WHITE PAPER

CALCULATING LIFE EXPECTANCY OF THE SURGE PROTECTOR PD-OUT/SP11

Introduction

Electronic devices and components are vulnerable to the damaging effects of lightning and switching transients. In today's world, the significant challenge is in protecting ethernet equipment such as switches, routers and network cards, while maintaining performance. The equipment is more vulnerable to surges produced by lightning as it could be networked with other equipment that may reside outside. Hence, surge protection has become a much more complex and important issue in recent years. This whitepaper describes the calculation of life expectancy of Microsemi's PD-OUT/SP11 surge protector.

High voltage transients are a common occurrence on twisted pair communication cables. In particular, lightning-induced transients can occur quite frequently. In geographic regions with high thunderstorm activity, such as the southeastern USA, South America, and Africa, the density of cloud-to-ground lightning strikes can exceed 10 strikes per square kilometer per year. The magnitude of these cable surges depends not only on the geographic region where the cable is deployed, but also on a variety of other factors such as the length of the cable, its relationship to local earth ground, and nearby structures that can affect the path taken by lightning discharge currents. Lightning-caused voltage, current and wave shapes are very difficult to predict.

Lightning

Lightning is a natural phenomenon caused by separation of electrical positive and negative charges by atmospheric processes. When the separated charge gets very large, the air between the positive and negative regions breaks down in a giant spark (an intra-cloud stroke), or a charged region breaks down to ground (a cloud-to-ground stroke). In a typical storm most (~80%) lightning strokes are within a cloud and while the remainder are mostly cloud-to-ground strokes. Each visible event, referred to as a flash, typically consists of 1–6 (or more) individual strokes, separated by <0.1 second.

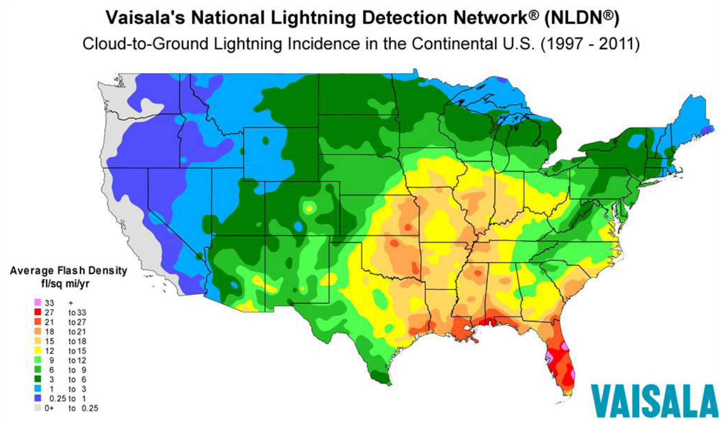

Figure 1. 1997-2011 Average US Lightning Flash Density, in flashes/mi^2/year

The frequency of lightning flashes varies widely with location and season. Figure 1 is a cloud-to-ground flash density map of continental US showing the wide variation in lightning frequency, from <0.25 flash/mi^2/year in the Pacific Northwest to >33 flash/mi^2/year in Florida a100x higher. In addition to this broad range, there are wide local variations due to local topography. Hilltops and ridges are generally struck much more frequently than valleys. Also, year-to-year weather changes create major variations. Figure 2 illustrates the flash density around the world.

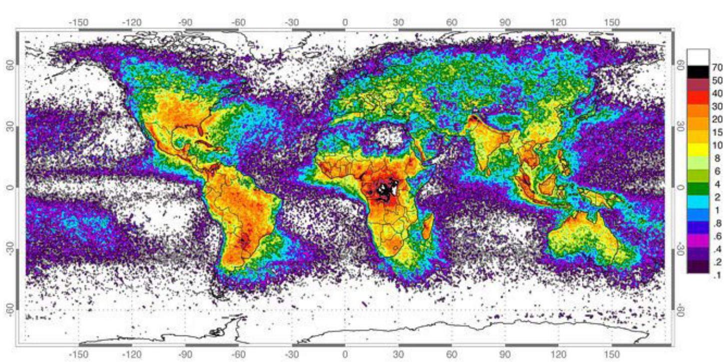

Figure 2. Worldwide Annual Lightning Flash Rate

Below is a table of measured lightning strikes/month, within a 20 mile radius, published by NASA after a 10 year investigation on the Kennedy space center.

