Predictive maintenance solutions
Circuit Breaker Analyzer
On-line monitoring

Presented by

a div of MSO Technologies Inc.
Introducing the **Circuit Breaker Analyzer** by XEGsys.

- Why use an Online Monitoring system?
- What is a CBA?
- Where can the CBA reduce costs?
- How does the CBA operate?
- How is the captured data analyzed?
- Breaker Simulation Demo.
Why use an Online Monitoring System?

- Reduce operating and maintenance costs.
  - Yields a competitive edge in the deregulation environment.
- Increase system reliability.
  - Reduces customer outages.
  - Reduces operating costs.
Why use an Online Monitoring System for Circuit Breakers?

- In Distribution Stations, circuit breakers were the No. 2 targeted monitoring application*
- In Transmission Stations, circuit breakers were the No. 1 targeted monitoring application*

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<thead>
<tr>
<th>ACTIVITY</th>
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<th>TRANSMISSION SUBSTATION</th>
<th>BUSINESS DRIVERS</th>
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<td>O&amp;M Cost Reduction</td>
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<td>Automatic Voltage Control</td>
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<td>Integration of IED Data</td>
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<td>Comm.physi measurements</td>
<td>13</td>
<td>9</td>
<td>Increased Reliability</td>
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* Source of information provided by Newton-Evans Research Company.
What is a XEGsys Circuit Breaker Analyzer (CBA)?

- A microprocessor based device which continuously monitors a circuit breaker for proper mechanical and electrical conditions by capturing key electrical signals from a trip or close operation.

- Uses the Momentum form factor and it’s standard communication adapters.

- Is offered in two packages:

  **Portable**

  ![Portable Circuit Breaker Analyzer](image)

  **To Breaker**

  **Permanent**

  ![Permanent Circuit Breaker Analyzer](image)

  **To Breaker Wiring**

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Where can the Circuit Breaker Analyzer reduce costs?

- **Predictive Maintenance**: The CBA is a hardware, software, and connectivity solution which makes a predictive maintenance program more efficient.

- **Troubleshooting**: The CBA significantly reduces the time identifying potential mechanical failures using operational analysis vs. mechanical teardown and inspection.

- **Deployment of Workforce**: The CBA interface software analyzes the captured data and identifies the specific area of the breaker requiring repair.

- **Breaker Operation Reliability**: System uptime is increased by timely determination of what and when a breaker component needs repair.
How does the Circuit Breaker Analyzer operate?

The portable unit is taken to a substation and placed near the circuit breaker.

An interface cable is connected between the CBA and the circuit breaker.

To Breaker
How does the Circuit Breaker Analyzer operate?

..and the signals from the breakers operation are digitized and captured by the CBA
How is the data acquired?

- Interface software (called LENS) logs the captured data and graphically displays it.
Functionality of the CBA Software (Lens)

- Configure CBA.
- Acquire data from the CBA.
- Store data in Microsoft Access database format.
- Graph data for visual analysis.
- Analyze data for alarming of basic operational parameters (i.e. timing of the auxiliary contacts).
Functionality of the CBA Software (Lens)
- Graphical Representation
How is the data analyzed?

- Each trace on the graph represents a different signal from the breaker. The data from each signal represents a change in voltage over time (volts vs time).
How is the data analyzed?

- For simplicity sake, we will only look at how the signal trace for the auxiliary contacts is used for failure prediction.
How is the data analyzed?

- Standardizing the timing points.

With a new breaker, these timing points are used as the ‘footprint’.

Bands are placed around these traces which represent acceptable movement of the timing function.
How is the data analyzed?

- Breaker mechanism wear and age changes the traces over time.

The timing traces will move as the breaker ages or wears.
How is the data analyzed?

- Through successive operations, the breaker begins to show out of tolerance wear.

Eventually, the breaker will generate traces outside of the acceptable band.
How is the data analyzed?

- The software alarms this condition. The type of trace movement dictates the necessary repairs.

Eventually, the breaker will generate traces outside of the acceptable band.
How is the data analyzed?

