DYNAMIC RATINGS

E Series

Transformer Monitor

- **Improved Reliability**
- **Reduced Maintenance Costs**
- **Maximized Life & Loading**
- **Safety**

RESPONSIVE

ASSET HEALTH SOLUTIONS

Data Driven Monitoring Solution

The E Series utilizes field proven technology in data collection, analysis and visualization to communicate and notify changes in transformer conditions. Dynamic Ratings E3 monitoring solution and LIFESTREAM® support services provide a comprehensive, data driven approach to condition based monitoring for bushings, windings, OLTC, cooling system and insulation of power transformers.

Full Service Solution

The E3 Transformer Monitor provides monitoring, control and communication solutions for power transformers.

- Monitors all key transformer components.
- Consolidates data and manages communication to third party IEDs and DGAs on the transformer.
- Provides a single point of communication for alarms.
- LIFESTREAM® Support Services verifies units are implemented properly and provides training and support for users throughout the life cycle of their asset management programs.

Improved Reliability

With online condition-based data, users receive alarms when problems first arise allowing early detection so that appropriate actions can be taken before problems escalate. Transformer failure can be catastrophic. Knowing the condition of assets allows users to reduce failure rates and unplanned outages.

Reduced Maintenance Costs

The advanced analytics within the monitoring system filters through the condition data to automatically identify issues requiring maintenance attention. This allows the Operations & Maintenance crews to focus on resolving problems rather than manually collecting data for off-line condition assessment. E3 Transformer Monitor analytics provides an optimal platform for condition based maintenance.

Maximized Life & Loading

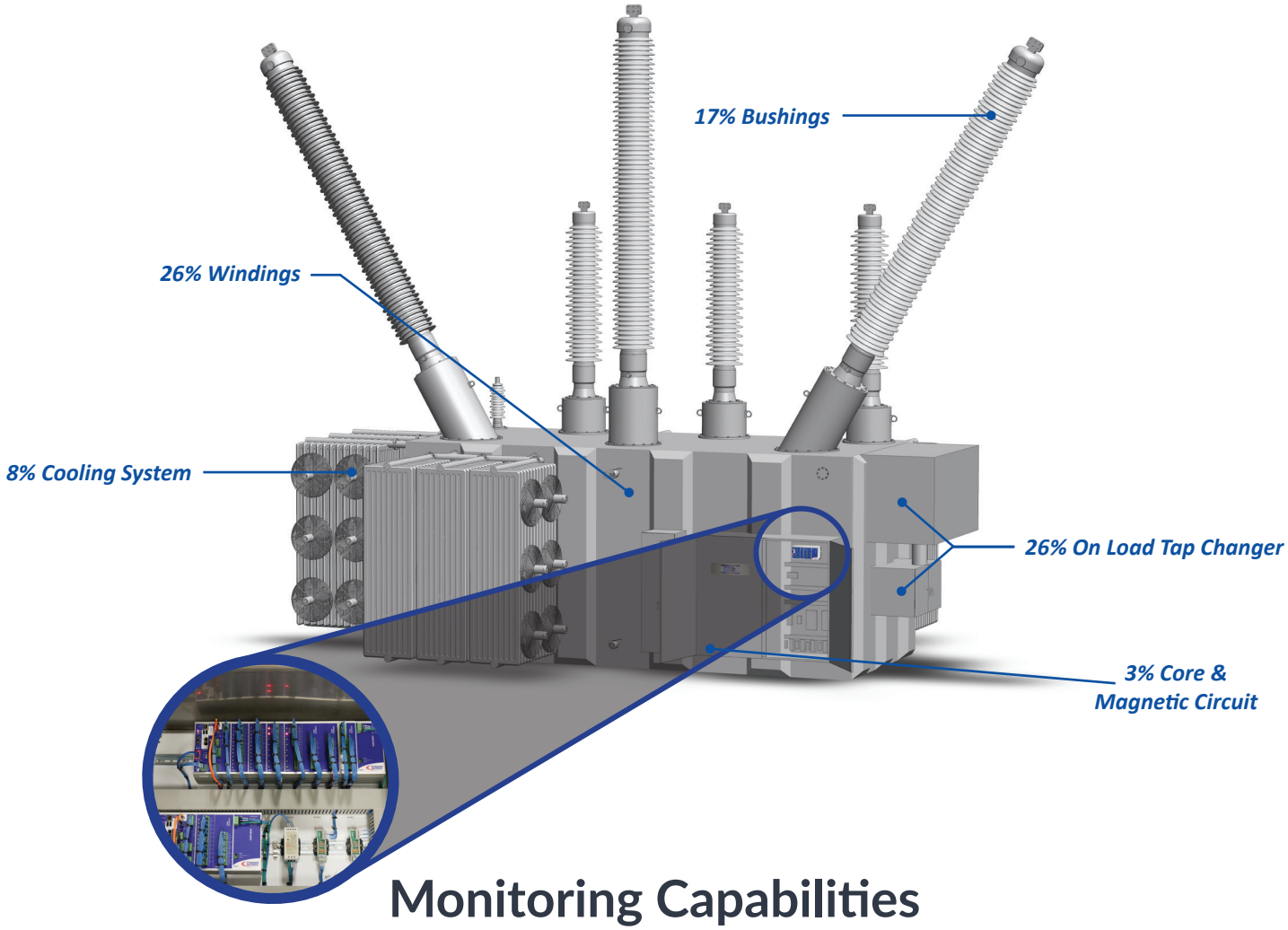
The real time measurement of operational parameters allows visibility into the condition of an asset. Real time understanding means you can load a transformer with confidence. Using data to make strategic decisions helps maximize asset life and planning for replacement.