Table 1: Measured Lightning Strikes/Month

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Totals
Jan	0	2	131	164	594	99	869	0	8	39	1906
Feb	0	1	1	0	0	672	341	24	1	113	1153
Mar	0	132	98	30	0	423	268	365	1594	1302	4212
Apr	0	753	0	79	157	2	650	877	857	267	3642
May	0	956	0	0	1197	675	6623	658	1073	102	11284
Jun	1580	2518	600	5864	2034	1538	4120	3218	13761	3197	38430
Jul	17	3083	6011	1200	5051	3204	2643	8363	8510	2337	40419
Aug	0	1847	1898	4015	5538	4588	5829	2858	6950	5711	39234
Sep	317	1904	290	4218	292	2373	4053	7590	3367	1026	25430
Oct	160	2967	0	22	228	380	510	7	1509	1226	7009
Nov	0	0	1	0	50	0	8	32	77	13	181
Dec	0	2	0	0	107	0	0	0	0	7	116
Totals	2074	14165	9030	15592	15248	13954	25914	23992	37707	15340	173016

As per Table1, the number of lightning strike per months and per years are unequal. For example, the number of lightning strikes in 1999 exceeds the number of lightning strikes in 1993 by almost 12 times. Hence, it is very difficult to predict exact number of strikes per specific protection device for a short period of time (couple years). Hence, to derive a better life expectancy for the protection device the average number of strikes per 10 years should be considered for the calculating the life expectancy.

Damage from Lightning

Lightning almost never strikes telecom cables directly [2]. When it does, the result is usually catastrophic and includes melted cable conductors, charred materials, and significant physical damage to the connected equipment. The current that flows in the lightning channel of a direct strike can be 100,000 Amps or more. There is little that can be done to protect telecom equipment from damage due to a direct lightning strike.

Fortunately, the majority of lightning surges that appear on telecom cables occur due to an indirect coupling mechanism. As the initial lightning impulse is very strong, equipment connected to cables a mile (1.6 km) or more from the site of the strike can be damaged.

Typically, one of the following coupling mechanisms are involved when lightning creates a transient on a nearby cable:

1. Lightning strikes an object nearby and induces a transient through electromagnetic coupling.
2. Lightning strikes a building and travels to ground through the building's steel structure or a grounding cable. The high currents induce a transient through electromagnetic coupling.
3. Lightning strikes the ground near a building and causes the building's local ground reference to momentarily rise (known as 'Ground Potential Rise' or GPR).

Calculation of Life Expectancy of Surge Protector

The main protection component used in Microsemi's PD-OUT/SP11 surge protector is Gas Discharge Tube (GDT). GDTs typically have a 'crowbar' characteristic, meaning that when they trigger, GDT becomes effectively a short circuit and remains shorted until the surge current drops to a low level. This characteristic minimizes power dissipation in the protection devices, and allows them to handle very large surge currents without overheating.

GDTs have a finite life expectancy, and can handle a few very large transients or a greater number of smaller transients. GDTs used in PD-OUT/SP11 are selected from well-known and reputable manufacturers with established practices that use quality materials in construction. A good quality GDT with a long life expectancy reduces replacement in the field and ultimately saves cost.

The life of the GDT is expressed in a surge waveform and the number of surges. PD-OUT/SP11 employs premium class GDTs with the following characteristics of impulse discharge current:

Table 2: GDT Characteristic Table for Calculating Life Expectancy

Impulse Discharge Current	Waveform Duration	Number of Operations
20,000 A	8/20 µs	1 operation minimum
10,000 A	8/20 µs	> 10 operations
200 A	10/1000 µs	> 300 operations
200 A	10/700 µs	> 500 operations

Unfortunately, there is no standardized procedure to calculate life expectancy of the surge protection device. Each manufacturer offers their own method based on their experience for calculation life expectancy.

The following methods help in calculating the life expectancy of the Microsemi PD-OUT/SP11:

- Select location of installation. For this example, use Florida as the example location as it has the highest number of lightning strikes in the USA
- From Figure1 select number of strikes per year within a 1 mile square area: 33
- Based on following assumption from [2] that 99% of peak short –circuit current is about 100A, select from the GDT table the number of operations for an impulse discharge current that is more than 100A and with the longest waveform of 10µs/1000µs which will be 300 operations
- Calculate life expectancy - Operations/number of lightning strikes300/33=9.1year
- Assume an engineering margin of 20%, the final life expectancy is: 9.1x0.8=7.27years

The life expectancy of PD-OUT/SP-11 used in the location with the highest number of lightning strikes in the USA is **7.27** years.

References:

1. *Lee Bums, Ryan Deckert, "The Distribution of Cloud to Ground Lightning Strike Intensities and Associated Magnetic Inductance Fields near the Kennedy Space Center"*
2. *Joseph Randolph, " Introduction to Lightning and AC Power Fault Surge Protection for Telecom Signaling Cables"-Product Compliance Engineering (ISPCE), 2012 IEEE Symposium , 5-7 Nov. 2012*

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