Features & Benefits

• Bushing Monitoring
• Partial Discharge Monitoring
• Optional Thermal Modeling with Cooling Control
• Flexible and Modular Hardware Platform
• Advanced Analytics

DM-Series
ENGINEERED TO ORDER SOLUTIONS
for Transformer Bushing and PD Monitoring

www.dynamicratings.com
The diagnostic transformer monitor (DTM) can detect problems in the bushings, windings, de-energized tap changer, OLTC/LTC and/or the bus connected to the transformer. Equipment health is easy to understand via Red-Yellow-Green indicators. Monitor configuration, historical data and detailed diagnostics provide an indication of the location, type and rate at which a problem is developing.

**Design Advantages**

The modular design allows selection of the appropriate scope of monitoring for any distribution, transmission or generation application. Systems can be provided with the partial discharge capabilities built-in or with provisions to support periodic on-line partial discharge testing using a Dynamic Ratings portable partial discharge analyzer.

Partial discharge monitoring compliments the bushing monitoring features of the DTM and the monitoring capabilities of a DGA device by identifying the location of the problem (identifying which phase and which winding). On-line partial discharge monitoring will respond faster than dissolved gas analysis allowing correlation of the problem activity with various operating conditions. In all cases, the DTM's partial discharge monitoring can be used to provide a second level diagnostic confirmation of problems without taking an outage.

**Features & Benefits**

- Provides indication of the bushing power factor and bushing capacitance while transmitting the high frequency partial discharge signal to support a second level diagnostic.
- DTM's correlation of temperature and humidity with the measured condition provides better and earlier indication of bushing problems.
- Designed for harsh ambient conditions including -40°C to 70°C (-40°F to 158°F), without the need of additional heating or cooling.
- A full range of advanced noise cancellation filters provide the ability to identify and eliminate external noise.
- The DTM with a Powerline Communications System (PCS) option offers secure and reliable communications as an affordable alternative to installing new communication cable or fiber.
Bushing Monitoring and Partial Discharge Monitoring Functionality

DTM systems allow up to four optional modules. Customer may select no more than two of each module below.

**Bushing Health Monitor**
Continuous online monitoring of bushings provides real-time information of bushing capacitance and power factor which can result in the early detection of a possible failure. The DTM may be ordered with up to two optional bushing modules.

**Unique Features**
- **Temperature Correlation:** The bushing module utilizes top oil temperature, load current and humidity inputs to provide a correlation with the bushing condition. This allows the system to reveal whether there is a specific inception point where the equipment deterioration accelerates.
- **Discrete Readings:** The bushing module provides a discrete reading for each bushing. The reference is rotated to each of the three bushings providing the same high quality of reading on each bushing.
- **PD Compatible:** DR BAU sensors are fully compatible with the use of Partial Discharge monitoring equipment. Whether the PD option is included in the system or whether a portable PD system is used as a second level diagnostic, this compatibility provides a great advantage in diagnosing issues.
- **Diagnostic Software:** Each system is provided with diagnostic software providing polar plots, trending and data correlation making it easy to diagnose the severity, rate of change and whether the deterioration has a correlation to Temperature, Load or Humidity.

**Electrical Partial Discharge (PD) Monitor**
The partial discharge module measures electrical partial discharges (PD) in the transformer, bushing and when applicable, the connected Iso-Phase Bus. The DTM may be ordered with up to two optional PD modules.

**Unique Features**
- **Complementing DGA and Bushing Monitoring:** Electrical PD monitoring is the perfect second level diagnostic tool to complement DGA and bushing monitoring systems. While a DGA system can indicate the type of fault, the electrical PD system can identify electrically, where a fault is in the tank (identifying the phase and the winding).
- **Identification of the Fault Inception Point:** DGA systems have an inherent delay in detecting problems due to the time it takes for fault gasses to diffuse throughout the oil, get to the sampling point, travel through the oil lines and then to wait for the next DGA sample test to occur. PD systems provide an immediate response to changes. On-line systems provide correlation between operating conditions (load, temperature, cooling status ...) to identify the specific inception point for the fault.
- **Detection of Additional PD Sources:** The PD module can detect PD activity in places that cannot be detected by DGA or bushing monitoring. This includes activity within the OLTC (LTC) or in the connected Iso-Phase Bus.
- **Advanced Filtering:** The system utilizes multiple filtering methods to differentiate high frequency signals originating from outside the equipment from actual PD activity within the equipment.
- **Sensor Compatibility:** The system can utilize a wide range of sensors including bushing sensors, Rogowski coils, coupling capacitors, radio frequency CTs (RFCTs) and ground path current sensors (GPCS).
Applications