Safety

Condition-based monitoring increases the safety of workers and the public through

- Situational Awareness.
- Reducing trips to site.
- Providing alerts, warnings and instructions.
- Complying to industry safety standards.

Major Failure Locations on Substation Transformers



Monitoring Capabilities

Thermal Monitoring
- Top Oil Temp
- Winding Temp
- Winding Temp (direct measure via fiber)
- Insulation Aging

Bushing Monitoring
- Change in Power Factor Detection
- Change in Capacitance Detection
- Partial Discharge Detection

Renewable Impact Monitoring
- Harmonic Monitoring
- Load Profile Monitoring
- Load Power Factor
- Voltage Level Monitoring

Transformer Fault Monitoring
- Fault Detection
- Fault Counting
- Fault Magnitude Accumulation

Core & Coil and DETC Monitoring
- DGA (Key Gas/Multigas)
- Moisture Monitoring
- Partial Discharge

GIC Monitoring
- DC Currents in the Neutral
- Harmonics (single or 3 phase)

OLTC Monitoring
- Time Since Last Thru Neutral
- Tap Change Counter for Each Tap
- Contact Wear for Each Tap
- Excessive Tap Operations in the Last Day
- OLTC Motor Incipient Failure Detection
- OLTC Contact Overheating (delta T)
- Slow Tap Change Alarm
- Monitoring of the OLTC Breather

Control System Monitoring
- Control Panel Heater Monitoring
- Loss of Cooling System Power
- Loss of Aux Power
- Breaker Trip Indications
- Control Cabinet Door Left Open Indication
- Not in Auto Detection

Oil and Preservation System Monitoring
- Oil Level with Alarm (low/high)
- Oil Leak Indication
- Conservator Bladder Rupture/Leak Detection
- Conservator Breather Monitoring
- Main Tank Nitrogen Pressure Alarm
- Nitrogen Bottle Pressure Monitoring and Alarm
- Nitrogen Regulator Failure Detection

Cooling System Monitoring
- Fan/Pump Current Monitoring (high and low)
- Loss of Cooling System Power
- Cooling Contactor Fail Detection
- Cooling System Breaker Trip Detection
- Cooler Efficiency Detection
- Pump/Fan Run Hours

Improved Reliability

Bushing Health Monitoring

50% of bushing failures can end in a fire and have a catastrophic impact on transformers as well as impact the safety of workers and the community. Offline testing is typically conducted every few years but failure can happen between offline tests. Unlike offline testing, online monitoring is continuous and is done at normal operating temperature at the network voltage. Continuous online monitoring of bushings provides asset owners with real-time information of bushing capacitance and power factor which can result in early detection of possible failure. The Bushing Health Monitor can capture the moment in time when bushings begin to exhibit symptoms of failure leading to planning for maintenance and outages.

