



DM-Series

ENGINEERED TO ORDER SOLUTIONS

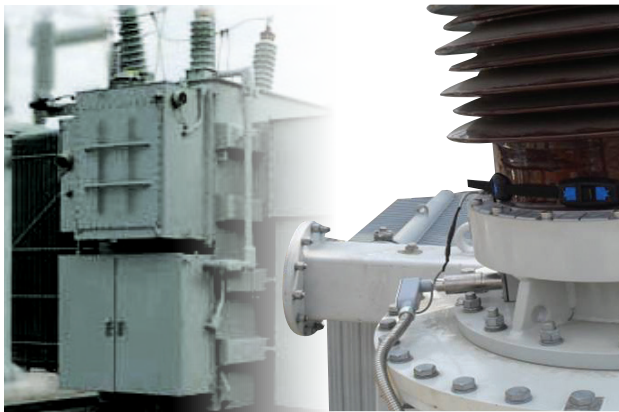
*for Transformer Bushing, Winding Hot Spot
and PD Monitoring*

Features & Benefits

- Advanced Analytics
- Flexible and Modular Hardware Platform
- Bushing Monitoring
- Optional Thermal Modeling with Cooling Control
- Winding Hot Spot Monitoring
- Partial Discharge Monitoring

Diagnostic Monitor





DTM-W shown with Bushing Health Module, Electrical Partial Discharge Module and Temperature Display.

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 and winding hot spot 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.

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.

Unique Features

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.

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.

PD Compatible: DR 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 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
- Winding Hot Spot Monitoring
- Transformer PD Monitoring
- Iso-Phase Bus Monitoring
- HVCT Monitoring



Reducing O&M Costs and Improving Reliability

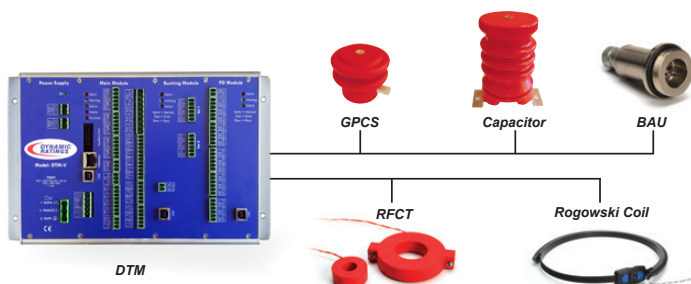
Intrusive, time based maintenance is costly and each time equipment is serviced, an element of risk is introduced by the maintenance task itself. CBM programs implementing DTM enable them to avoid unnecessary maintenance tasks and to focus their limited resources on equipment with immediate needs.

The DTM serves as the cornerstone of condition based maintenance (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.

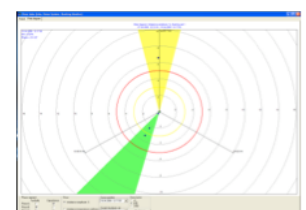
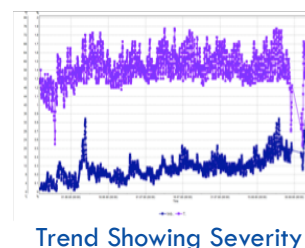
Compatibility with Multiple Sensors

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, winding hot spot, incoming cable connections and/or iso-phase bus.



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.



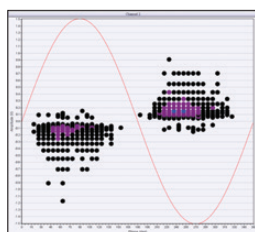


Electrical Partial Discharge

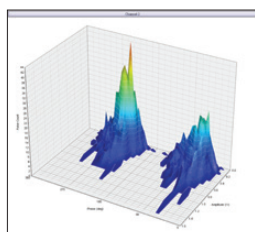
Trending is very important when analyzing partial discharge data. Trends of Magnitudes (mV or pC), Pulse Counts (Pulses Per Second) and Partial Discharge Intensity (PDI) are all key elements. The DTM will alarm on user selected values of both Magnitudes and PDI as well as trends. Correlating PD activity 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:

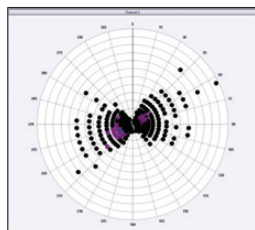
- 15 PD channels per module with simultaneous data acquisition on all channels
- Each channel is fully configurable
- Records pulse counts and pulse magnitudes
- Tracks full phase resolved data
- Stores up to 2 years of data with standard configuration
- Enhanced noise cancellation technology
- Two levels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



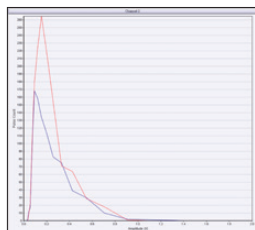
2D Phase Resolved



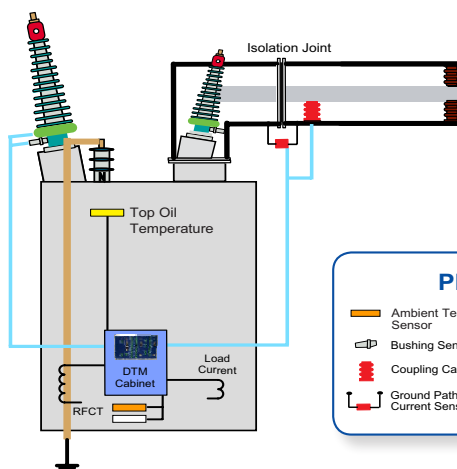
3D Phase Resolved



Polar Phase Resolved



Pulse Height Distribution



Transformer

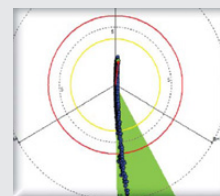
PRODUCT KEY

- Ambient Temperature Sensor
- Bushing Sensor
- Coupling Capacitor
- Ground Path Current Sensor - GPCS
- Humidity Sensor
- Rogowski Coil
- Top Oil Temperature Sensor

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 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.

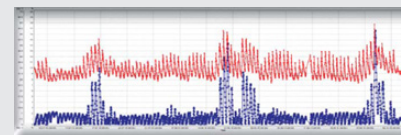


Chart shows temperature related to current imbalance.

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.

ID	NP %PF	%PF corr	Cap (pf)
H1	0.32	0.26	447.7
H2	0.31	2.22	452.02
H3	0.34	0.29	448.92

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 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 two stages of cooling.

Thermal Alarms: The system provides four 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

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

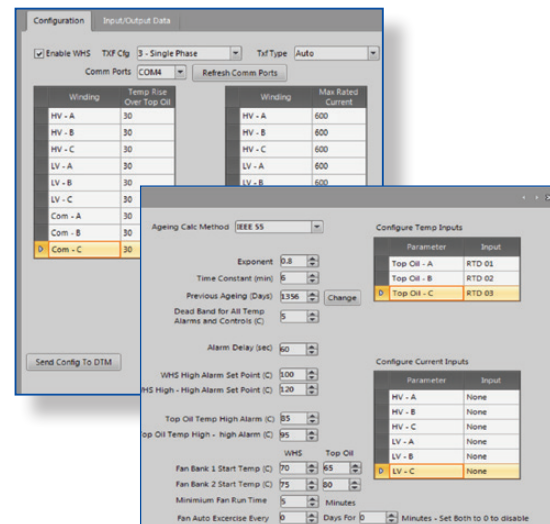
A physical 10/100 Base T, RJ45 Ethernet Port for local configuration, external networking or access to the DTM built-in Web Server Pages using Modbus or DNP over TCP/IP.

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.