- Bushing Monitoring
- Transformer PD Monitoring
- Iso-Phase Bus Monitoring
- HVCT Monitoring

Reducing O&M Costs and Improving Reliability

The DTM is serving as the cornerstone of condition based maintenance (CBM) programs at many utilities. The system is capable of detecting problems in the main transformer tank, LTC compartment, bushings and interconnected iso-phase bus, allowing utilities to reduce O&M costs by scaling back or eliminating many time based maintenance activities.

Intrusive, time based maintenance is costly and each time equipment is serviced, an element of risk is introduced by the maintenance task itself. CBM programs implemented by utilities are enabling them to avoid unnecessary maintenance tasks and to focus their limited resources on the equipment where it is truly in need.

Many transformer failure modes are easier to detect on-line at operating voltage and temperature than during 10KV tests conducted at ambient. Further, the gestation time of many failure modes is significantly less than the off-line testing cycle. DTM’s continuous assessment of equipment health will catch more problems and provide indication much earlier than off-line tests.

Compatibility with Multiple Sensors

The DTM’s ability to utilize a wide variety of sensors allows the system to be extended or expanded to provide coverage to all electrical aspects of the transformer including bushings, incoming cable connections and/or iso-phase bus.

Advanced Analytic’s of DM Bushing Modules

The key analytic for bushing monitoring is the magnitude and trend of the current imbalance. The DTM can provide system alarms on both of these quantities. Secondary analytics include behavior of the current imbalance with top oil temperature and the vector of the current imbalance. The magnitude of the current imbalance will provide information as to how severe the problem is. The vector will provide the indication of which bushing is failing and will identify if the power factor or capacitance of the bushing is changing.
**Electrical Partial Discharge**

Trending is very important when analyzing partial discharge data. Trends of Magnitudes (mV or pC), Pulse Counts (Pulses Per Second) and Partial Discharge Intensity (PDI) are all key elements. The DTM will alarm on user selected values of both Magnitudes and PDI as well as trends. Correlating PD activity with Load, Oil temperature and LTC position provides additional diagnostic insight. Phase resolved data patterns are also generated (see examples below) enabling diagnosis of the type of discharges that may be occurring.

Partial Discharge module features:

- 15 PD channels per module with simultaneous data acquisition on all channels
- Each channel is fully configurable
- Records pulse counts and pulse magnitudes
- Tracks full phase resolved data
- Stores up to 2 years of data with standard configuration
- Enhanced noise cancellation technology
- Two levels of alarming
- Configurable alarms for PD magnitude (mV or pC)

**CASE STUDY**

**Customer Avoids Costly Transformer Failure**

A west coast investor-owned utility implemented a condition based maintenance program (CBM) covering their transmission and distribution transformers to reduce their operational expenses while maintaining or improving their system reliability. The primary source of the CBM data was generated from Dynamic Ratings products including the bushing monitoring feature of the DTM product.

A few months after one of the installations, a bushing monitoring alarm was indicated. The DTM's diagnostic software indicated the phase B capacitance and power factor were changing. Trending indicated a high level of temperature dependency.

Before taking an outage, a partial discharge (PD) module was added to the system to verify the results. The PD module indicated significant levels of PD on phase B. An outage was scheduled and offline power factor tests were performed under ambient conditions. The offline tests verified that the phase B bushing was in a highly vulnerable state.

<table>
<thead>
<tr>
<th>ID</th>
<th>NP %PF</th>
<th>%PF corr</th>
<th>Cap (pf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>0.32</td>
<td>0.26</td>
<td>447.7</td>
</tr>
<tr>
<td>H2</td>
<td>0.31</td>
<td>2.22</td>
<td>452.02</td>
</tr>
<tr>
<td>H3</td>
<td>0.34</td>
<td>0.29</td>
<td>448.92</td>
</tr>
</tbody>
</table>

Following this successful catch, this same utility has been able to identify bushing problems on three other installations with the use of the DTM bushing module, thereby avoiding costly equipment failures and outages.
Thermal Model & Cooling Control

The DTM-V acquires the Top Oil temperature and Load Current (on up to 3 windings) and utilizes this information as part of bushing monitoring diagnostics. As a configuration option, these same measured values can be used to calculate the Winding Hot-Spot (WHS) Temperature on each winding measured.

