data at first. Let the measured values minus the standard to get the measurement error and then analyze the measurement error. The obtained experimental data were histogram, interval estimation, normal distribution hypotheses test. From **Figure 3**, the sample of single sensor of measurement error is not entirely belonging to the normal distribution.

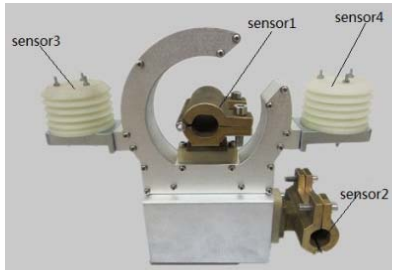

Figure 1. Temperature measurement device.

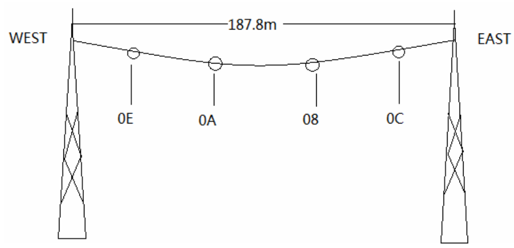

Figure 2. Device suspension schemes.

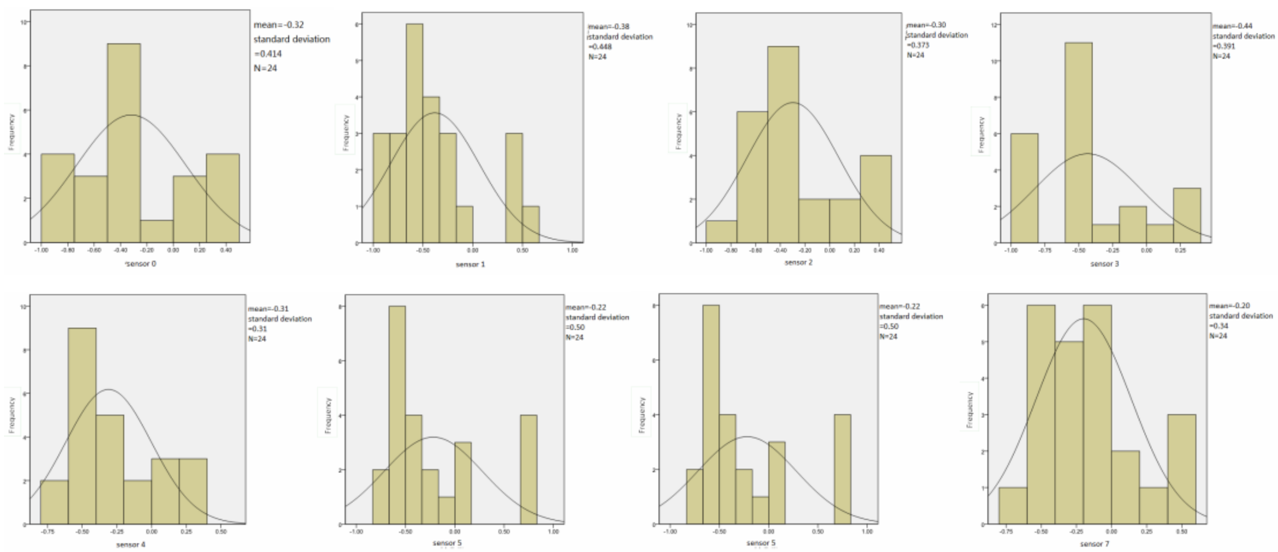

Figure 3. DS18B20's data histograms.

Table 1 [3] shows that the columns asymptotically significant (both sides) values greater than 0.05, based on hypothesis testing knowledge to know, the original assumption that the sample (each sensor measurement deviation) from a normally distributed population.

Single DS18B20 has no significant impact on measuring error, and multiple DS18B20's 95% upper and lower limits of the confidence interval of the difference are significantly lower than single DS18B20. So that multiple sensor measurement value of mean values can significantly reduce error. Using four DS18B20's is the most suitable plan, Considering both accuracy and economical efficiency.

3.2. Analysis on Experimental Data of Field Experiments

According to the curve of real transmission line measuring data [4], when DS18B20 enter the stable operation, data are changing smoothly, have no mutation, and hard real time. According to weather conditions, from the trend of the curve can be seen, the sensor mounted just needs a stable period of time, in order to accurately reflect the conductor and the ambient temperature; data for temperature measurement devices 0E is selected 11:13 as the start value, 0A is selected 11:16, 08 is selected 10:58, and 0C is selected 10:55s the start value. The standard of selecting the start value is the inflection point of the temperature started to climb. Each group extracts 253 data according to time sequence. **Figure 4** is the curve of real transmission line measuring data.

