



Diagnostic Monitor

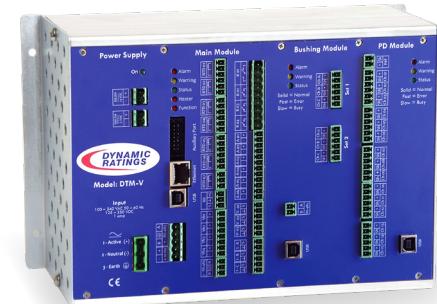
TRANSFORMER BUSHING
AND PARTIAL DISCHARGE
MONITORING

RESPONSIVE

ASSET HEALTH SOLUTIONS



DIAGNOSTIC TRANSFORMER MONITOR



**DTM-V shown with Bushing Health Module,
Electrical Partial Discharge Module.**

The diagnostic transformer monitor (DTM) can detect problems in transformer bushings and windings, de-energized tap changer, OLTC/LTC and 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.

Partial discharge monitoring complements 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 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.
- The DTM is 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 an iBridge, IED Networking Solution option, offers secure and reliable communications as an affordable alternative to installing new communication cable or fiber.

OPTION MODULES

Bushing and Partial Discharge Monitoring Functionality

DTM systems allow up to four optional modules with a minimum requirement of one optional module, selecting either a bushing health or partial discharge module. Select no more than two of each module below.

Bushing (B) Health Monitoring Module

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. DTM may be ordered with up to two optional bushing (B) modules.

Temperature Correlation The bushing module collects 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.

Diagnostic Software Each system is provided with diagnostic software capable of 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 (E) Partial Discharge (PD) Monitoring Module

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

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.

PD Compatible Dynamic Ratings model BAU bushing sensors are fully compatible with the use of the Partial Discharge module. 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.

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 uses 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 use a wide range of sensors including bushing sensors, Rogowski coils, coupling capacitors, radio frequency CTs (RFCTs) and ground path current sensors (GPCS).

CAPABILITIES

Reducing O&M Costs and Improving Reliability

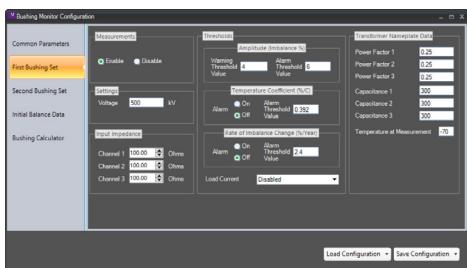
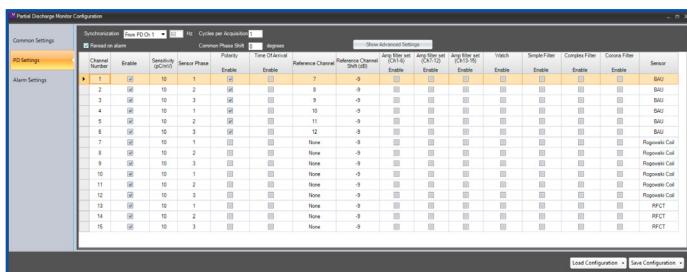
Intrusive, time based maintenance is costly and each time equipment is serviced, an element of risk is introduced by the maintenance task itself. Condition Based Maintenance (CBM) programs implementing DTM enable them to avoid unnecessary maintenance tasks and to focus their limited resources on equipment with immediate needs.

The DTM serves as the cornerstone of CBM programs at many utilities, 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.

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. The DTM's continuous assessment of equipment health will catch more problems and provide indication much earlier than off-line tests.

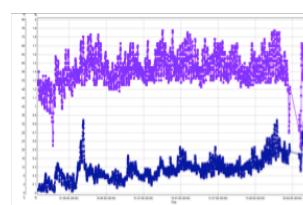
DTM Software

Configuration software is provided with each instrument making setup and configuration easy.

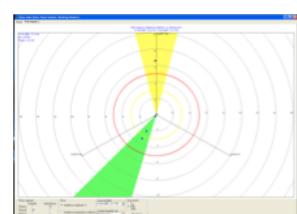


Advanced Analytics

The key analytic for bushing monitoring is the magnitude and trend of the current imbalance. A 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.



