Experimental Study on Lightning Characteristics of Electronic Equipment's Power Supply

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***Abstract*—Lightning protection for power supply of electronic equipment is an important problem of low-voltage lightning protection systems. In this paper, lightning characteristics of electronic equipment's power supply are studied. Firstly impulse generator is developed. Then lightning characteristics tests for different powersupply, such as switch model power supply, are done. Test results show: different power supply has different lightning impulse characteristics.Usually two different models are used for lightning performance evaluation: common and different model. Both impulse current and impulse voltage withstand capability in common model are stronger than those in different model. Flashover often occurs in the AC-DC conversion part inside of the switch power supply when there is lightning stroke. The manufacturing technology of the power supply has definite effect on withstand capability. The switch model power supply has some weak parts when there is lightning stroke, such as transformers in the AC-DC conversion part, the resistor and capacitor of the bridge rectifier. Switch model power supply have stronger lightning withstand capability than common small power supply we chose as equipment under test. It is necessary to measure lightning withstand capability when designing lightning protection system for power supply in low voltage electronic equipments. The data presented in this paper could provide reference for real situation**

***Index Terms* — Electronic Equipments, Power Supply, Impulse characteristics, Test.**

I. Introduction

Recent years, lightning protection in low-voltage power systems is not always considered seriously enough,so low-voltage transformers and load are often struck by lightning. Damage caused by lightning in low voltage electrical and electronic equipments may be not too large, but as the low voltage equipments are commonly used in many areas, related economic loss caused by lightning is huge finally[1]. The power supply system, which is an important part of low voltage electronic system, is the main way where lightning enters and possibly damages the electronic system. According to the literature [2], loss caused by lightning stroke from power supply systems occupies 70% of all losses caused by lightning stroke. However, research on lightning impulse characteristic of power supply of electronic equipments, especially some commonly used equipment like computers, is not done enough all over the world. It is important to find what is lightning impulse characteristic of power supply of electronic equipments when designing lightning protection for them [3]. Related research on this field is done and results are presented in this paper. Obtained test data can be referenced for lightning protection project.

There are two types of lightning impulse test. One is the impulse current test, and other is the impulse voltage test. Purpose of the impulse current test is to assess energy enduring capability. In this paper for impulse current test wave we chose typical values of ±8/20μs [4], [5], which is shown in Fig.1. Purpose of impulse voltage test is to assess insulation and withstand capability of equipment under test (EUT), and then offer some instructions for insulation coordination of Surge Protective Devices (SPD) and equipments in low-voltage system [6],[7,],[8]. Impulse voltage test wave is ±1.2/50μs [9], which is shown in Fig.2.

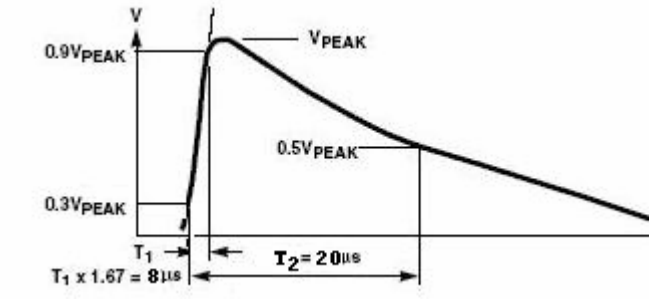

Fig.1 Impulse current test wave (±8/20μs)

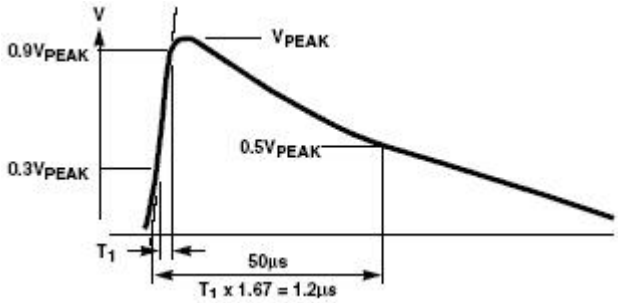

Fig.2 Impulse voltage test wave (±1.2/50μs)

Each test type, impulse current or impulse voltage test has two different models, which are: different model (DM) test and common model (CM) test. Different model test means that

impulse is input between live pin (L) and neutral pin (N) of EUT. Purpose of DM test is to test insulation withstand capability between interior phases, when there is over-current or over-voltage through lines of equipments. Purpose of CM test is to test insulation of lines (L or N) against the ground (G) when the ground potential is higher due to lightning stroke. In this paper, in the case when there is ground pin both model tests are performed, while only different model test is done for power supply without ground pin.

