Expediting Service Restoration with an Automated Fault Location System

by
Lee Wang, Ph.D.
Grid Sentinel Inc., Bethlehem, PA

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Outline

- Real-time automated fault location and analysis
- Limitations of traditional methods
- WebFL system architecture & data requirements
- Result delivery and notification
- Key benefits

Real-time fault location & analysis

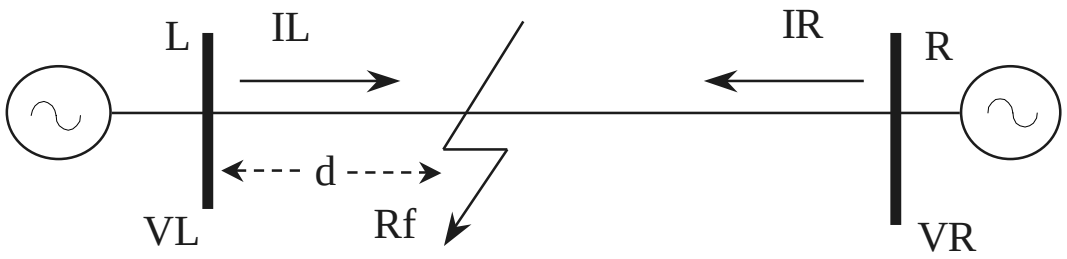
- Gaining competitive advantage in the marketplace
  - -- Save costs
  - -- Improve reliability, efficiency, customer satisfactions
- Conventional tools no longer satisfying the requirements under new environment
  - -- Real-time monitoring, analysis, and visualization
  - -- Enterprise-wide access to information (not just data)

Real-time fault location & analysis

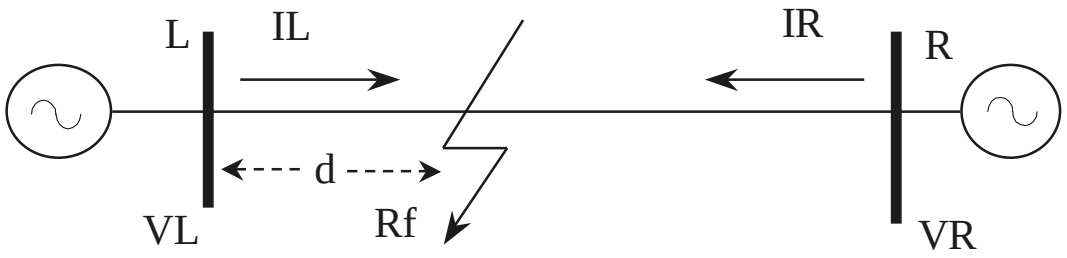
- System operators
  - -- Decision support tool
  - -- Faster service restoration: SAIDI & SAIFI
  - -- Improved situational awareness
- Protection (analysis) engineers
  - -- Improve productivity
  - -- Avoid time-consuming analysis of system conditions
  - -- Receive information in a timely manner
- Asset management
  - -- Optimize the availability of transmission infrastructure
  - -- Minimize helicopter patrolling area

Limitations of traditional methods

- Lack of network-wide analysis capability
- Limited accuracy – relying on various assumptions