*Available as a stand alone system or as a fully-integrated module for use with the E3 Transformer Monitor.

Partial Discharge Monitoring

Electrical partial discharge monitoring provides a much faster response than online DGA for PD events in the entire electrical circuit. PD Monitoring can diagnose the nature of PD activity and its persistence and severity.

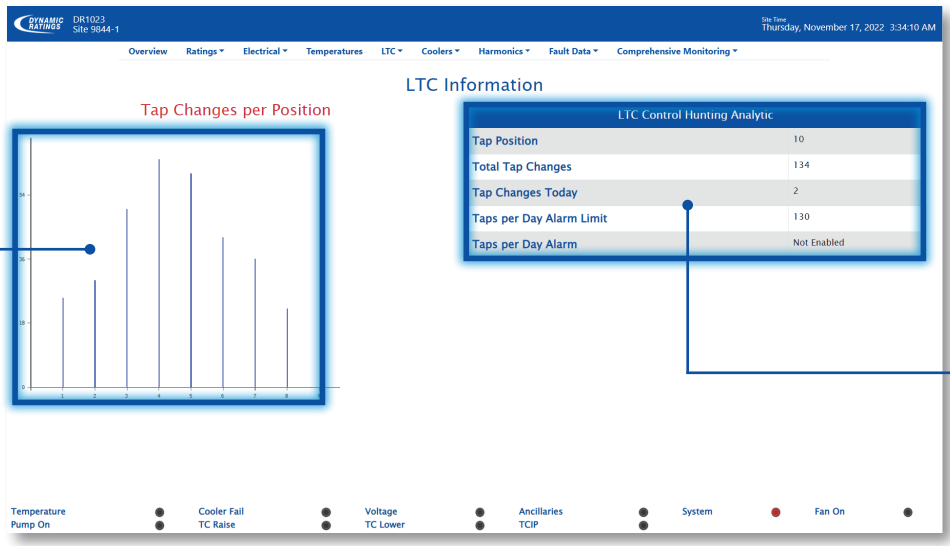
The Dynamic Ratings Partial Discharge Monitor (PDM) directly measures electrical partial discharges (PD) in power transformers and electrical power apparatus. Connection to the bushing capacitance taps provides a direct path for the PD signals and enables the system to see much further inside the transformer. Advanced noise cancellation technologies utilized in the Dynamic Ratings PDM enables the system to automatically differentiate between internal and external signal sources.

When PD occurs inside the core and coil assembly, detection via acoustic monitoring is more difficult. Use of the PDM directly measures the electrical signatures caused by a PD event. It can also monitor gas leaks and forecast when low gas limits will be reached, allowing proactive maintenance scheduling.

OLTC Monitoring

OLTC has the highest failure rate of all devices on the transformer. When OLTC fails, transformers can no longer regulate voltage which can cause significant negative problems. Monitoring data is critical for OLTC maintaining the reliability of a transformer.

The E3 provides early indication of OLTC/LTC drive or motor problems by monitoring the OLTC/LTC motor current and voltage and alarming on any unexpected deviation. An individual OLTC counter is maintained for each tap position providing a summary of the historic operation of the OLTC/LTC.



Tap Changes Per Position

Indicates frequency of each tap position for condition-based maintenance of LTC.

LTC Information

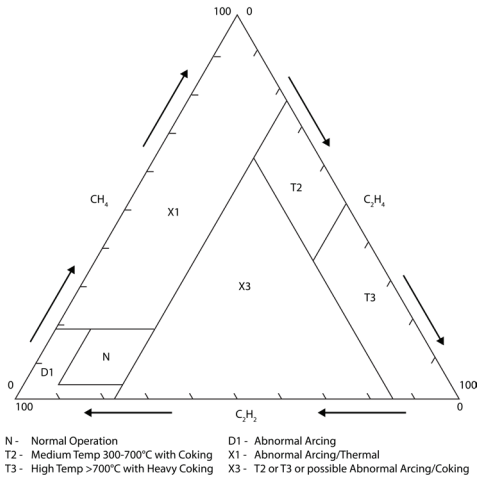
Provides detail measurements of tap changing control hunting analytic to monitor for excessive operation of LTC.

