LOG OF MEETING
DIRECTORATE FOR ENGINEERING SCIENCES

SUBJECT: Presentation and Demonstration of New Arc Fault Circuit Interrupter Testing Technology by Zlan, Ltd.

DATE OF MEETING: September 28,1999

PLACE OF MEETING: STMicroelectronics Laboratory, 1310 Electronics Drive, Carrollton, Texas

LOG ENTRY SOURCE: Doug Lee, ESEE

DATE OF LOG ENTRY: October 15, 1999

CPSC ATTENDEES:
Doug Lee, ESEE
Andrew Trotta, ESEE

NON-CPSC ATTENDEES:
George Spencer, Zlan, Ltd.
Lee Blanton, Zlan, Ltd.
Ken Krogh, Zlan, Ltd.
Robert Clunn, Zlan, Ltd.
Tom Hopkins, STMicroelectronics, Inc.
Paul Marcik, Leviton Manufacturing Company

SUMMARY OF MEETING:
The purpose of the meeting was to demonstrate Zlan's testing capability with their Arc-Fault Circuit (AFCI) technology. Zlan had previously met with the Commission's technical staff in March of 95, April of 96, and May of 98. A copy of the Zlan view-graphs is appended to the meeting log.

Mr. Spencer opened the meeting and described the project relationship between Zlan, STMicroelectronics, and Leviton Manufacturing Company. Mr. Spencer reiterated from a previous meeting that Zlan is a research and development company of electrical safety technology and not in manufacturing. Zlan had previously set up a relationship with STMicroelectronics to manufacture a custom chip set for the arc-fault detection technology. Recently, STMicroelectronics and Leviton Manufacturing have teamed up to produce portable AFCI/GFCI (Ground-fault circuit interrupter) outlet protection technology for field-testing and marketing.

Mr. Blanton described some of the test features in Zlan's arc-fault detection technology. The features are summarized in the attached Zlan view-graphs. The Zlan digital technology allows for extensive power-up, self-test, and manual testing that could improve product reliability and

could provide important fault identification information to the consumer. Mr. Blanton stated that all of the test features presented could be customized and manufactured into a device as required.

Mr. Blanton presented conventional current sensing techniques for GFCIs and AFCIs. Typically, AFCI technologies use either resistors or toroids with an air gap to sense current. He revealed Zlan's new current shunt technology, which is patent pending, for AFCIs. One of the benefits of the Zlan technique is that the control algorithm for detecting unwanted arc signatures can be tested with scaled currents. Presently, one of the drawbacks in testing AFCIs is that arcing events by their nature are not readily repeatable. Therefore, Zlan devised a system to test their AFCIs using a library of arc current waveforms and a power amplifier to inject the currents into the AFCI-under-test. The library is a collection of waveforms of actual currents that were acquired and digitized for storage. The Zlan system uses a PC (personal computer) to drive a power amplifier to produce a scaled version of the stored waveforms. Using a scaled current makes the power amplifier smaller and less expensive and using the library of waveforms makes testing repeatable.

The CPSC staff asked if this method for capturing and simulating arcing can be used to test other AFCI technologies. Zlan staff responded they believe that this method could be used to test AFCIs with conventional current sensing techniques by using an unscaled current from a higher-powered power amplifier. Zlan staff also indicated that it may be possible to test an AFCI, although more difficult to do, using a PC with their system at the full-scale current and voltage.

Mr. Clunn demonstrated how waveforms can be captured and played back with the Zlan system to accurately simulate arcing. A Leviton portable duplex receptacle with AFCI and GFCI technologies was used as the device under test. Both "bad" and "good" arcs were demonstrated. Upon tripping. the device de-energized power to the load and flashed an LED (light emitting diode) encoded for fault identification.

United States
Consumer Products Safety Commission

Presentation
September 28, 1999 (11:30a. m. – 4:00 p. m.)

Objectives:
To provide a review and update on the relationship between Zlan, Ltd. and chip set manufacturer STMicroelectronics. To introduce the project relationship between STMicroelectronics and Leviton Manufacturing Company to produce AFCI/GFCI outlet protection units for field testing and marketing. To provide an update of Arc Fault Circuit Interruption technology and present new concepts and features as they relate to the implementation of AFCI technology specifically:

- Self-test Features of the Digitally Enhanced Circuit Breaker
- Current Sensor Technology
- External Low Current Level Stimulus, and
- Standards Resource of the Arc Waveform Library

Agenda:

I. Welcome to CPSC, Visitors and Guests

II. Introductions
- CPSC Electrical Engineering Division staff,
- Meeting Visitors & Guests;
- ST-Microelectronics staff;
- Leviton Manufacturing Company staff;
- Zlan, Ltd. staff.