Thermal Model: The calculation follows the standard equation found in the loading guides of both IEEE and IEC.

Up to 3 Windings: Discrete calculations are made for each of the current inputs. The three winding hot-spot temperatures are then compared for identification of the highest value. This hottest computed value is then used for driving the cooling control and for alarming.

Cooling Control: The output can be utilized to do simple cooling control on up to 2 stages of cooling.

Thermal Alarms: The system provides 4 temperature alarms including:

- High Top Oil Temp
- High-High Top Oil Temp
- High Winding Hot Spot Temp
- High-High Winding Hot-Spot Temp

SCADA: In addition to providing the cooling control relay output, the output status is available in the point list providing visibility via SCADA.

Communications

The DTM offers secure and reliable communications. Each DTM Main Monitor features communication ports as follows:

A physical 10/100 Base T, RJ45 Ethernet Port for local configuration, external networking or access to the DTM built-in Web Server Pages using Modbus or DNP over TCP/IP.

A USB, Type B port for local device configuration and data upload.

Two (2), RS-485 Serial port connections for Modbus or DNP slave and master ports to link with Intelligent Electronic Devices (IED). Consult the factory for a list of supported IED’s.

Diagnostic Software

The configuration software provided with the instrument makes the setup and configuration easy. The assignment of inputs and the thermal model options are selected from drop down menus minimizing the potential of data entry errors. The thermal model parameters, control settings and alarm set points are all entered in one simple configuration screen.

Diagnostic Display Options

The primary system information a user needs to know is provided by high visibility “red – yellow – green” LED status indicators. Diagnostic LEDs are provided on the optional bushing and PD modules.

Cooling Control Display Option: A Cooling Control Display is available as (Option WD) for systems configured with the thermal modeling function. The display is designed for panel mounting and automatically scrolls defined information every 15 seconds, with the name of the variable, and value displayed. When alarm conditions exist, a short alarm message appears with details of the alarm value exceeded.

The display is provided with (1.52 m / 5.0 ft.) of cable for ease of installation.
Main Module and Power Supply (Base System)

Two base systems are available, DTM-I or DTM-V. Both base systems include a Main Monitor, Universal Power Supply and the ability to add up to four optional modules.

**Universal Power Supply**
- (1) Power status LED
- Auxiliary Power Outputs:
  - 24 VDC 100 mA
  - ±5 VDC 500 mA
- Power Input:
  - 120 – 300 VDC
  - 90 – 264 VAC 50/60 Hz

**Main Monitor**
- Status Indication:
  - (5) Status LEDs
- Communications:
  - (1) 10/100 Base T RJ45 Ethernet Port for Modbus or DNP over TCP/IP
  - (1) USB Type B Configuration Port
  - (2) RS-485 Serial Port connections for a Modbus or DNP slave port and Master port to link to (IED’s). (Consult the factory for a list of supported IED’s)
- Temperature (RTD) & Humidity Inputs:
  - (7) RTD Inputs used for Ambient & Top Oil Temperature, others defined by application
  - (1) Humidity Input is used for Ambient Relative Humidity
  - (4) Vibration Inputs are unused

**Relays**
- (1) Form C Relay Output
- (3) Form A Relay Outputs
- (6) Analog Inputs, 4-20mA DC

**Bushings Health Module**
- (3) Status LEDs
- (6) Bushing Sensor “Inputs” provide Bushing PF and Capacitance monitoring for one or two sets of 3 phase bushings
- (1) RS-485 Serial Communication Port
- (1) USB Type B Communication Port

**Electrical Partial Discharge (PD) Module**
- (3) Status LEDs
- (15) PD Input channels:
  - Each Channel is compatible with Bushing Capacitive Tap Sensors, Rogowski Coils, Coupling Capacitors, GPCS, or RFCT sensors
- (1) Voltage reference connection

**Expansion Module Options**
Select from the following expansion module offerings for slots (1–4).
- Select at least one bushing health or one partial discharge module
- Select no more than (2) bushing health modules
- Select no more than (2) electrical (PD) modules