DTM Software

Configuration software is provided with each instrument making 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. Thermal model parameters, control settings and alarm set points are all entered in one simple configuration screen.

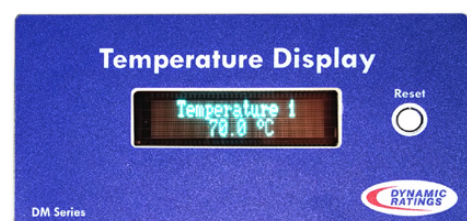


Diagnostic User Interfaces

LEDs provide the primary system information a user needs to know using high visibility "red – yellow – green" status indicators. Diagnostic LEDs are also provided on optional bushing and PD modules.

DTM-W base systems include a Display Port connector located on the main module. A temperature display is connected to the display port, and shipped with each monitor.

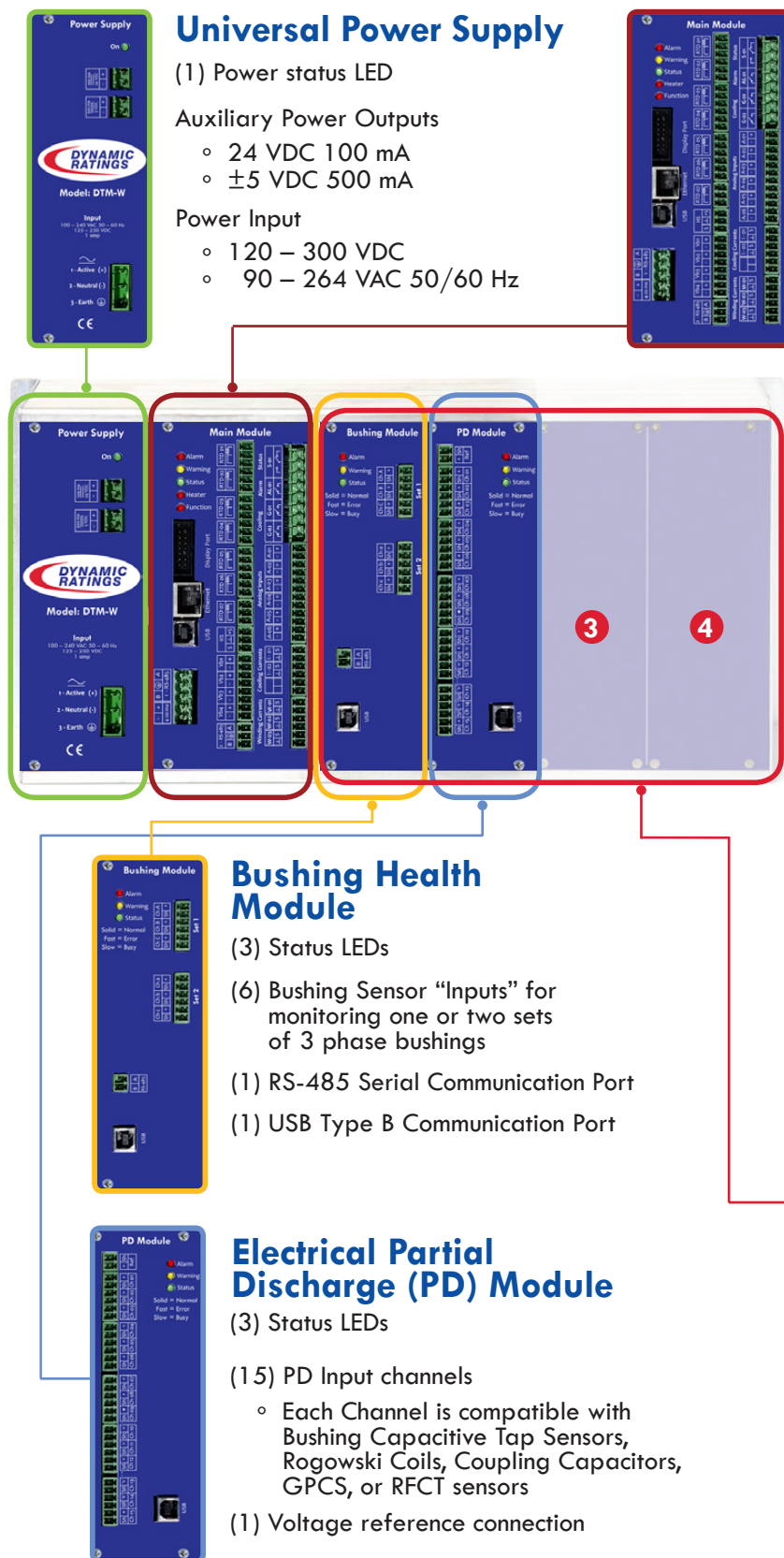
DTM-W system is configured with the thermal modeling function. The display automatically rotates defined information every 15 seconds, with the name of the variable, and value displayed. When alarm conditions exist, a short alarm message appears with details of the exceeded alarm value.