DGA Monitoring

Dissolved Gas Analysis monitoring is a major component of a comprehensive transformer monitoring system. Hydrogen, detected by Dynamic Ratings key gas DGA, is the earliest indicator of most types of faults within the transformer, especially for insulation problems.

The open architecture design of the E3 Transformer Monitor allows the system to be integrated with a wide array of third party multigas DGAs and moisture monitors. The communication link to these devices utilizes a serial link to ensure information is sent in digital format preserving the precision of the measurements and providing access to additional diagnostic information.

The data is displayed on web pages which enables asset managers to monitor the transformer from anywhere.



Moisture in Oil and the Effects of Bubble Evolution

Moisture in the oil and paper of a transformer has a high impact on insulation life. Studies show that with every 1% increase in moisture in paper, the aging rate doubles. High moisture content in the insulation can induce bubbling in the windings which can lead to flashover and arcing.

The E3 Transformer Monitor integrates moisture sensor data and other parameters as part of the moisture management model. The E3 moisture model also looks at the transformer characteristics and applies various rules to the data to determine the moisture content. This data allows operations and maintenance staff to plan ahead and take action if required.

Voltage Control

The E3 Transformer Monitor provides voltage control for a transformer. Voltage control with the E3 can reduce the number of devices on an asset to help eliminate potential failure points in the monitoring system. The E3 can be configured to provide primary voltage control or can be used to provide backup control for an existing voltage control system.

Reduced Maintenance Costs

Alarms

Online condition based alarms allow users to detect problems before they escalate into more expensive repairs. The E3 allows asset managers to select which alarms go to which stake holders through multiple SCADA connections and email notifications. Alarms and status points can be grouped with other transformer information to generate common, major, and minor alarm groups to simplify use.

Keys to Fleet Management

Advanced analytics reduce resources required to collect and analyze data and can be better utilized in resolving issues. E3 Transformer Monitor analytics include:

- Active moisture modeling
- Advanced thermal modeling
  - Precise winding temperatures
  - Insulation aging
  - Dynamic rating
  - "What If" rating calculations
  - Predictive oil temperature model
  - Cooling efficiency
  - Cooling system health
- Insulation Health
  - Fault Counting

E3 Webpage

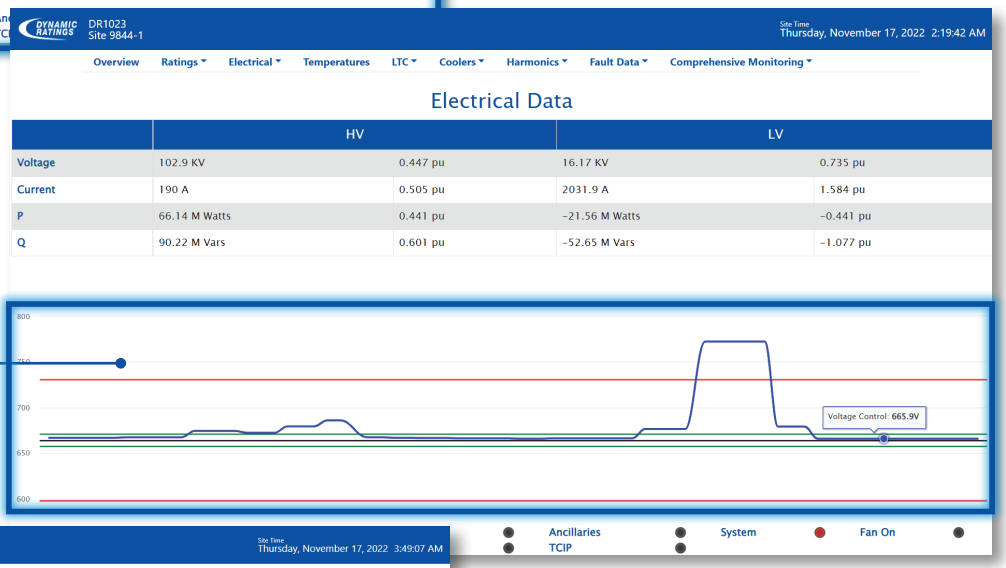
Every E3 product comes with a software system to analyze and communicate the data gathered into an easy-to-understand format. This also has the added advantage of making information available at any time, and from a remote location. The dashboard provides all the critical information you need to determine the health of your transformer.