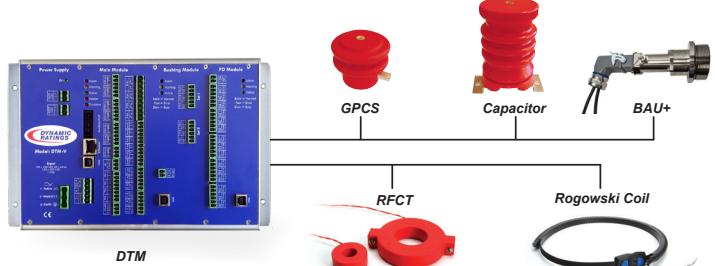
Trend Showing Severity



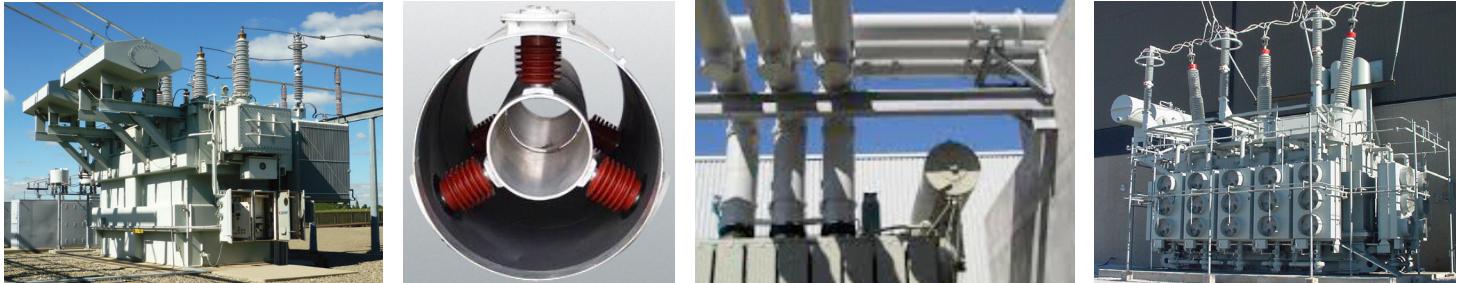
Vector Identifies Bushing Phase

Compatibility with Multiple Sensors

The DTM's ability to use 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.



CAPABILITIES



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.

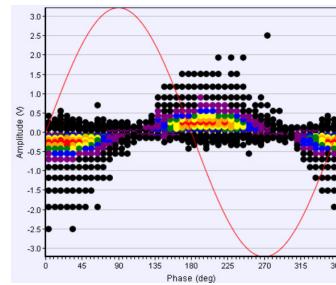
Partial Discharge module features:

- 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)

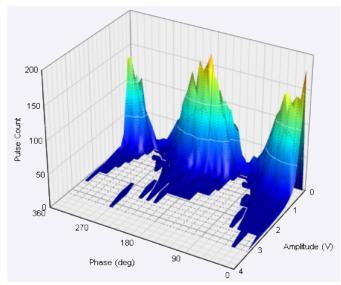
Communications

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

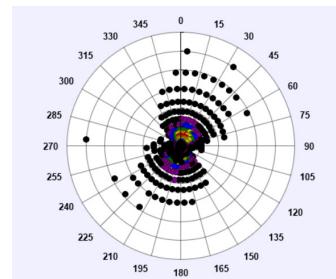
- A USB Type B port for local device configuration and data upload.
- Two RS-485 Serial port connections for Modbus.
- External Modbus connection can be achieved via Serial over Ethernet.