We do paired sample T-test on the difference between sensor 3 and 4 of these four measured devices. The significance probability of measurement device 0E, 0A and 08 are greater than 0.05, so that there are no significant differences between paired sample data.[3] However measurement device 0C is different from others, the reason maybe anthropic factor. The difference between the sensor 3, 4 were less than 0.2°C, in line with project requirements error which is lower than 0.3℃.[4]

4. Conclusions

We could make conclusions from the analyzing above. Single DS18B20 has no significant impact on measuring error, and multiple DS18B20's 95% upper and lower limits of the confidence interval of the difference are significantly lower than single DS18B20. So that multiple sensor measurement value of mean values can significantly reduce error. Using four DS18B20's is the most suitable plan, considering both accuracy and economical efficiency.

Table 1. DS18B20 statistics.

NO.		0	1	2	3	4	5	6	7
Mean value		-0.3192	-0.3817	-0.2983	-0.4358	-0.3108	-0.2192	-0.2942	-0.1983
Standard deviation		0.41444	0.44767	0.37261	0.39113	0.30974	0.49959	0.42007	0.34016
Mean 95% confidence interval	Lower limit	-0.4942	-0.5707	-0.4557	-0.601	-0.4416	-0.4301	-0.4715	-0.342
	Upper limit	-0.1442	-0.1926	-0.141	-0.2707	-0.18	-0.0082	-0.1168	-0.0547
Asymptotically significant (both sides)		0.667	0.367	0.353	0.478	0.131	0.155	0.916	0.502

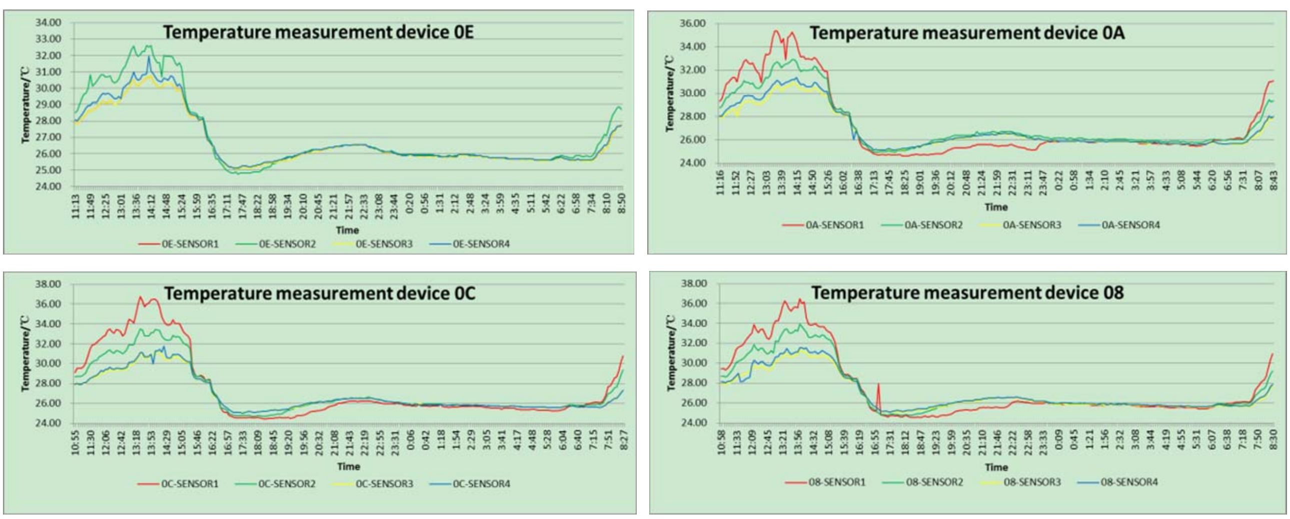

Figure 4. Curve of real transmission line measuring data.

According to the curve of real transmission line measuring data, when DS18B20 enter the stable operation, data are changing smoothly, have no mutation, and hard real time. The significance probability of measurement device 0E, 0A and 08 are greater than 0.05, so that there are no significant differences between paired sample data. However measurement device 0C is different from others, the reason maybe anthropic factor.

According to the analysis above, DS18B20 is suitable for measuring the temperature of conductor and ambient in dynamic capacity increase, and helpful to improve the accuracy of the calculation of capacity-increasing.

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