DTM-W Temperature Display

Main Module and Power Supply (Base System)

Three base systems are available, DTM-I, DTM-V or DTM-W. 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
- (2) RS-485 Serial Port connections for a Modbus or DNP slave port and Master port to link to (IEDs). (Consult the factory for a list of supported IEDs)

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.

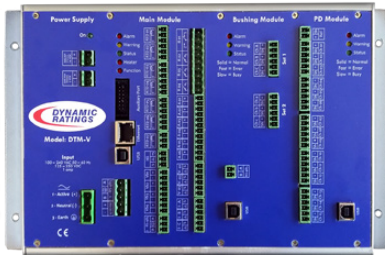
Select no more than (2) bushing health modules.

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

Packaging Options

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.

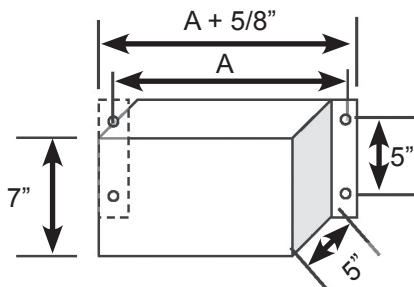
Standalone (S)



Model DTM-V shown

Includes:

- Monitoring instrument populated with field wiring connectors
- Diagnostics software



Dimensions

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.

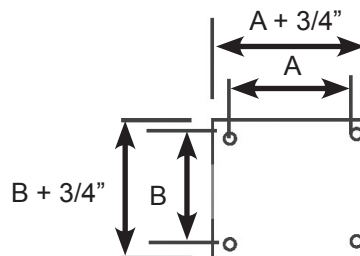
Panel Mounted (P)



Model DTM-W 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



Dimensions

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	

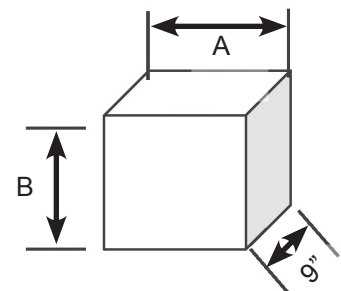
Enclosure Mounted (E)



Model DTM-W 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



Dimensions

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	

SPECIFICATIONS

Power Requirement:	100 - 240 VAC line voltage (50 to 60Hz), 125 - 250 VDC
Internal Memory:	8 MB
Temperature Range:	- 40° C to 70° C / - 40° F to 158° F
User Interface:	Status LEDs and PC. DTM-W model includes a Temperature Display

DTM — ORDERING INFORMATION

Fill boxes with feature selections

Base System Select V, I or W

V = 3 Voltage + 3 Current Inputs (Standard) (no display available)

I = 6 Current Inputs (no display available)

W² = 3 Winding Current + 2 Cooling Current Inputs +
a Temperature Display

V or I or W

Expansion Modules* Select B, E or N

B = 6 Input Bushing Power Factor and Capacitance Module

E = 15 Channel Partial Discharge Module

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

* A Minimum of (1) B or E module is required per system with
a Maximum of only (2) modules of each type allowed.