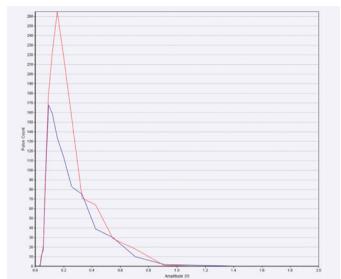
2D Phase Resolved



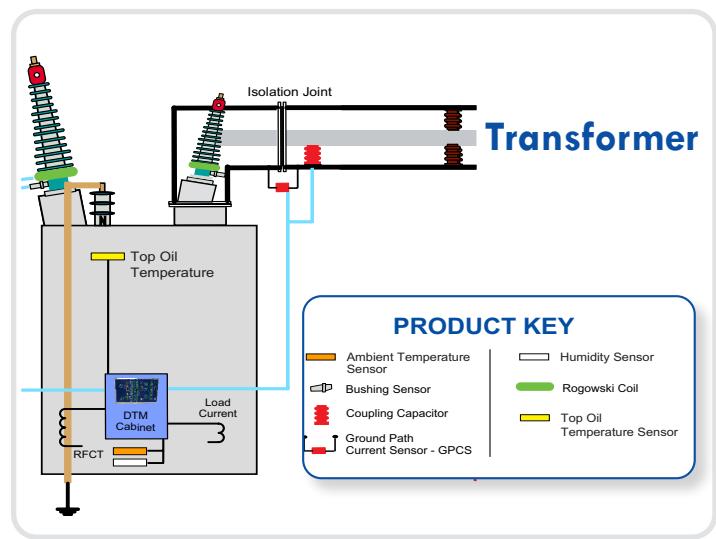
3D Phase Resolved



Polar Phase Resolved



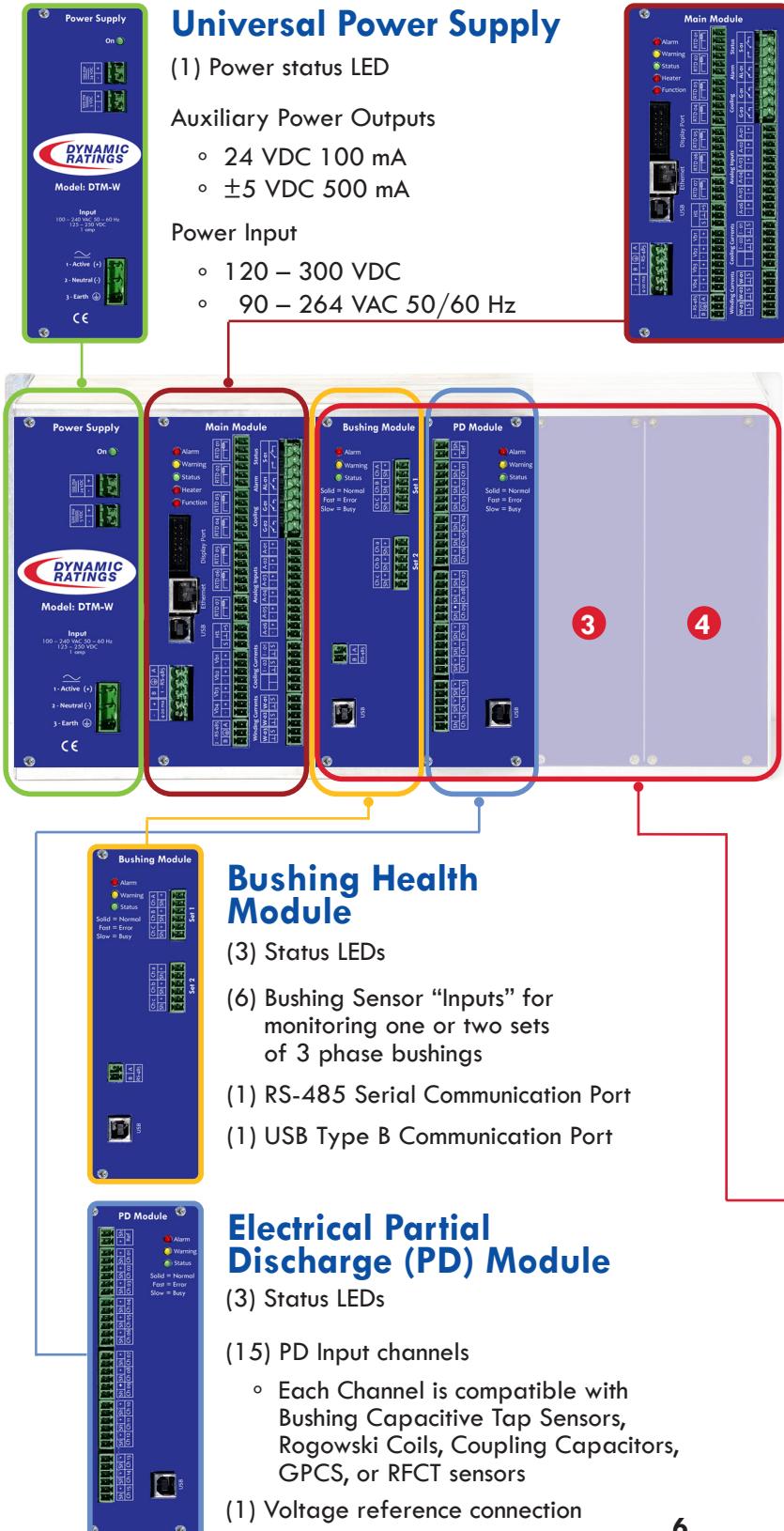
Pulse Height Distribution



DM BASE SYSTEM AND OPTIONS

Main Module and Power Supply (Base System)

Two base systems are available, DTM-I or DTM-V. All base systems include a Main Monitor, Universal Power Supply and the ability to add up to four optional modules with a minimum requirement of one optional module, selecting either a bushing health or partial discharge module.