Limitations of traditional methods

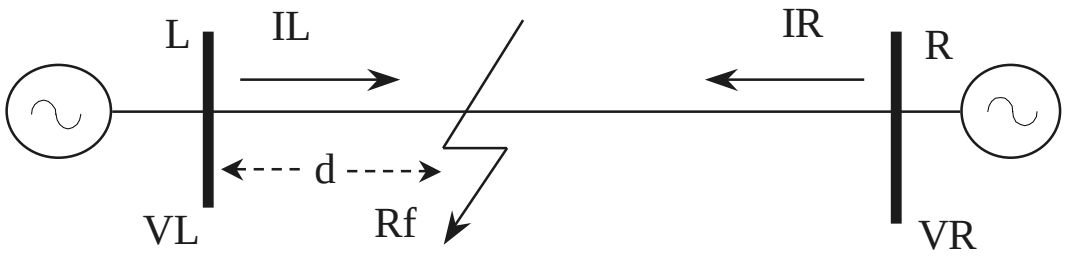


ASSUME local measured current is in phase with the total fault current

– Reactance method

$$d = \frac{\mathrm{Im}(\frac{V_L}{I_L})}{\mathrm{Im}(Z)}$$

Limitations of traditional methods

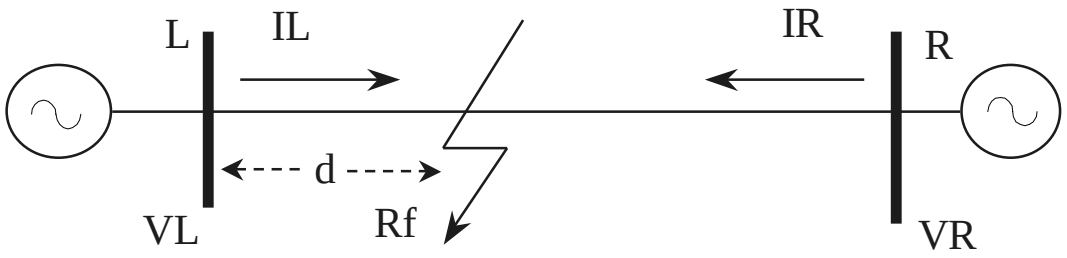


ASSUME local fault current is in phase with the total fault current

– Modified reactance method

$$d = \frac{\mathrm{Im}(V_L I_{fL}^*)}{\mathrm{Im}(I_L I_{fL}^* Z)}$$

Limitations of traditional methods

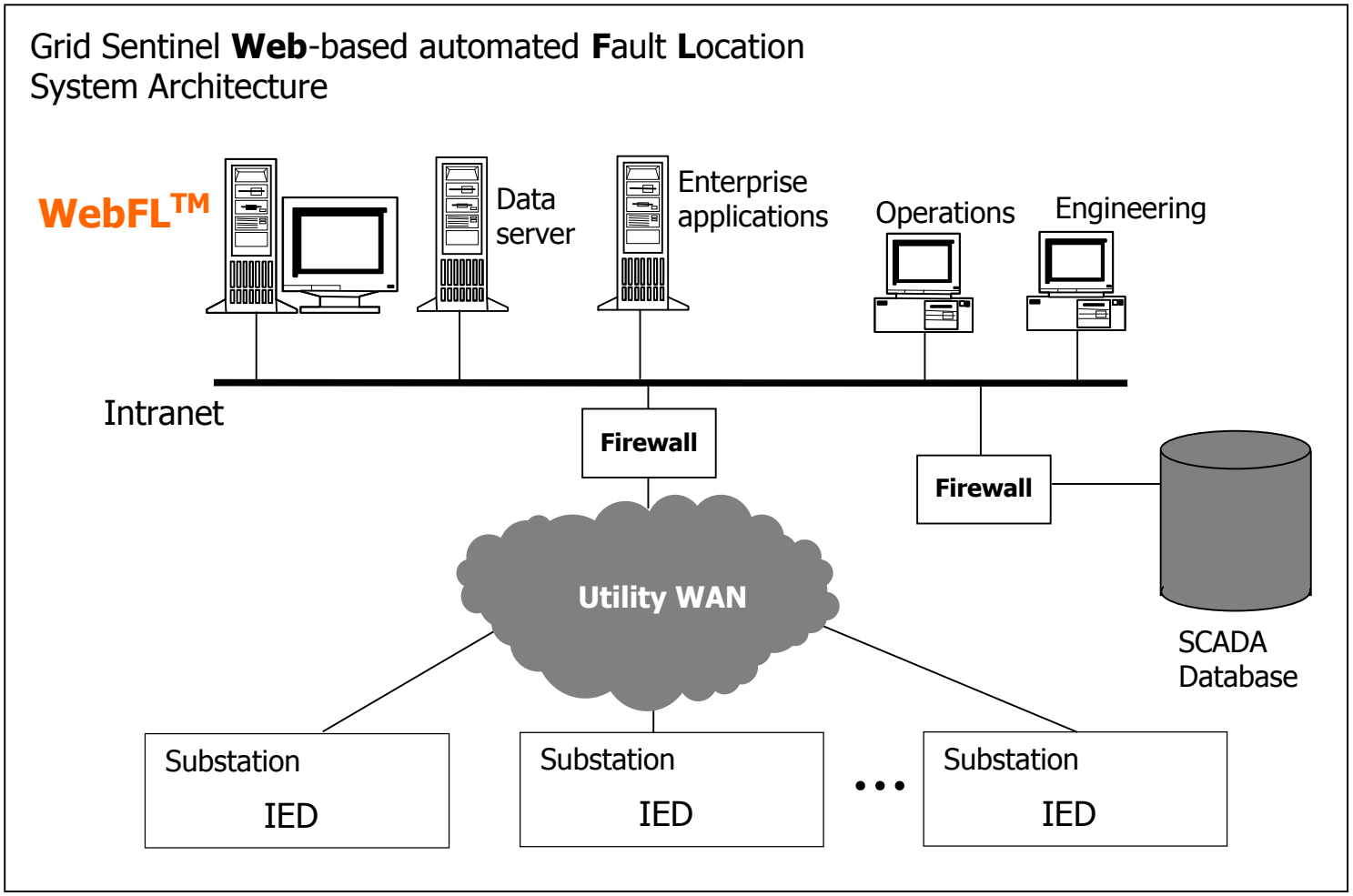


ASSUME local negative sequence current is in phase with the total fault current

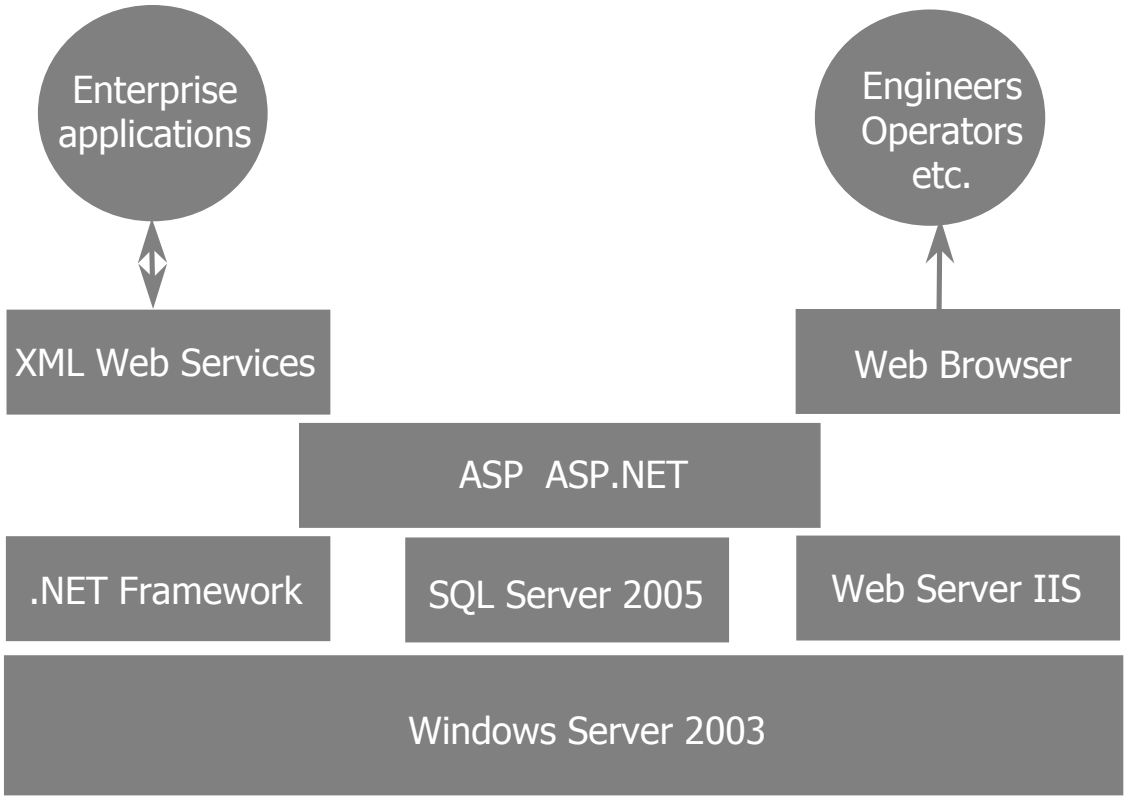
-- Modified reactance method

$$d = \frac{\mathrm{Im}(V_L I_2^*)}{\mathrm{Im}(I_L I_2^* Z)}$$

WebFL System Architecture



- Complete web-based solutions
- Built with Microsoft .NET technology



- Innovative algorithms
- Error less than 0.5%

Covering:

- Multi-terminal lines
- Two-terminal lines
- Un-transposed lines
- Series-compensated lines
- Mutually-coupled lines
- Tapped lines