B or E or N
NNNN is NOT a valid part number

System Packaging Options Select S, P or E

S = Stand-Alone

P = Panel Mounted¹

E = NEMA 4, Enclosure Mounted¹

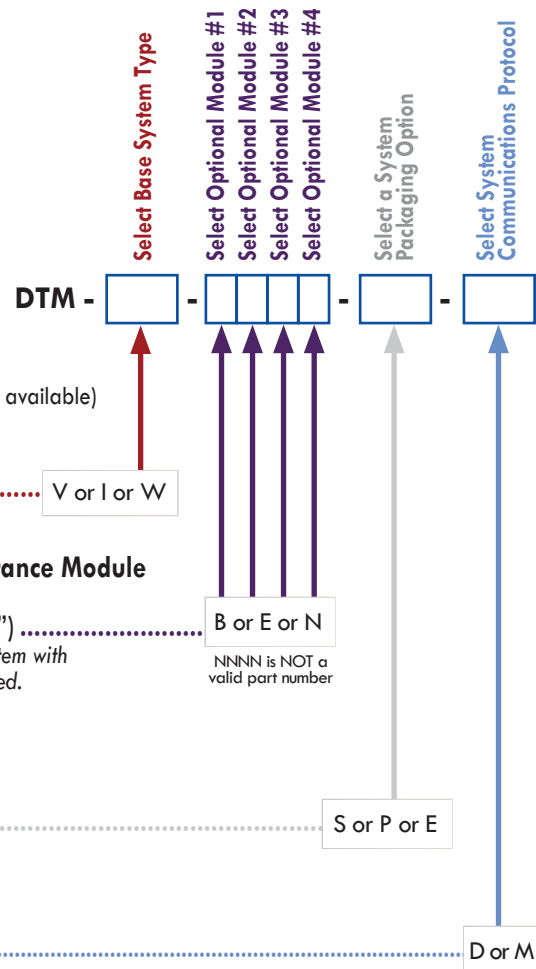
S or P or E

Communication Protocol Select D or M

D = DNP 3.0

M = Modbus Communication (Standard)

D or M



Notes ¹ = Packaging options P and E include the instrument mounted with all terminals wired out to terminal blocks. All bushing sensor connections have shunting terminal blocks. A fused incoming power connection is provided. Panel size may vary to accommodate base system selection. One of each sensor in the table below is included with each DTM.

² = Base System W, includes two cooling, current transformers (CTs). Consult Dynamic Ratings for proper sizing of these CTs. Enclosure size may vary to accommodate packaging choice and options ordered.



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SENSORS — ORDERING INFORMATION

Part#	Description
AuxCT	Current Transformer, with burden resistor (5 Amp Primary)
AmbH	Ambient Humidity Sensor
AmbT	Ambient Temperature Sensor

iBridge DEVICES and ACCESSORIES — ORDERING INFORMATION

Part #	Description
CE-520	iBridge with a 1.83m / 6 ft. power cord with NEMA 5-15 plug
CE-525	iBridge with a field wiring plug
CE-530	Gateway with a 1.83m / 6 ft. power cord with NEMA 5-15 plug
CE-535	Gateway with field wiring plug
CE-562	One RS-232 connection adaptor
CE-564	One RS-232 (25 pin) connection adaptor
IND2000N	One 9mm / 0.35 in. signal coupler
IND2020N	One 13mm / 0.51 in. signal coupler
IND2040N	One 18mm / 0.71 in. signal coupler
IND2100N	One 25mm / 0.98 in. signal coupler



iBridge



iBridge CE-520



iBridge CE-525



CE-562



CE-564



(IND-; 2000N, 2020N, 2040N 2100N)



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