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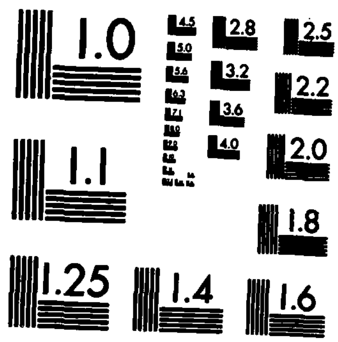

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AIR FORCE

HUMAN RESOURCES

ELECTRICAL POWER LINE PROTECTION

By

Weldon M. Dube

OPERATIONS TRAINING DIVISION
Williams Air Force Base, Arizona 85224

March 1983

Final Technical Paper

LABORATORY

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

This paper has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The AC Power Line Protection System has demonstrated the ability to eliminate AC power line transient overvoltage spikes caused by lightning and equipment switching surges, and thus protect expensive state-of-the-art electronic equipment. Furthermore, it has reduced extensive and costly repairs to sensitive and vulnerable electronic equipment at the Air Force Human Resources Laboratory, Operations Training Division, Williams AFB, Arizona.

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Item 19 (*Continued*)

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ELECTRICAL POWER LINE PROTECTION

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This publication is primarily a working paper. It is published to document work performed and for consideration in future military construction programs.

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1.0 INTRODUCTION

The Air Force Human Resources Laboratory, Operations Training Division, established an in-house project to determine the best approach to decrease or eliminate the damage to state-of-the-art flight simulator electronic computers caused by transient voltage surges. With the increase of solid-state computers using transistors and integrated circuit (IC) chips, computers are considered to be extremely reliable equipment. When unprotected, however, they are vulnerable to damage by electrical transient voltages.

The degrading effects of transient voltages of short duration, both in micro- and nano-seconds on solid-state semiconductors and integrated circuits, are of prime concern to users of electronic computers and equipment. The effects can inflict immediate and extensive damage to on-line equipment, resulting in random failures. Extreme damage or destruction of vital circuitry can and has occurred. This results in days or weeks of downtime and costly repairs. Additional expenses are incurred when test data, life cycle tests, training missions or other operations have to be redone.

2.0 SCOPE

The work described herein deals with the identification of the transient voltage problems caused to computers by surges, the selection of AC power line protection equipment, and recommended performance capabilities and characteristics of commercially available AC power line protection equipment.

3.0 BACKGROUND

The Air Force Human Resources Laboratory, Operations Training Division was established at Williams AFB, Arizona in 1968. Thunderstorms and high static conditions are frequent, and at times daily phenomena in the area. In addition, the power distribution systems and equipment at this 40-year-old base generates voltage transients within the distribution system itself which can cause problems to solid-state computers. After several years of transient voltage problems, the division performed a study and implemented a solution which has eliminated these problems.

Prior to 1978, the Division was routinely shutting down computer operations when storm warning alerts were received. They reviewed several options to correct this work delay situation and selected a commercially available off-the-shelf AC power protection system. It was installed in 1978 adjacent to and on the output side of the transformer located in the open on the northwest side of Building 558. The downtime for installation was 30 minutes. No other modifications were made to the equipment or utility system. Since that time, they have had no system outages due to vicinity storms and lightning strikes.

The following technical data and recommendations for the selection of commercially available AC power protection systems are based on Operations Training Division experience.

4.0 TECHNICAL CONSIDERATIONS

4.1 Sources of Transients

a. Lightning strikes near and on utility power transmission lines induce transient voltages of various amplitudes. These voltages may be transmitted into vulnerable power or signal lines or both.

b. Utility switching of power factor correction capacitors may be a severe source of problems to all nearby computer equipment. This may occur several times a day as changes are made to accommodate utility customer demand levels.

c. Other causes include in-plant operations such as circuit breaker opening and closing, operation of large motors, welding, etc.

4.2 Protection Approaches

Three methods are presently employed to protect equipment from the effects of transient over-voltages. They are isolation transformers, uninterruptable power, and AC power line protectors. An AC power line protector is considered the most cost-effective method. The units are designed for one job only. That job is limiting transient over-voltages to levels that sensitive equipment can safely handle. Again, this is considered to be the most cost-effective method.