Dynamic Rating

Provides the time remaining at the current state and the maximum safe load.

Transformer Overview

Provides graphical representation of alarm conditions.

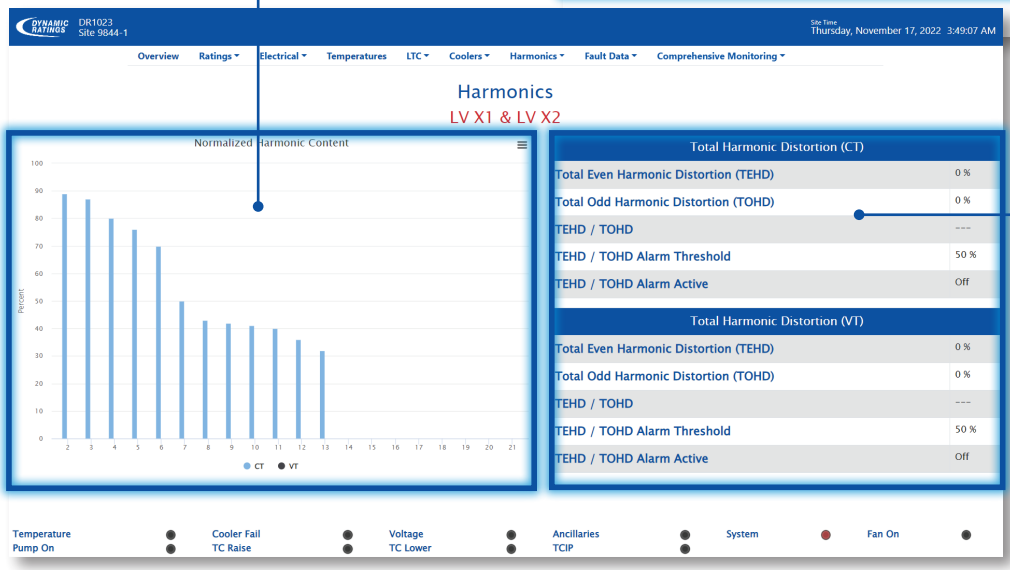


Harmonics

Harmonic contribution for both voltage and current inputs is visualized for more efficient diagnosis of power quality issues.

Voltage Control

Trending data shows measured voltage with respect to defined voltage control setpoints for optimization of power quality.

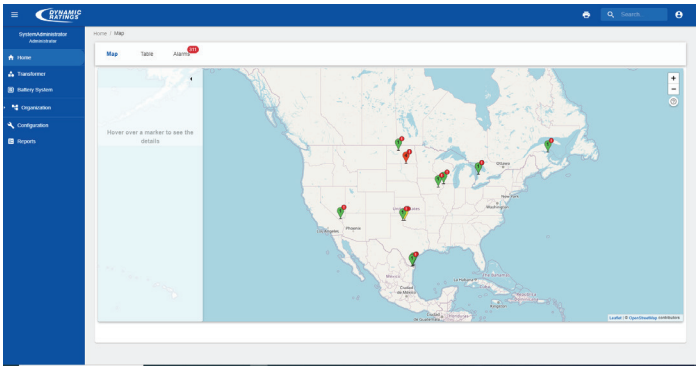


Total Harmonic Distortion

The total harmonic distortion is broken down into odd and even harmonic contents for better understanding of impacts to transformer.