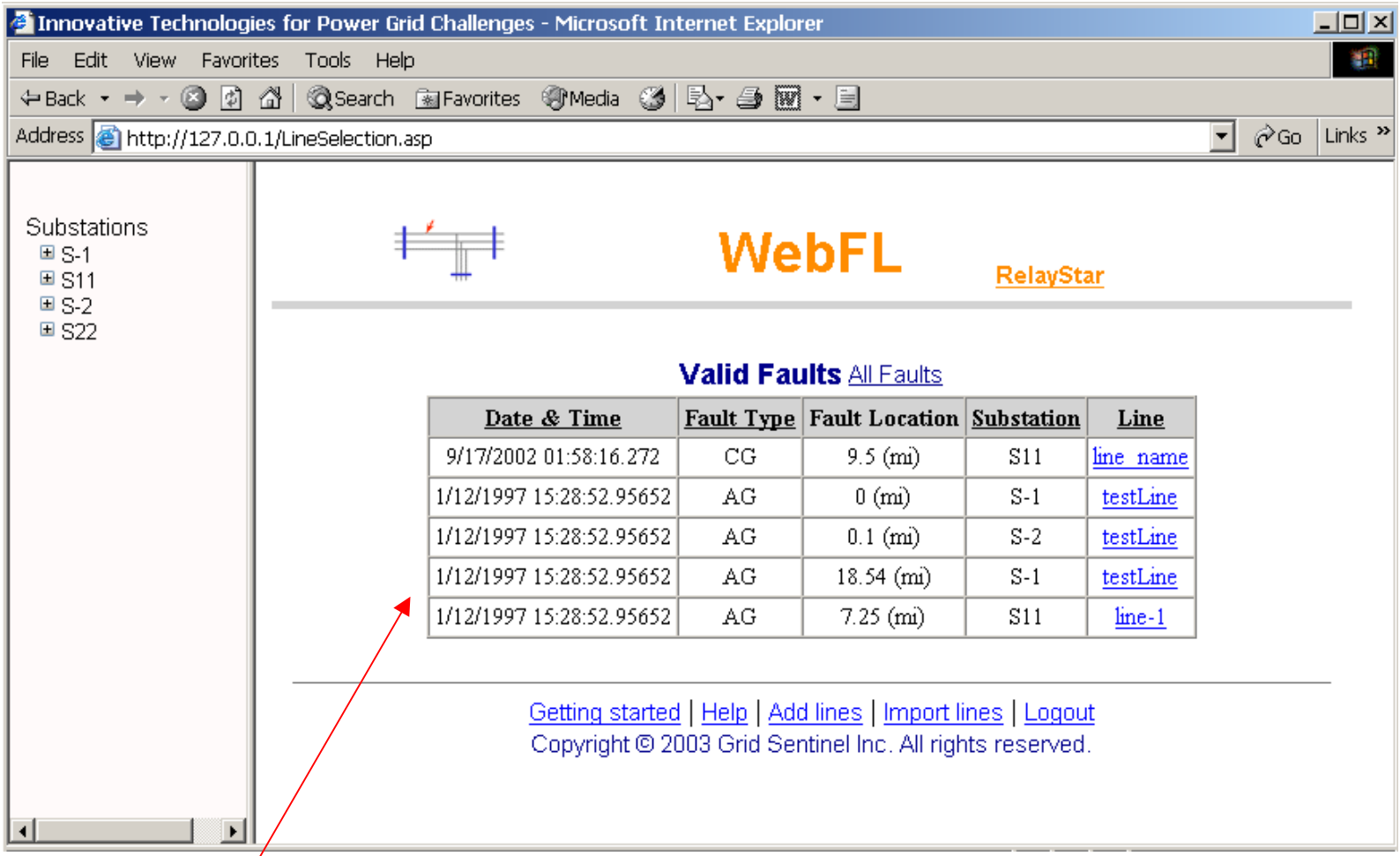
Data requirements

- System data
  - -- Line parameters (Import from existing tools, CAPE)
  - -- Substation connection
  - -- IED (DFR, Relays) installation
- Fault or disturbance data
  - -- Recorded by IEDs at line terminals
    - multi-ended algorithms
    - single-ended algorithms
  - -- COMTRADE or proprietary

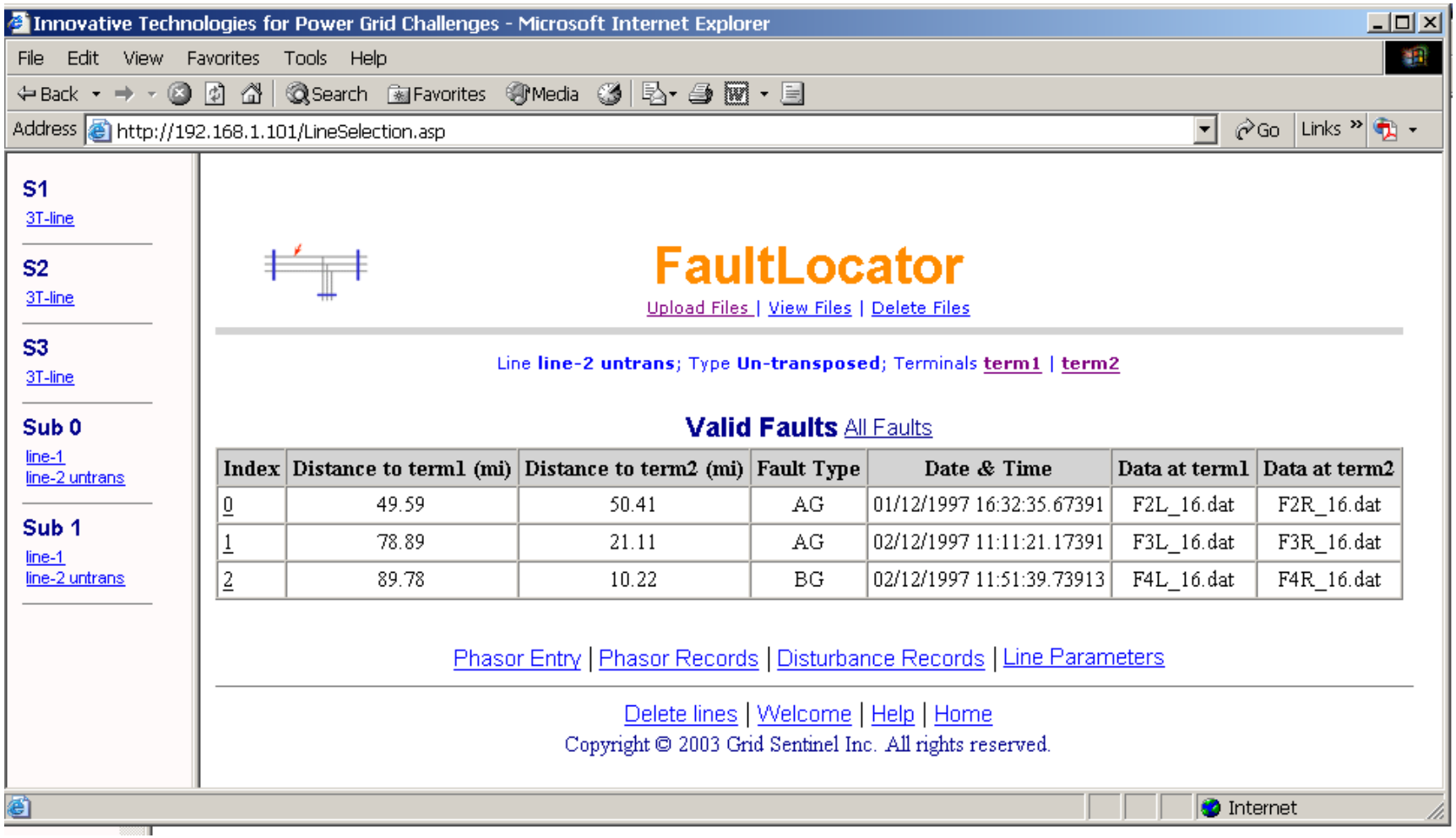
Result delivery and notification

- To system operators
  - -- Web interface
  - -- Integration to existing visualization tools (GIS or others) via XML data format
  - -- Email (Event-driven)
- To analysis (protection) engineers
  - -- Web interface
  - -- Email (Event-driven)