II. Equipment under Test and Testing Method

As equipments under test (EUT), we choose switch model power supply of computers and CRT monitors, and also some common chargers of recorders, mobile phones, etc. Other equipment necessary for performing tests include: impulse generator,oscilloscope,shunt,voltage divider,isolation transformer, etc.

It is well known that initialization value of impulse current or voltage, which is generated by high voltage impulse generator in modern electrical power systems, is much higher level [11]. For example, one device in Wuhan University High Voltage LAB only can generate voltage whose peak value is 10kV at least. This kind of impulse generator is not suitable for tests presented in this paper, so new impulse generator which can generate lower impulse current and voltage levels is developed in this paper. The name of that lightning impulse generator is LJDY—I and its circuit diagram is shown in Fig.3. C0 is total value of all parallel capacitors group, while inductor L and resistor R are used for adjusting current wave form. As it can be seen from Fig3,voltage divider FYQ1, FYQ2 and shunt FLQ are used to provide easy access for oscilloscope to measure current or voltage value at testing points of the EUT. Working principle of this impulse generator will be described below.

Look at part 1 in the Fig.3, where impulse current is generated. Firstly parallel capacitors group C0 is charged by rectifier, and then the spherical gap is breakdown by high voltage triggered pulse from triggering device, after that, C0 will discharge through R, L and EUT.

Now look at part 2 in the Fig.3, where impulse voltage is generated. Firstly, wave-head of impulse voltage waveshape is produced, because main capacitor C0 discharges into capacitor C1 through resistors R1 and R2. Then wave-tail of impulse voltage waveshape is generated because capacitors C0 and C1 discharge through resistor Rt. All electronic components can be adjusted whether part1 or part2, in order to generate different value of ±8/20μs impulse current or ±1.2/50μs impulse voltage waveform [12].

Circuit diagram of lighting stroke test is presented in Fig.3 where following abbreviations are used：

T－200/50000 transformer, L1－charging inductor, C2－charging capacitor, V2－charging voltage indicator, R3－charging resistor, D －silicon stack, C0－charging main capacitor, R －resistor for adjusting impulse current waveshape, L －inductor for adjusting impulse current waveshape, C1-capacitor for adjusting impulse voltage waveshape, Rt,Rf －resistors for adjusting impulse voltage waveshape, R1,R2－charging resistors,S－EUT,FLQ －shunt, DHQ －pulse lighter, FYQ －voltage divider, CRO －oscilloscope.

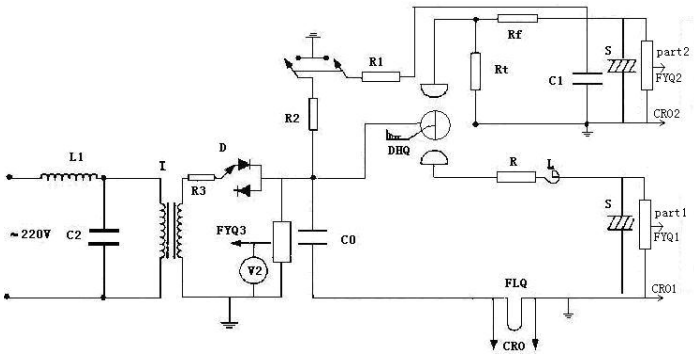

Fig3: Circuit diagram of lighting stroke test

In the test, under the condition of lightning stroke, critical value when there is no blast, no breakdown of air gap or any electronic component, or no any smell from EUT, etc. is regarded as maximum value of lightning withstand capability. Test is performed by is increasing impulse value by 5%, until first sign of damage occurs.

III. Test Data and Analysis

All test data are shown in table 1, where "-" means that case is not tested. All tests are done in normal temperature.

Table 1: Withstand lightning capability of electronic equipment's power supply

Name of power supply	Devices applied in	I_{MAX}/kA		U_{MAX}/kV	
		L-N (DM)	L-G (CM)	L-N (DM)	L-G (CM)
HLY-300ATX	computer	2.6	3.52	4.52	6.09
PLD-250	computer	2.62	3.53	4.63	6.07
PS-250G	computer	2.44	3.96	5.13	6.08
ST-ATX315	computer	2.38	3.52	4.12	6.25
Envision	monitor	1.52	3.83	3.96	4.48
PHILIPS 105A	monitor	1.22	3.51	3.74	4.24
PA-8480	monitor	1.34	3.24	3.54	4.18
SyncMaster 730	monitor	1.32	3.61	3.65	4.51
AOC 771S	monitor	1.23	3.74	3.80	4.35
AOC 550S	monitor	1.52	3.63	3.95	4.24
M600	electrograph	1.94	2.65	5.40	5.90
SY-E141	charger for recorder	2.06	--	4.89	--
UE350503A2	OKWAP adapter	2.15	--	5.16	--
TAD137CSC	charger for mobile phone	1.55	--	5.02	--
ACP-7C	charger for mobile phone	1.65	--	4.94	--

In the table 1, L denotes live pin, G ground, while N means neutral.