Data Visualization with DynamicMetrix®

DynamicMetrix® is a sophisticated web-based data visualization solution for your assets. DynamicMetrix® aggregates data from multiple monitors, making it easier for asset managers to make prioritization decisions across a large fleet of transformers. Using web-based technology, it is designed to provide easily understandable information about asset status and health at a glance, whether it be current or historical. This allows for greater flexibility and planning in maintenance, reductions in outages, overall optimization of assets, and promotes proactive maintenance as opposed cost-ineffective reactive maintenance.



Maximized Life and Loading

Advanced Thermal Modeling

The thermal modeling analytic is designed with the latest industry standards to enhance the precision of modeling with transformer design, cooling system, cooling system health, losses adjusted for each tap position, and cooling efficiency adjusted based on cooling system performance.

Cooling System Health & Control

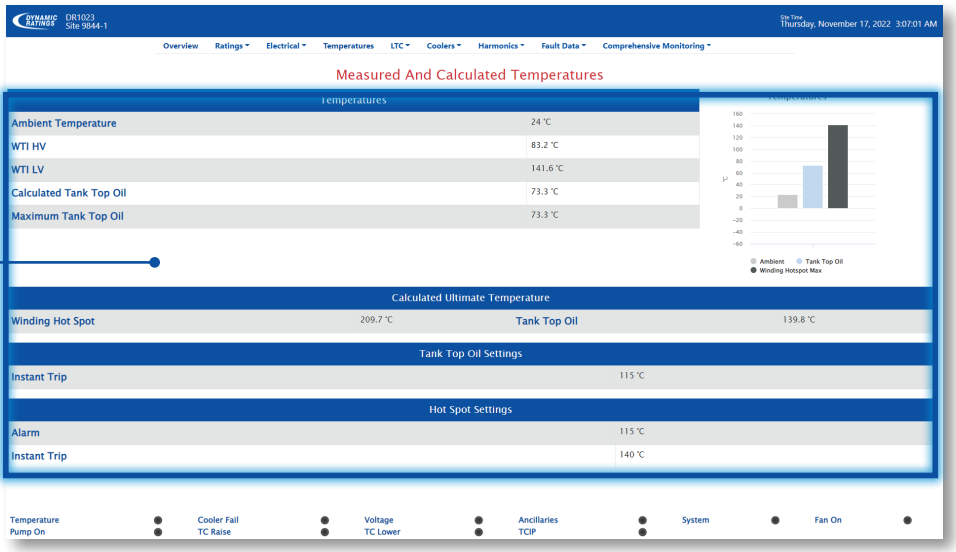
Cooling system failure can trip the transformer. Monitoring the cooling system can increase operation reliability of a transformer and help with condition-based maintenance such as when to replace fans or pumps. The E3 thermal model adjusts the calculated winding temperature hot spot based on the health of the cooling system.

The E3 Transformer Monitor provides cooling control function to support a wide variety of different cooling system designs and provides improved operational performance and reliability. This system provides:

- Discrete Control: The system can provide discrete control for more than 4 discrete stages of cooling control.
- Dual Speed Fan Control: For low noise applications, the system has dual speed fan control logic built in.
- Parallel Pump Control: For systems designed with parallel pumps, the system automatically manages the duty cycling of the pumps to ensure equal wear.
- Variable Speed Control: For coolers that operate with variable speed fans, the system provides the output to directly drive the VSD system.

Temperatures

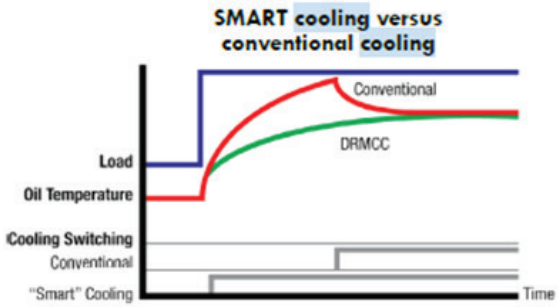
Provides comparison of both measures and calculated Ambient, Tank Top Oil and Winding Hotspot temperatures for thermal diagnosis of transformer.