- Analysis of the other captured traces, and the interrelationships between them, allow additional failure prediction of the electrical and mechanical areas of the circuit breaker.
Summary of the signals captured by the CBA

- **Supply voltage**
  - Channel 1 (high voltage)

- **Trip event**
  - Channel 2 (high voltage)

- **Close event**
  - Channel 3 (high voltage)

- **Auxiliary contacts**
  - Channels 4 & 5 (high voltage)

- **Trip coil current**
  - Channel 6 (low voltage)

- **Close coil current**
  - Channel 7 (low voltage)

- **Phase currents**
  - Channels 8, 9, 10 (low voltage)

*Phase currents not shown*
Circuit Breaker Analyzer Brochure Review

Circuit Breaker Analyzer
Predictive Maintenance Tool

Application Discussion: Regulatory changes are causing the Utilities to place greater emphasis on coal reduction. Circuit Breakers are a key asset. To assist in managing these assets, Utilities develop predictive maintenance programs. Some programs involve mechanical disassembly of the breaker to verify its condition. Others use a planned outage, exercising the breaker to determine proper operation. These types of programs are inherently resource intensive.

Using a predictive maintenance program based on captured signal traces from a breaker operation can reduce costs when compared against programs using manual verification of breaker condition. Analysis of the collected data determines whether the mechanical and electrical components of the breaker are working properly. Coupled with a product which continuously collects this information and makes it available via standard network protocols to the Enterprise, and you have a truly useful cost reducing predictive Maintenance tool.

Competitive Features:
- Compact cost effective design.
- Industry standard high speed network protocols are used (i.e. Ethernet, Modbus Plus, and others).
- Signals are captured and digitized using a 14 bit A/D at a 200 micro-second interval.
- Captured data is stored in Microsoft Access format and ported to SQL databases at the Enterprise level.

Specifications:
- Ten capture channels, (5) input channels of 0-300VDC and (5) input channels of 0-10VDC.
- Simultaneous signal capture of all (10) channels.
- 16MB of battery backed RAM used to store events.
- Flash RAM for storage of user configurations.
- User configurable data capture sample rate from 320Hz to 50KHz.
- User configurable capture duration (length of capture).
- Eight user definable unique capture events.
- 14 bit data capture resolution.
- Real time clock with 1 microsecond resolution and optional GPS interface.
- Physical Dimensions: 48VDC & 125VDC unit, 5.75" x 2.75" x 6.0" (W x D x H). 250VDC unit, 12.5" x 2.75" x 6.0" (W x D x H).

Software Solutions
Enhanced Data Acquisition

Circuit Breaker Analyzer Software: LENS® software is a browser based software package which works with the Circuit Breaker Analyzer. LENS® uses standard Web based browser technology, such as Internet Explorer, to perform a number of functions. It configures the CBA, retrieves the captured data, and stores it to hard drive in standard Microsoft Access format. It graphically displays the stored data allowing multiple events from multiple circuit breakers to be simultaneously displayed for visual comparison and analysis.

The LENS® software package provides the following functionality:

Circuit Breaker Analyzer System Architecture:
- Configures the flexible memory architecture of the CBA for the number of channels to capture, length of capture, sample rate, channel, etc.
- Displays the captured CBA data in list form allowing the user to easily filter the data for graphical display.
- Graphs the displayed signals as individual traces. Multiple event traces can be simultaneously displayed for tolerance comparison.

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Travel Timer Recorder Plot compared to a Circuit Breaker Analyzer Plot

OLD WAY - more work, less information

NEW WAY - less work, more information

CBA Captured Data Summary
- Auxiliary switch opening and closing times -
  - detects binding mechanisms/contact linkages.
- Open and close coil current profiles -
  - determines latch times, solenoid energy requirements, control contact condition.
- Trip and close signal duration and magnitude -
  - detects relay and control circuit problems.
- Battery voltage levels at breaker and battery house -
  - detects battery charger/control cable problems.
- Current profiles for all three phases (not shown in above plot) -
  - detects current transformer problems, main interrupter problems, a slow mechanism.