4.3 AC Power Line Protection

The AC line protectors are designed to protect equipment on the AC power lines from electrical transients caused by lightning induction and switching surges. Operating in nano-seconds, they reset immediately and automatically, and thus are ready for the next transient. They provide the protection required to keep expensive equipment (i.e., computer systems, process instrumentation, radar systems, etc.) on line. They are commercially available and easily installed.

5.0 TECHNICAL EVALUATION

5.1 Desired Features

a. Automatic status and monitoring capabilities.

b. Resettable digital counter for transient readout with 36 to 48 hours ride-through if power is absent.

c. Remote control panel with fully independent operating controls status indicators and digital readout.

d. Field repairable "downtime" of less than 1 hour.

e. Protection available 100% of the time, even if the utility is blacked out and no power is available to the facility.

f. Extended warranty on parts, labor and workmanship.

5.2 Discussion of Performance Features

a. Specifications: An AC power line protector must act quickly and be able to handle large amounts of transient energy. Specifications include a response time of 5 nanoseconds (or less), peak power dissipation of 2 megawatts/phase, and an energy handling of 6000 joules/phase.

b. Field repairable: The protectors should employ modular construction techniques so that on-hand replacement modules can be rapidly replaced (within 30 to 60 minutes).

c. Reliability and Long Life: This must be incorporated into the equipment design. Units should be designed to withstand two major faults per month for 100 to 120 months and still be within 10% of its rated specification.

d. Degradation: The units must be able to avoid catastrophic failure of the protection equipment. The equipment should be designed to "fail-safe" so that individual protection elements within the protection unit can fail and be disconnected from the circuit. A fault indication must be immediately given.

e. Continuous Self-Test and Status Controls: This is a capability in which the protector assembly continually and automatically checks its protection integrity. Should the protection capability be compromised then the "protector" should immediately indicate a fault condition.

f. Transient Indication: This should occur in two ways. An indicator light should illuminate and a counter should record the event.

g. Status Controls: The status controls should have a continuous self-test feature and individual module switches. A fault condition should be shown by a red indicator light.

h. Remote Control and Indicator Assembly: The protection system should include an assembly which contains all of the operating controls and indicators (normal, fault, transient counter, etc.) in an enclosure that can be located remotely. This will provide a fully independent method of controlling the unit from a location other than the site of the unit.

i. Full-Time Protection: If a lightning strike were to cause the utility to lose power, then protected equipment would be subjected to severe and expensive lightning damage if another strike occurred; that is, if the protected equipment depended on the availability of AC power to operate the protection equipment. The protection units must be designed to be always present across the AC line. In this way 100% full time protection is provided.

j. Warranty: The equipment should be sturdy and reliable and be able to withstand hard use. A warranty on materials and workmanship should be obtained.

5.3 Electrical Specifications

Electrical Service	
Voltage	120/240/277/480
Frequency	50/60/400HZ
Phase	1 phase, 3 phase
Peak Power Dissipation	2,000.000 watts/phase

Energy Handling per Pulse	3000 joules/phase
Response Time	5 nano-seconds
Duty Cycle	.05%
Temperature	
Operating and Non-Operating	-20°C to + 85°C

6.0 CONCLUSIONS

6.1 An AC power line protection system eliminates one of the most common sources of AC power line problems; i.e., transient overvoltage spikes caused by lightning and switching surges. It is recommended that all present and future military construction projects (MCP) (P-321) and minor construction (P-341) projects include an AC power line protection system for all computer systems, radar systems, process instrumentation, and other transistorized or integrated circuit equipment.

6.2 User benefits provided by a protected site are:

a. Increased "up time,"
b. Reduced data base pollution,
c. Reduced maintenance costs for electronic/electrical equipment,
d. Reduced losses from repeating tests.

6.3 AC Power Line Protectors should have the following characteristics:

a. Exceptional energy handling capability
b. Rapid response (5 nano-seconds) capability
c. Test/reset and status indicators
d. Remote control and indicator location
e. Sturdy and conservatively designed equipment
f. Field repairability
g. Reasonable price

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