Predictive SMART Cooling

Predictive cooling is a feature which can help extend the life of a transformer. It is enabled to proactively turn on the cooling system earlier to reduce insulation loss of life and to keep the transformer cooler, reserving more overload capacity for later in the day.

The predictive cooling uses the ultimate top oil temperature and the ultimate winding hot spot temperature calculations to recognize when the transformer temperatures are increasing beyond a desired level. Discrete set points may be used to control the turn on and turn off temperatures for both ultimate top oil temperature and ultimate winding temperature.



DRMCC SMART cooling keeps transformers running cooler than conventional systems thereby avoiding unnecessary "loss of life" and reserves more overload capacity for later use.

Dynamic Rating & "What If" Rating

The dynamic rating provides the time remaining at the current state and the maximum safe load. The time remaining provides the amount of time before the temperature will exceed the maximum thermal limit. The maximum safe load indicates the maximum load the transformer can safely carry given the present health of the cooling system and the present environmental and operating conditions of the transformer without pushing the transformer beyond the thermal limit.

Utilizing the predictive oil temperature model combined with the dynamic rating calculation, a "What If" is used to allow additional calculations including:

- Load for Time – given an assumed load, how long before the transformer would exceed a specified thermal limit.
- Time for Load – given a specific time duration, what is the maximum load the transformer could sustain without exceeding a specified thermal limit.

Through Fault Monitors

Though transformer failure most commonly occurs as the result of a through fault, it is typically not a single through fault which leads to failure, but the cumulative effects of a multitude of through faults to which the transformer is exposed during its lifetime.

The E3 Transformer Monitor harmonics and fault counter card is designed with the latest industry standards to capture the total fault count, maximum fault current, accumulated fault current, THD, and the ratio in percent of even/odd harmonics. Additionally, installing a circuit breaker monitor can help limit the number of faults that occur and provide additional protection for your transformer.

Geomagnetic Induced Currents (GIC)

GIC events and harmonics can lead to over saturation of the transformers' core, resulting in thermal deterioration of the solid insulation system, greatly diminishing the useful service life of equipment. The presence of these excessive harmonics can often go undetected for extended periods of time until abnormal thermal conditions begin to manifest as irregular gassing patterns when analyzing dissolved DGA results.

The E3 Transformer Monitor harmonics and fault counter card is designed with the latest industry standards to capture the total fault count, maximum fault current, accumulated fault current, THD, and the ratio in percent of even/odd harmonics. GIC sensors can also be installed to measure GIC events and communicate to the E3 in a matter of minutes without the need to de-energize equipment and without making modifications to the transformer neutral ground connection.

Safety

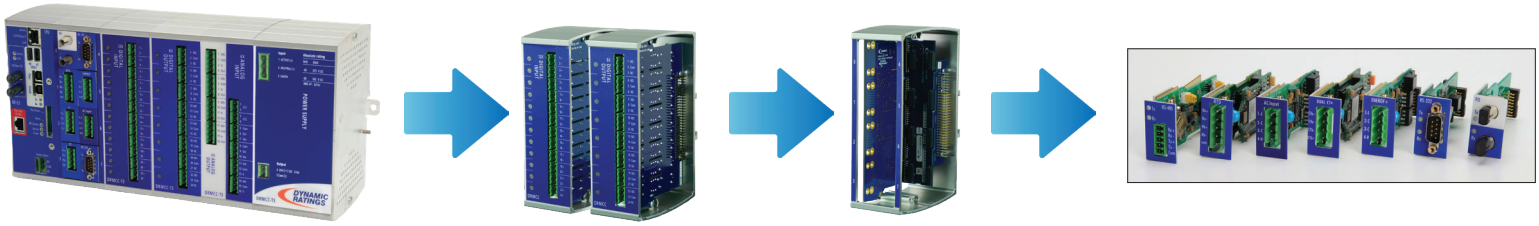
Safety

Safety is a key theme for an asset management strategy. The E3 Transformer Monitor provides:

- Online monitoring through SCADA connectivity to increase situational awareness for crews entering substations
- Advanced analytics to ensure crews are bringing proper equipment and replacement parts to resolve alarms correctly. Less trips to site means less opportunity for safety hazards
- User interfaces to provide key safety warnings, diagnostic interpretations and trouble shooting tips

Benefits of LIFESTREAM® Support Services

Asset management is more than just installing a monitor. Successful asset management is a process flow of planning, designing, managing, implementing, verifying, and supporting. Dynamic Ratings offers LIFESTREAM® Support Services to ensure successful monitoring throughout the entire life cycle of an asset.