CBA Wiring Diagram

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Breaker Performance Monitoring
Enterprise System Overview

Circuit Breaker Analyzer
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What Functionality is Required in a Product for Predictive Maintenance of a Circuit Breaker?

- **Cost Effective:** Complete installation has to provide a justifiable return on investment, 1-2 years.

- **Continuous Monitoring:** Allows detection of poor performing breakers by continuously monitoring all breaker operations.

- **Networking and Protocols:** Connectivity between monitors is needed to reduce costs associated with manually moving data to a central storage area. The monitor should offer industry standard protocols for integration into existing information systems.

- **Data Storage:** Captured data should be stored in an industry standard database format allowing non-proprietary software interface and analysis of data.

- **Signal Capture:** A monitor should capture all necessary electrical signals allowing for thorough analysis of both breaker mechanism and interrupter wear. The signals have to be captured using resolutions for proper analysis.
CBA Product Features

- **Low Cost:** The CBA has a return on investment potential of 1½ years by providing a high level of product functionality, pricing, non-invasive connections, and din rail mounting.

- **On Line Monitoring:** The CBA is permanently installed and provides continuous monitoring of the circuit breakers activity.

- **Networking and Protocols:** The CBA is networked using Modbus Plus, Ethernet, Interbus-S, DeviceNet, Pofibus DP, FIPIO. Third party protocols available through hardware licensing.

- **Data Storage:** The data captured by the CBA software is stored in Microsoft Access format and ported to SQL databases at the Enterprise level.

- **Signal Capture:** The CBA has 10 signal channels for electrical interface to the circuit breaker allowing analysis of breaker mechanism and interrupter wear. The signals are captured and digitized using a 14 bit A/D at a 200 micro-second interval.
Protective Relays used as a Breaker Monitor

- **Cost:** The implementation expenses for the protective relay to provide breaker analysis is arguably more than the cost of a dedicated breaker monitor.

- **On Line Monitoring:** Continuous monitoring is provided.

- **Networking and Protocols:** A limited number of manufacturers offer Ethernet and Modbus Plus.

- **Data Storage:** The data captured by the protective relay software is generally stored in a proprietary format requiring a proprietary software interface for data analysis.

- **Signal Capture:** Protective relays traditionally monitor phase currents, which only predicts interrupter wear from the I^2^T calculations. Resolutions are generally adequate for accurate analysis.
Failure Areas of Circuit Breakers.

- **Mechanical Failures**: 90%
- **Interrupter Failures**: 10%

Legend:
- **Mechanical Failures**
- **Interrupter Failures**
CBA Specifications:

- The CBA has four main components; an I/O base, a DSP ring, a communications adapter, and a connection cable.

- The following lists summarizes the product features.
  - (5) input channels of 0 ± 300VDC and (5) input channels of 0 ± 10VDC.
  - Real time clock with 1 millisecond resolution and optional GPS interface.
  - 16MB of battery backed RAM used to store events.
  - Flash RAM for storage of user configurations.
  - User configurable data capture sample rate from 200Hz to 5KHz.
  - User configurable number of data points for a capture event.
  - (16) user definable trigger threshold constants and (10) user selectable relative thresholds.
  - (8) user definable capture events which allows variation of any definable parameter.
CBA Installation Options

- Level 1a – Portable CBA is attached each use, using Test Clips and Clamp on devices
- Level 1b – CBA is attached through standardized prewired connector
- Level 2 – CBA mounted in circuit breaker enclosure.
- Level 3 – CBA networked via Modbus Plus or Ethernet. This provides a central point for data downloads.
- Level 4 – Local PC in substation is added to the network and used for 24/7 event data collection and archiving.
- Level 5 – Substation PC is connected to central enterprise database server(s).
## CBA Types Compared

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<tr>
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<th>Level 1A</th>
<th>Level 1B</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
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<tr>
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<td>Y</td>
<td>Y</td>
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<td>24/7 Monitoring</td>
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<td>Capture of Interrupter Current</td>
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Permanent 48 Volt CBA Module
Permanent 125 Volt CBA Module

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Permanent 250 Volt CBA Module
Portable Circuit Breaker Analyzer
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