Web interface



Past 30 minutes by default



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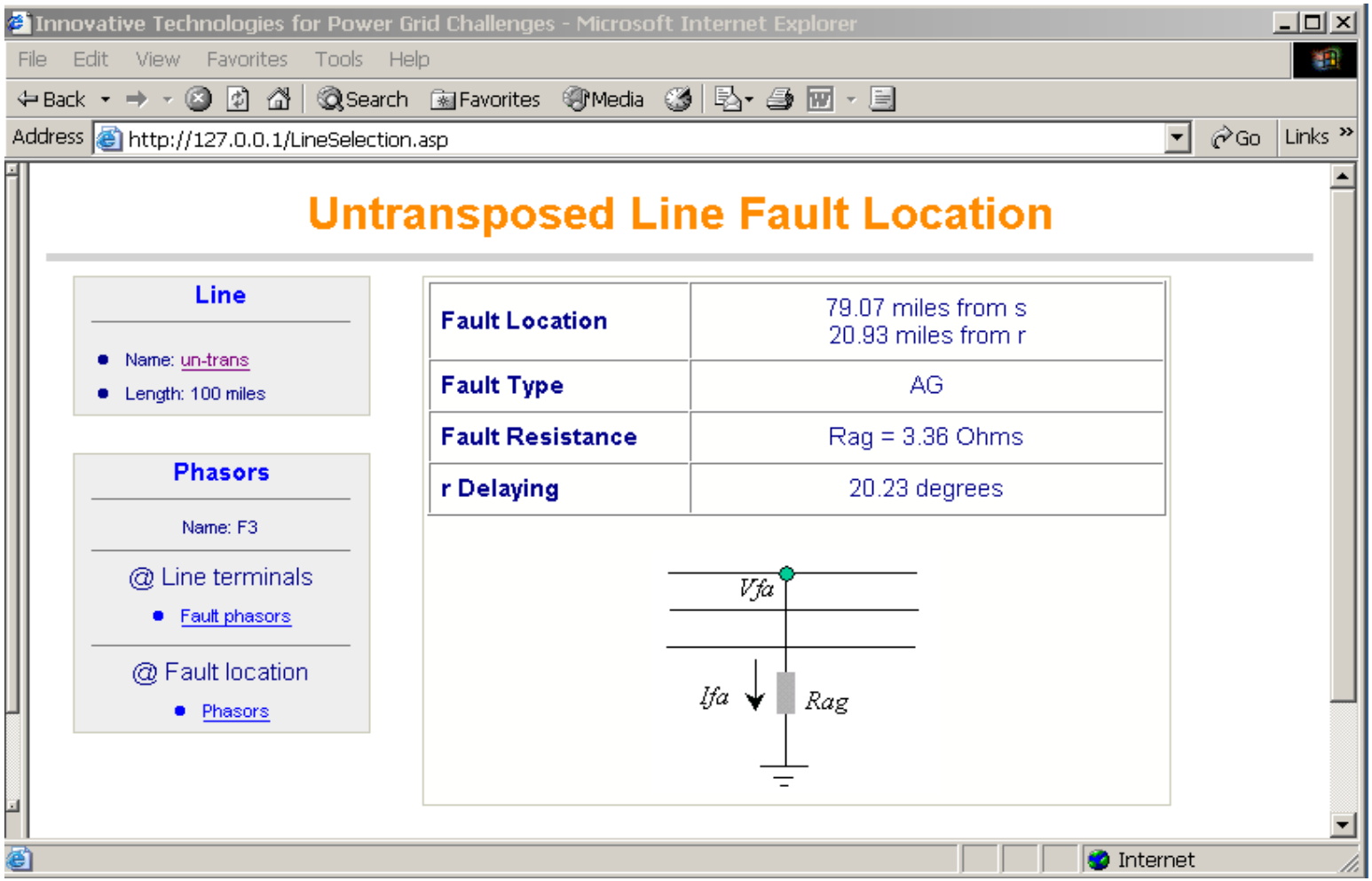
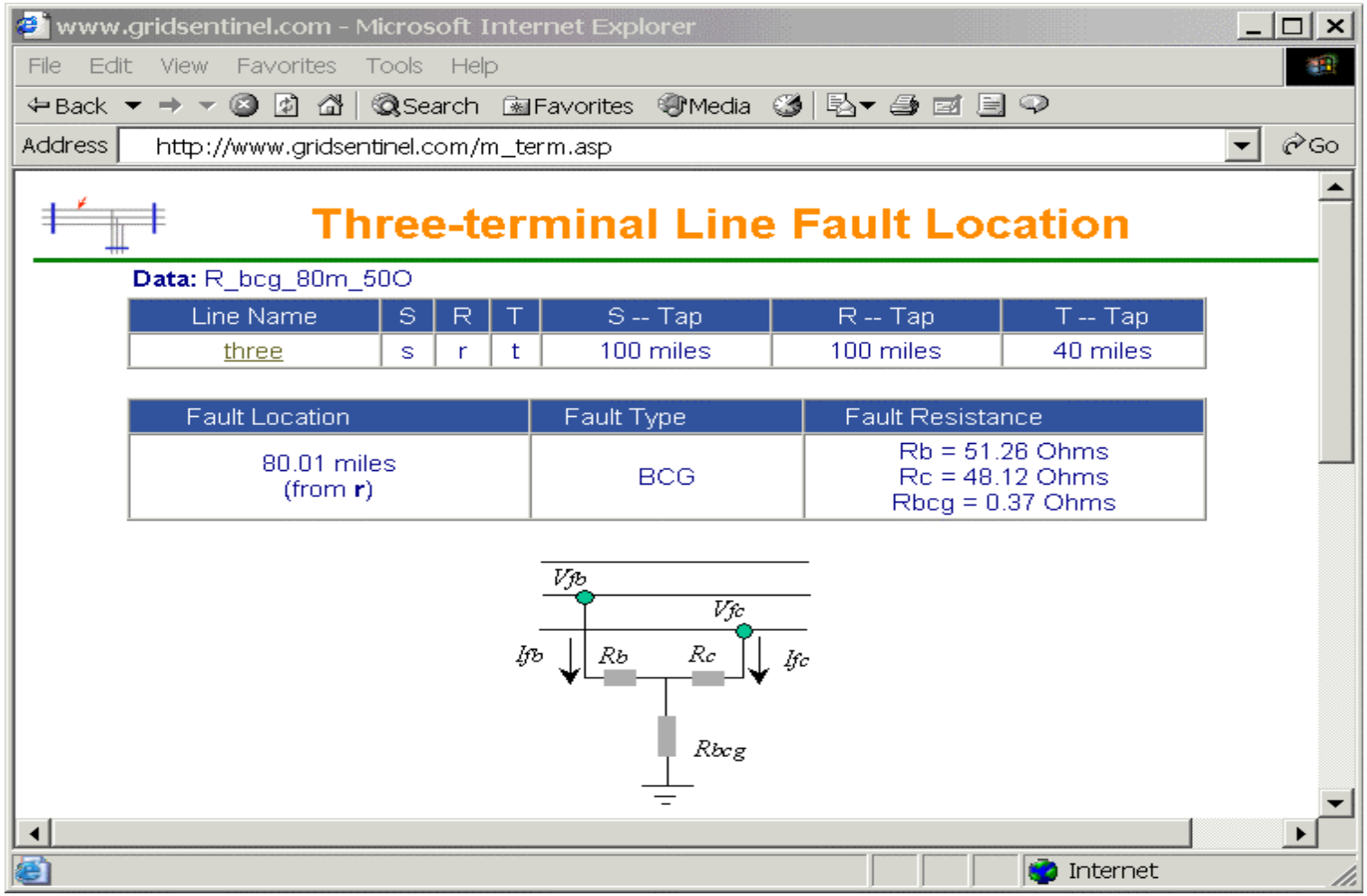
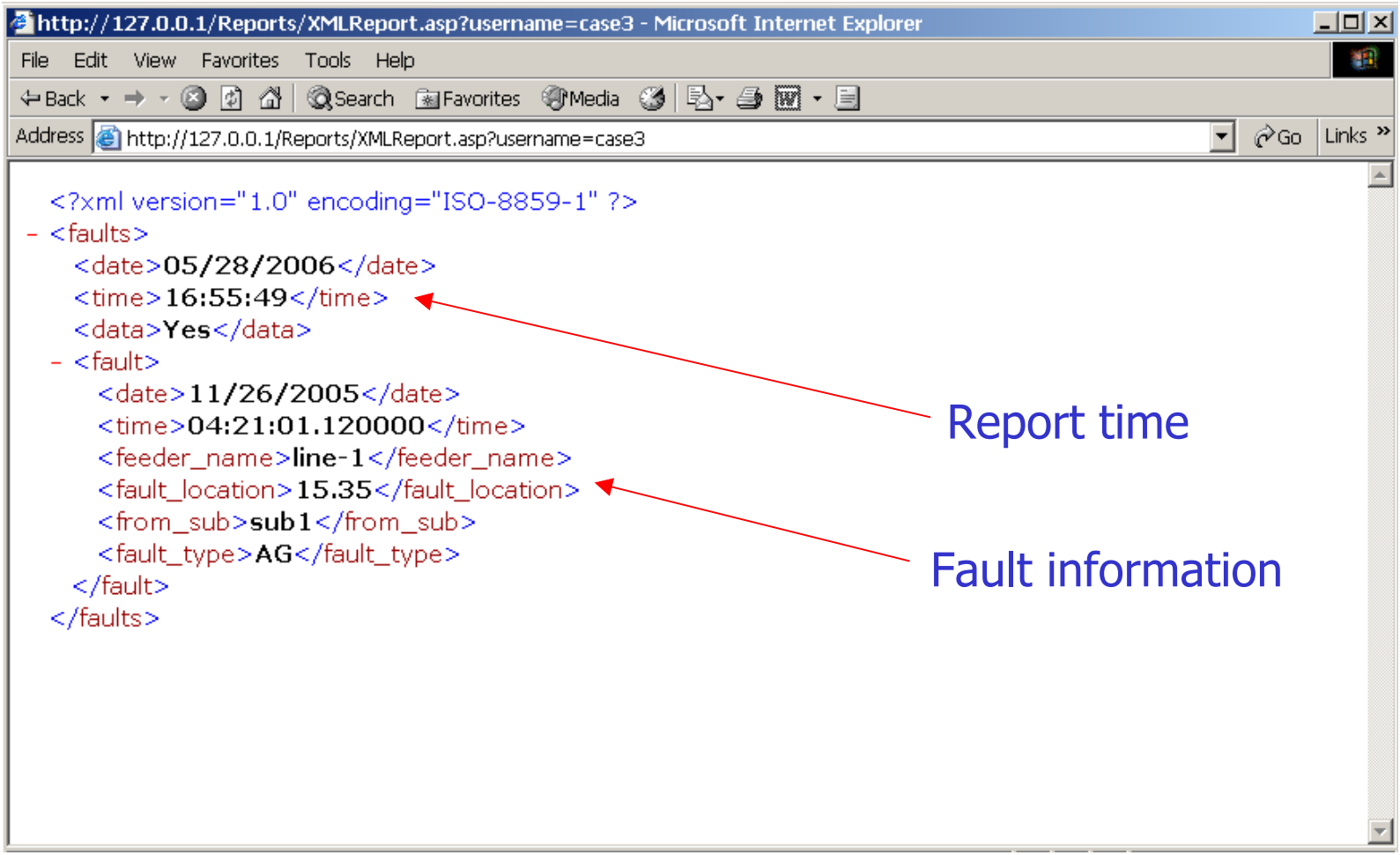