Main Monitor

Status Indication

- (5) Status LEDs
- (1) Auxiliary Display Port

Communications

- (1) 10/100 Base T RJ45 Ethernet Port for Modbus or DNP over TCP/IP

- (1) USB Type B Configuration Port

- (1) RS-485 Serial Port connection for a Modbus

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

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).

Expansion Module Options

Select from the following expansion module offerings for slots (1–4):

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

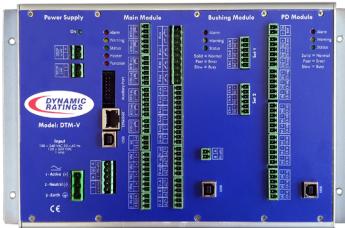
Select at least one bushing health or one partial discharge module.

Select no more than (2) bushing health modules.

Select no more than (2) electrical (PD) modules.

PACKAGING OPTIONS AND ACCESSORIES

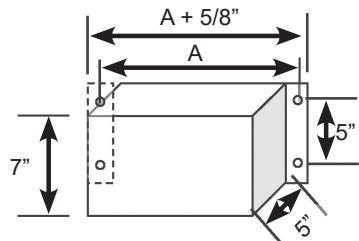
Standalone (S)



Model DTM-V shown

Includes:

- Monitoring instrument populated with field wiring connectors
- Diagnostics software



Number of Optional Modules	Dimension "A" (Mounting Hole Dimension)
1	20.64 cm / 8.125 in.
2	25.72 cm / 10.125 in.
3	30.80 cm / 12.125 in.
4	35.88 cm / 14.125 in.

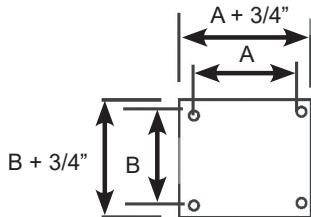
Panel Mounted (P)



Model DTM-V shown

Includes Option (S) and:

- 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



Number of Optional Modules	Mounting Hole Dimensions
1	31.12 cm x 36.20 cm (12.25 in. x 14.25 in.)
2	43.50 cm x 43.50 cm (17.125 in. x 17.125 in.)
3	Consult Factory
4	Consult Factory

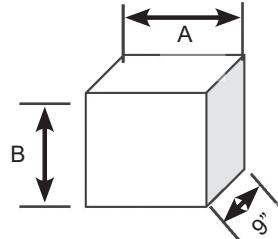
Enclosure Mounted (E)



Model DTM-V shown

Includes Option (P) and:

- 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



Number of Optional Modules	Dimension "A x B"
1	35.56 cm x 40.64 cm (14.0 in. x 16.0 in.)
2	50.80 cm x 50.80 cm (20.0 x 20.0 in.)
3	Consult Factory
4	Consult Factory

Sensors & Accessories



Part #	Description
AuxCT	Current Transformer with Burden Resistor (5A Primary)
AmbH	Ambient Humidity Sensor
AmbT	Ambient Temperature Sensor
SE-060	RTD temperature sensor probe for 1/2" NPT Thermal Well
MMTS-3C	Magnetic Mount Temperature Sensor (3 wire PT-100 RTD) *Includes 1/2" NPT conduit connection.*
MMTS-3Wxx	Magnetic Mount Temperature Sensor (3 wire PT-100 RTD) *Includes stainless steel armored cable. Specify length of 25 ft., 50 ft. or 75 ft. (7.62m, 15.24m or 22.86m).

*Minimum required: RTD for top oil and one CT for winding temperature.

ORDERING INFORMATION & SPECIFICATIONS

How To Order

DTM - - - - -

Base Unit

DTM DTM Base Unit

DTM

System Options

V 3 Voltage + 3 Current Inputs (Standard)

V

I 6 Current Inputs

I

Expansion Modules

N None (no more than three digits can use "N")

N N N N

B 6 Input Bushing Power Factor and Capacitance Module

B B B B

E 15 Channel Partial Discharge Module

E E E E

System Packaging Options

S Stand Alone

S

P Panel Mounted¹

P

E NEMA-4 Enclosure Mounted¹

E

Communications Protocol

D DNP 3.0

D

M Modbus Communication (Standard)

M

¹ Packaging options P and E include the instrument mounted with all terminals wired out to terminal blocks.
All bushing sensor connections have shorting terminal blocks. A fused incoming power connection is provided.
Panel size may vary to accommodate base system selection.

Specifications

Parameter	Specification
Power Requirements:	100 - 240 VAC line voltage (50 – 60 Hz), 125-250 VDC
Internal Memory:	8 MB
Temperature Range:	-40°C to 70°C (-40°F to 158°F)



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