From results presented in Table 1, it can be seen：

Different EUT has different withstand capability. Even power supply of same type have different withstand capability. For example, different computer switch model power supply

have different withstand capability.

For switch model power supply chosen in this paper, due to their stronger anti-interference capability (most of the powersupply of this kind have filter circuit), so withstand capability of switch model power supply is stronger than withstand capability of small common power supply like that for charger for recorder or some of the other similar powersupply we chose for the test.

For switch power supply withstand capability under the common model is stronger than that obtained under the different model. For example, withstand impulse current peak value of computer power supply in different model is between 2.38kA and 2.62kA, while impulse current peak value of computer power supply in common model is between 2.52kA and 2.96kA. Also, impulse voltage peak value of computer power supply in different model is between 4.12kV and 4.63kV, while impulse voltage peak value of computer power supply in common model is higher then 6 kV. It is almost same situation for monitors. To sum up, lightning protection in different model must be considered more seriously for real lightning protection project.

Test results also show that withstand impulse current and voltage peak value of computer power supply in different model are about 2.5kA, 4.5kV respectively. Withstand lightning current and voltage peak value of computer power supply in common model is about 3.6kA, 5.8kV respectively.

Withstand lightning current and voltage peak value of CRT monitor power supply in different model are about 1.36 kA, 3.77kV respectively; Withstand lightning current and voltage peak value of CRT monitor power supply in common model are about 3.62kA, 4.33kV respectively.

For small common electronic power adapters, such as recorder, input voltage is AC 220V and output voltage is DC 5V or DC 9V. Most of this kind of power supply only has lightning impulse characteristic in different model. Its withstand lightning current peak value is about 2kA, and its withstand lightning voltage peak value is between 5kV and 6kV. All those data can be referenced for real situation.

IV. Test Phenomenon and Analysis

As we know, function of electronic equipment's power supply in most countries in the world, is to provide low-voltage DC for electronic equipment from AC 220V system. Most switch model power supply consist of four parts, such as conversion circuit from AC to DC, switch oscillation and voltage regulating, switch tube protection, and pulse rectifier [13], [14].

Test shows that most of flashover or other damage phenomenon occurs at the first part, when there is impulse current or voltage. First part is the conversion circuit from AC to DC. That conversion circuit consists of the input circuit, degauss circuit, and bridge rectifier. Moreover, input circuit whose function is to input 220V consists of main switch, delay AC tube, and high frequency filtering capacitor. Test results shows, that flashover occurred most often between pins of main switch and crust. Also high frequency filtering capacitor is easy to be damaged when there is impulse. Bridge rectifying filter consists of resistor, high power resistor and high voltage filtering capacitor. Test shows that resistors and high voltage capacitor inside of this part are easy to be damaged .

The inside structures of the power supply adapter of recorder and charger of mobile phone are not so complicated, so only different model insulation is tested. Test results show that withstand lightning impulse capability is low.

From presented test results we can conclude that lightning protection capability will be stronger when manufacturing technology is better. Also weak part of switch model power supply are the first part of inside structure, such as high frequency filtering capacitor, resistor and capacitor inside of bridge rectifying filter. From that reason choosing higher capacity electronic components can make withstand capability higher.

V. Conclusion

In this paper, tests related to the lightning impulse characteristics of common electronic equipment powersupply have been presented. Main results and conclusion are drawn below:

A new relatively lower scale lightning impulse generator is developed. Current waveshape ±8/20μs or voltage waveshape ±1.2/50μs can be generated.

Different electronic equipment has different withstand lightning capacity.

For switch model power supply as EUT, withstand lightning impulse capacity in common model is stronger than that in different model. That means that withstand capacity between lines is weaker than withstand capacity between lines and ground. So, for real lightning protection situation it should be paid more attention to this facts. Specific data can be referenced from table 1.

Withstand capacity of computer's power supply is stronger than that of CRT monitor. And both these kind of power supply are stronger than those of small electronic equipment, like switch for communications and other small electronics equipment which was chosen for the test.

Test shows that weak part of switch model power supply is located in first part, whose function is to transform AC to DC system. Also we concluded that manufacturing technology definitely affects withstand lightning level. Choosing nice manufacturing technology power supply and higher capacity electronic components can make withstand capability higher.

Switch model power supply has stronger capacity than common power supply, so switch power supply is recommended for power system in low voltage electronic equipment.

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