XML report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File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://127.0.0.1/Reports/XMLReport.asp?username=case3
Go Links
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- <fault>
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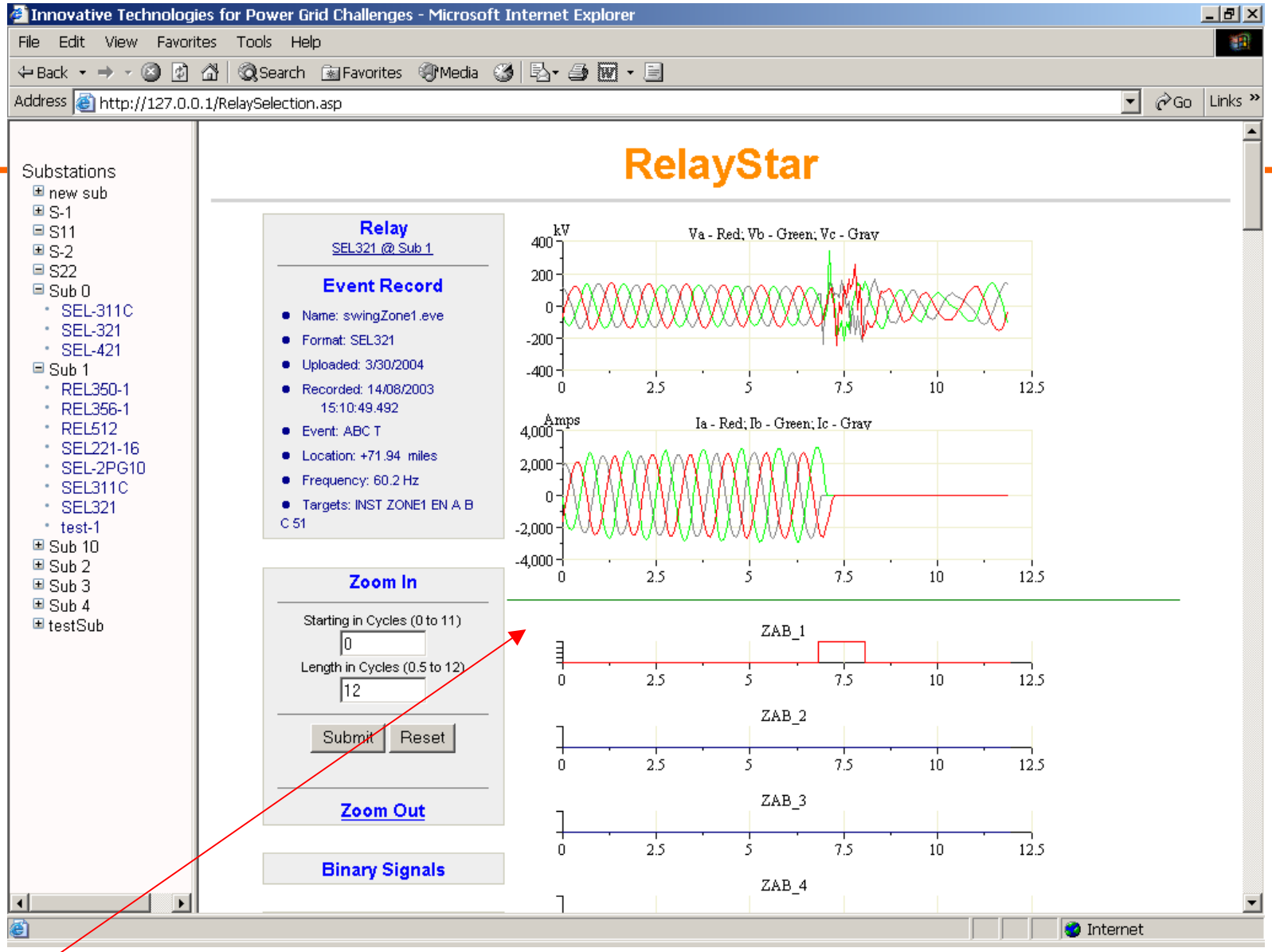
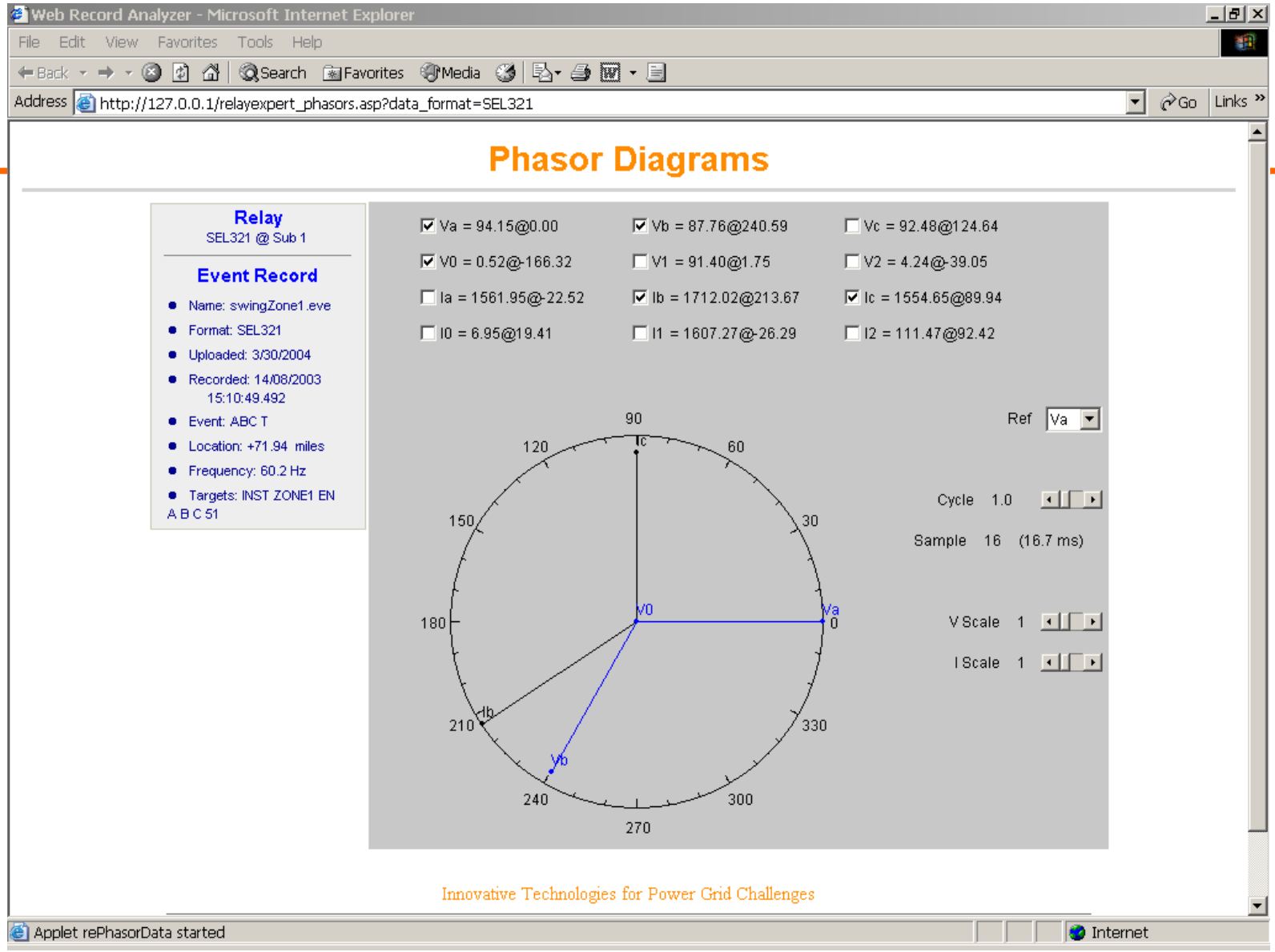
<fault_location>15.35</fault_location>
<from_sub>sub1</from_sub>
<fault_type>AG</fault_type>
</fault>
</faults>
Report time
Fault information