(N) — None
(B) — Bushing Health Module
(E) — Electrical Partial Discharge Module

**Relay Definitions**
- Form A = SPST-NO. A single, normally open contact that closes upon actuation.
- Form B = SPST-NC. A single, normally closed contact that opens upon actuation.
- Form C = SPDT. A Form A contact connected to a Form B. The Form C contact has three wires, NO (normally open), NC (normally closed) and C (common). Upon actuation, the NO contact closes (continuity from NO-C) and the NC contact opens (no continuity from NC-C).
Packaging Options

The DTM may be ordered as a standalone instrument, panel mounted or in a NEMA 4 enclosure. For other enclosure options, please contact the factory.

### Standalone (S)

**Includes**
- Monitoring instrument populated with all functional connectors
- Diagnostics software

**Dimensions**

<table>
<thead>
<tr>
<th>Number of Optional Modules</th>
<th>Dimension &quot;A&quot; (Mounting Hole Dimension)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.64 cm / 8.125 in.</td>
</tr>
<tr>
<td>2</td>
<td>25.72 cm / 10.125 in.</td>
</tr>
<tr>
<td>3</td>
<td>30.80 cm / 12.125 in.</td>
</tr>
<tr>
<td>4</td>
<td>35.88 cm / 14.125 in.</td>
</tr>
</tbody>
</table>

### Panel Mounted (P)

**Includes**
- Instrument mounted on an aluminum sub-panel with all functional connections wired to terminal blocks
- Shorting blocks are provided for bushing sensor connections
- Ambient temperature sensor wired
- Ambient humidity sensor wired
- Diagnostics software

**Dimensions**

<table>
<thead>
<tr>
<th>Number of Optional Modules</th>
<th>Mounting Hole Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31.12 cm x 36.20 cm</td>
</tr>
<tr>
<td></td>
<td>(12.25 in. x 14.25 in.)</td>
</tr>
<tr>
<td>2</td>
<td>43.50 cm x 43.50 cm</td>
</tr>
<tr>
<td></td>
<td>(17.125 in. x 17.125 in.)</td>
</tr>
</tbody>
</table>

### Enclosure Mounted (E)

**Includes**
- Instrument mounted inside a Nema 4 painted steel enclosure with all functional connections wired to terminal blocks
- Shorting blocks are provided for bushing sensor connections
- Ambient temperature sensor wired
- Ambient humidity sensor wired
- Diagnostics software

**Dimensions**

<table>
<thead>
<tr>
<th>Number of Optional Modules</th>
<th>Dimension &quot;A x B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35.56 cm x 40.64 cm</td>
</tr>
<tr>
<td>2</td>
<td>50.80 cm x 50.80 cm</td>
</tr>
</tbody>
</table>

Consult Factory for more information.
SPECIFICATIONS

<table>
<thead>
<tr>
<th>Power Requirement:</th>
<th>90 - 264 VAC line voltage (50 to 60Hz), 120 to 300 VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Memory:</td>
<td>8 MB</td>
</tr>
<tr>
<td>Temperature Range:</td>
<td>-40˚C to 70˚C / -40˚F to 158˚F</td>
</tr>
<tr>
<td>User Interface:</td>
<td>Status LED’s, PC and/or an optional, Local User Display</td>
</tr>
</tbody>
</table>

DM SERIES—ORDERING INFORMATION

Fill boxes with feature selections

Base System: Select (I) for (6) six current inputs only or (V) for (3) Voltage + (3) Current Inputs

Expansion Modules: Select (B) for Bushing, (E) for Electrical Partial Discharge, (N) for None
Select no more than (2) Bushing Modules
Select no more than (2) Electrical Partial Discharge Modules

System Packaging Options: (S), Stand-Alone (P), Panel Mounted, includes: shorting blocks, Ambient Temp and Humidity sensors and (1) Aux. Load CT
(E), NEMA 4, Enclosure Mounted, includes: shorting blocks, Ambient Temp and Humidity sensors and (1) Aux. Load CT

Local User Display Options: (NN), No Local User Display (WD), Local Display with (1.52 m / 5.0 ft.) of cable for winding temperature applications

System Communication Options: Select (D) for DNP 3.0 or (M) for Modbus Communications

Notes 1 = Panel size may vary to accommodate base system selection.
2 = Enclosure size may vary to accommodate packaging and display selections.