III. Overview of Circuit Protection Technology (Mr. Lee Blanton, Vice-President, Zlan, Ltd.)

IV. Self-test Circuit Breaker Features
- Current Sensor Technology
- Low level Current Stimulus

V. Demonstration of Circuit Protection Technology (Robert Clunn, SMTS, Zlan, Ltd.)
- Circuit Breaker Testing Technology
- Application of Low Level Current Stimulus
- Demonstration of Arc Detection

VI. Feedback and Discussion

Company Overview

Zlan, Ltd.

Zlan, Ltd. (pronounced Zee'-Lan) is an electronics research and development laboratory dedicated to providing a FIRE SAFE electrical environment The formation of the company began in 1976. And for over two decades research focused on the problem of electrical fires in homes and buildings throughout the United States. The Zlan, Ltd. partnership was formed in 1990 by Mr. George Spencer and Mr. Karl Davenport.

The emphasis was first devoted to the assumption that faulty wiring was the main cause of electrical fires. Thus, Mr. Spencer devoted his early research to building a tester, the CRV-2, to analyze installed electrical wiring. Since the tester only detected the problem but did not solve it, the tester was never extensively marketed. The solution proved to be in providing a safer circuit breaker that would respond faster stop the flow of electrical current when a problem was detected.

Zlan has now developed and patented this new, safer Digitally Enhanced (DE) Circuit Breaker. In addition Zlan has developed and patented support technology in the Load Center Monitor (LCM) to aid in the installation, maintenance and consumer's security in home electrical safety. Zlan, Ltd. is located in Wylie, Texas.

STMicroelectronics, Inc. (ST)

STMicroelectronics is a global independent semiconductor company which designs, develops, manufactures and markets a broad range of semiconductor integrated circuits ("ICs") and discrete devices used in a wide variety of microelectronic applications, including telecommunications systems, computer systems. consumer products, automotive products and industrial automation and control systems.

In 1997, STMicroelectronics' net revenues were US$4.02 billion and net earnings were US$406.6 million. On the basis of the most recent independent industry data, STMicroelectronics is the world's leading supplier of analog ICs, mixed-signal ASICs, Smartcard ICs, non-volatile EPROM and EEPROM memories, special automotive ICs and MPEG-2 decoder ICs.

ST currently offers more than 3,000 products to major corporations including: Alcatel, Bosch, Creative Technology, Ford, Hewlett-Packard, IBM, Motorola, Nokia, Northern Telecom, Philips, Seagate Technology, Siemens, Sony, Thomson Multimedia and Western Digital. In 1997, more than 56% of ST's revenues were derived from differentiated products, a combination of dedicated, semi-custom and programmable products designed to suit a specific customer or a specific application and therefore having a high system content.

ST has 28,000 employees, 9 advanced research and development units, 31 design and application centers, 17 manufacturing sites and 60 sales offices in 24 countries.

LEVITON

The Leviton Manufacturing Company has its origins at the dawn of the electrical era in 1906. Originally engaged in the fabrication of mantle tips for gas lighting, the Company soon converted to production of a single electrical product -- a pull-chain lamp-holder. Today, Leviton's product offering comprises more than 20,000 distinct catalog numbers, and the Company stands as a leader in the electrical industry as it serves industrial, commercial, OEM and residential markets through retail and distribution channels. Leviton offers an enormous selection of cords, wire and cable produced by its subsidiary, American Insulated Wire. Electricord, another Leviton Company, manufactures a complete line of cordsets in both domestic and foreign configurations, as well as audio and video accessories, telephone devices, and electrical accessories. And Leviton's Telcom Division manufactures an extensive offering of voice/data communications products for premise wiring. Leviton's Macro Electronics focused business unit provides lighting controls and lighting control systems.

Building on nine decades of experience, Leviton's engineers, designers and researchers apply the latest technologies to development of new products and product refinements that satisfy the needs of emerging new market segments. Equipped with the latest CAD/CAM design tools, direct model-making capability, and industry-leading R & D and testing facilities, Leviton continues to introduce premium specification grade devices, power-quality equipment, microprocessor controls, and a host of other new products that set the pace of progress in the industry. These electrical and electronic devices are produced in Leviton factories throughout North America. Employing vertically-integrated manufacturing, the Company fabricates virtually all parts for the devices it produces. This assures unmatched quality not only in finished products but also in components and subassemblies.

Industrial robotics and automated assembly improve the manufacturing process dramatically. Production times are measured in minutes, and often in seconds. Quick product changeovers to accommodate rapid changes in market requirements can be carried out efficiently to keep Leviton at the leading edge of responsiveness. State-of-the-art manufacturing also enables the Company to harness automated production technologies that facilitate zero-defect factory output in combination with lower costs of manufacture.