Relay simulator

- Overcurrent
- Voltage
- Directional – phase & ground
- Distance – phase & ground
- Current differential
- Phase comparison



Oscillographic display



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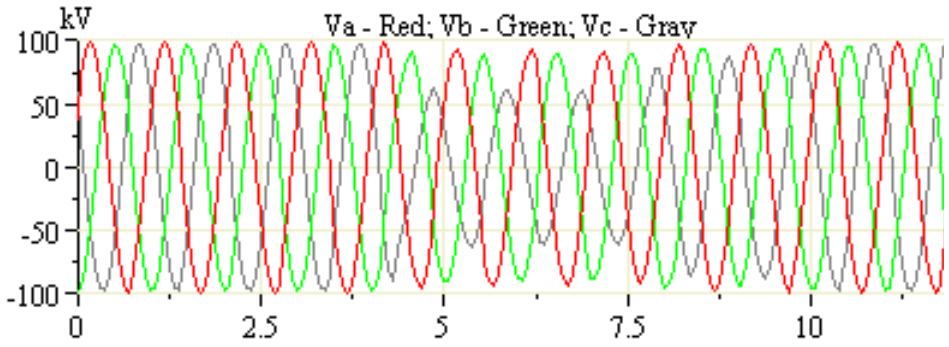

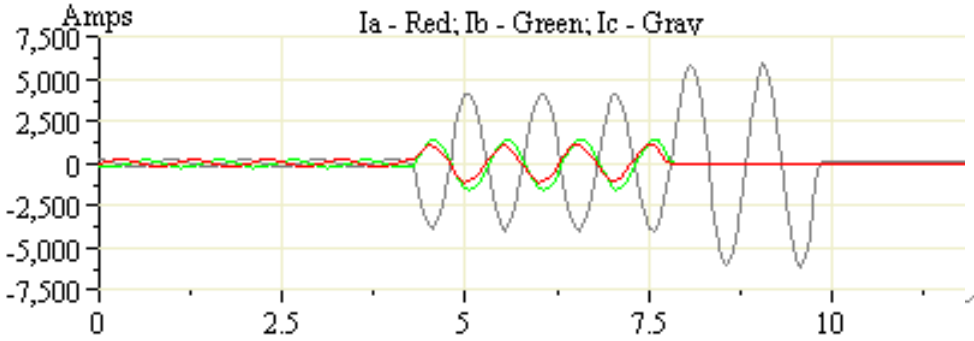

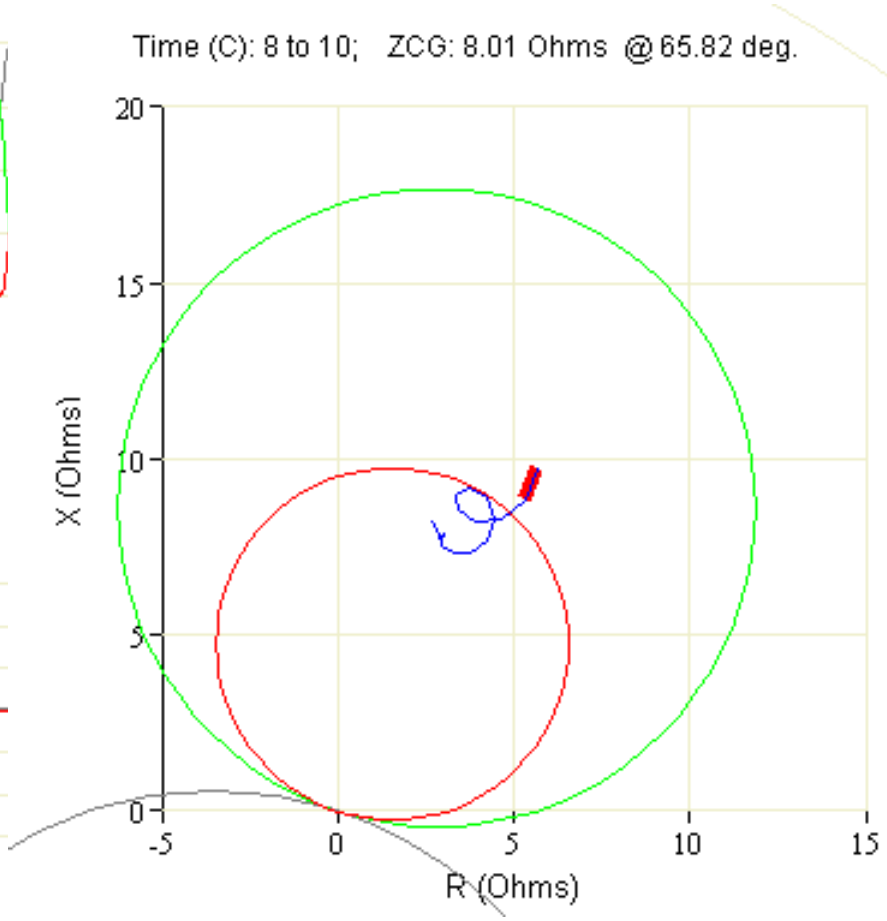

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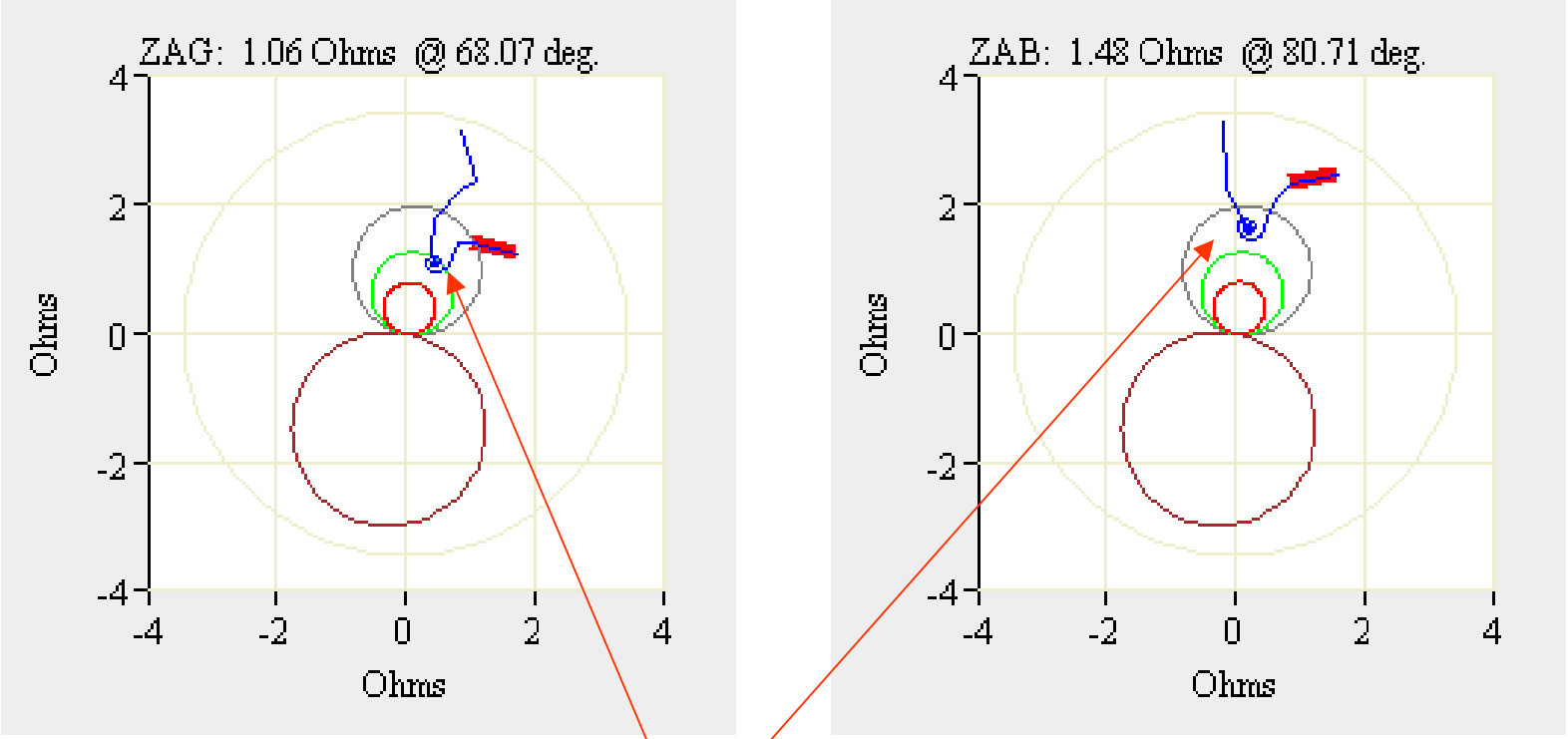
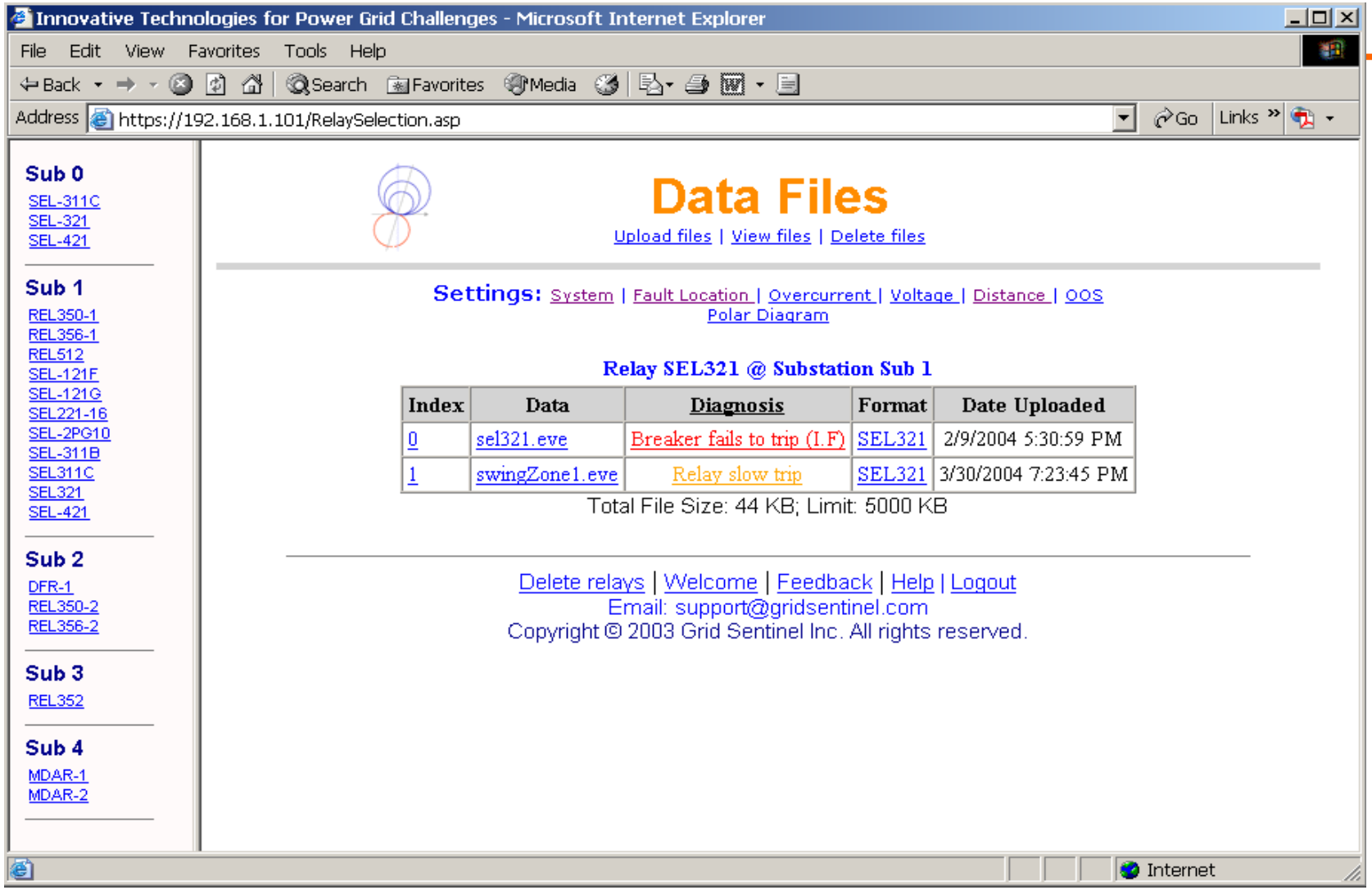
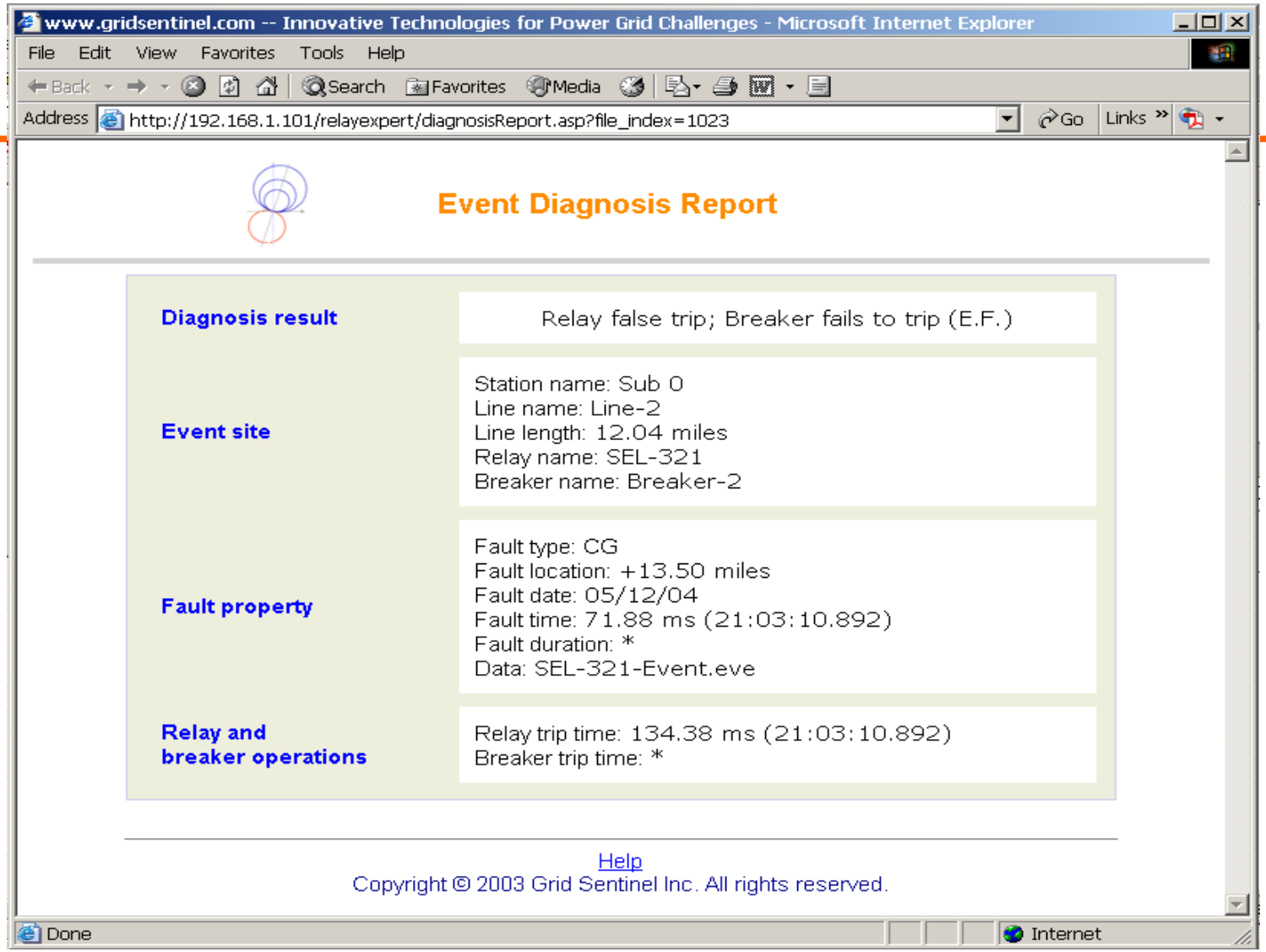


Ground distance element overreaches for a line-line-to-ground fault

Automated event diagnosis





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WebFL™ key benefits

- **Saves money** by helping system operators achieve fast and correct service restorations with real-time fault location – Decision support tool
- **Saves** protection engineers **time** through automated fault diagnosis and relay performance evaluation – Productivity improvement solution
- Readily extensible to distribution circuits improving **SAIDI** and **SAIFI**

Questions?

Grid Sentinel Inc.
Bethlehem, PA 18015
(610) 419-6532