DE Breaker Test Principles

- AFCI analog calibration signal injected at burden resistor.
- GFCI signal injected into primary of its current transformer.
- Verify Analog performance through the ADC.
- Digital filters verified via arc signatures from look-up tables.
- Verify that solenoid (if present) has continuity.
- Real-time arcing signals have higher priority than Auto-test.
- Repeat Auto-test every 10 minutes (with different signature).
- LED status indicator light encoded for fault identification.
- "And" results of AFCI & GFCI test into a "trip" signal.

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Upon Self-Test Failure:

- If Auto-test, verify trip output "adequate" to trigger an SCR.
  - But, ***do not*** remove power from load.
  - Indicate / signal homeowner of an Auto-test failure.
  - Set non-volatile flag to prevent re-enabling circuit breaker after next manual-test or power interruption.
- If Manual-test, trip SCR/solenoid (or remove Relay drive).
  - Remove power from load if possible (using fail-safe design rules).
  - Set non-volatile flag to prevent re-enabling circuit breaker.
  - Indicate / signal homeowner of defective device.

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Optional DE Breaker Features

- Signal homeowner periodically for the need to perform a Manual test.
- Detect ground to neutral short.
- Detect open upstream ground wire.
- Verify digital filters with Must-Not-Trip arcing signatures.
- Provide enhanced response for non-arcing hazardous electrical overload problems.
- Temporary external override of AFCI/GFCI functions to allow problem diagnosis by service personnel.

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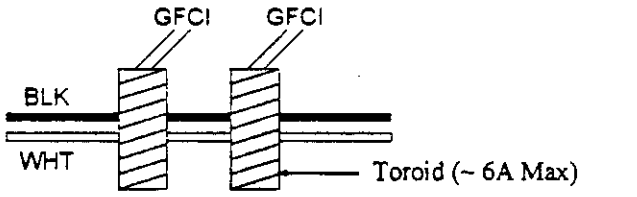
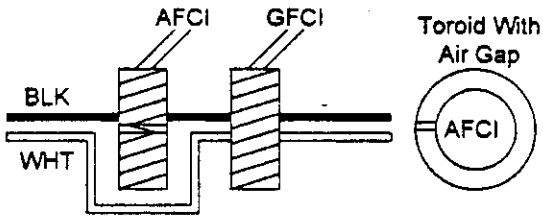
Conventional Current Sensors



$I_{GFCI} = (I_{BLK} - I_{WHT}) / N_T$; Differential Transformer



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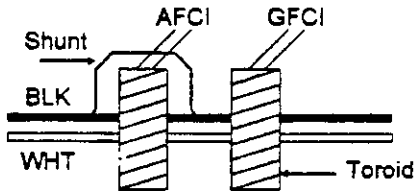
Zlan Current Shunt



$$I_{GFCI} = (I_{BLK} - I_{WHT}) / N_T \cong 0A$$

$$I_{AFCI} = ((I_{BLK} - I_{SHUNT}) - I_{WHT}) / N_T$$

$$\therefore I_{AFCI} \cong I_{SHUNT} / N_T$$

$$\& I_{SHUNT} \cong I_{BLK} \times \Omega_{BLK} / \Omega_{SHUNT}$$

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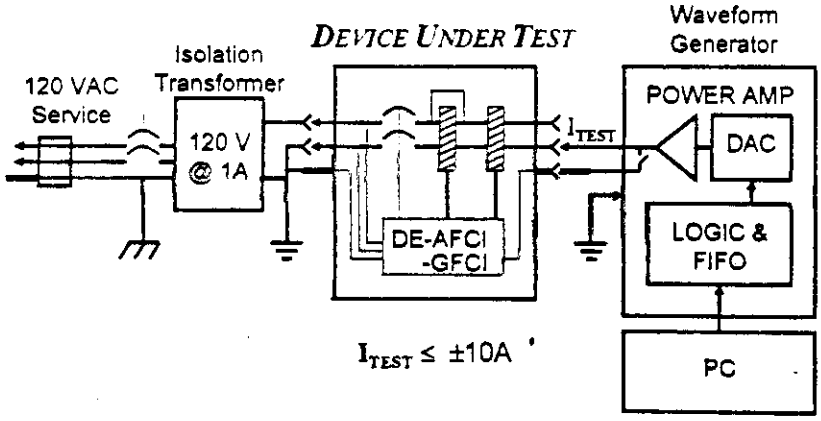
AFCI/GFCI Device Tester



$I_{TEST} \leq \pm 10A$

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