E3 Modules

Main Processor (CPU) and Universal Power Supply Modules[1]

The main processor (CPU) module enables connection for setup, configuration or downloading files using either the USB ports, copper ethernet or fiber ethernet ports.

The power supply module allows operation with DC or AC sources ranging from 48 to 275 V DC and from 60 to 275 VAC at 50 or 60Hz.

[1] Main Processor (CPU) Module & Universal Power Supply Module are mandatory and must be included in any E3 product.

Digital Input Module

Each input module provides 12 digital inputs for monitoring the status of alarm contacts, switch positions, contactor status or other status points. The system can be expanded by adding any combination of modules.

Each input is isolated to 2.5kV AC for 60 seconds and 5kV impulse. Individual isolations allow the use of different AC or DC sources for wetting voltages up to 250 VAC or VDC.

Status indication LEDs for each input provides a user friendly feature for field technicians.

Digital Output Module

Each output module provides eight form C outputs for cooling control, voltage control, audible alarm or panel lights.

Each relay output has both NO and NC contacts and is individually isolated to 2.5kV AC for 60 seconds and 5kV impulse. Each output can be configured for either continuous or pulse output with adjustable pulse duration. Contacts are rated for 6A @ 250 VAC / 6A @ 30 VDC and 0.4A @ 125V DC resistive / 0.15A @ 125V DC inductive.

Analog Input Only Module

Each Analog Input module provides 6 inputs including 2 AC current inputs for monitoring transformer load, fan/pump current or other AC currents, 2 PT100 RTDs (3-wire) input for monitoring temperatures and 2 DC analog inputs for any DC sensor such as tap position, nitrogen pressure or other analog signals. DC analog inputs can be configured for 0-1mA, 4-20mA or 0-10VDC.

Analog Input/Output Module

Analog Input/Output modules include the above inputs plus eight analog outputs per module with a 4-20mA DC output supporting a burden of up to 400W. Accuracy +/- 0.2% of range (plus CT, RTD, sensor and transducer errors).

Direct Fiber Temperature Monitor

Fiber Optic temperature probes provide direct winding temperature measurement. This modular add-on to the E3 system provides an economical solution with the following advantages:

Close monitoring of the winding hot spot on critical transformer applications including large Auto, GSU, mobile or other critical installations.

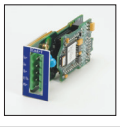
Collection of precise winding hot spot data to develop an optimally refined winding hot spot model. This model is copied to the Dynamic Ratings control system on all thermal duplicates gaining the accuracy of fiber optics on multiple units with minimal expense.

In addition to the CPU and Power Supply, the E3 can support up to twelve modules. The multiport module counts as one of the twelve modules regardless of how many multiport cards are installed on it. Below are available module options:

- One CPU Module (CPU)
- One Multiport Communications Module
- Zero or more Digital Input Modules (12 x Digital Input)
- Zero or more Digital Output Modules (8 x Digital Output)
- Zero or more Analog Input Modules (6 x Analog Input)
- Zero or more Analog Input/Output Modules (6 x Analog Input / 4 x Analog Output)
- One Power Supply Module (Power Supply)

Any combination of the option cards can be used to populate the eight port multi-port module.

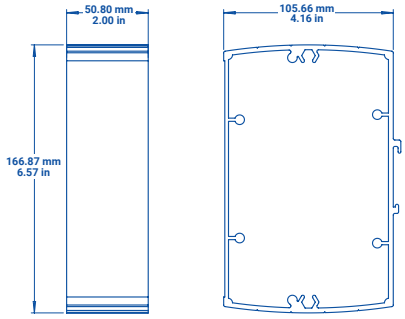
Multi-Port Module Options

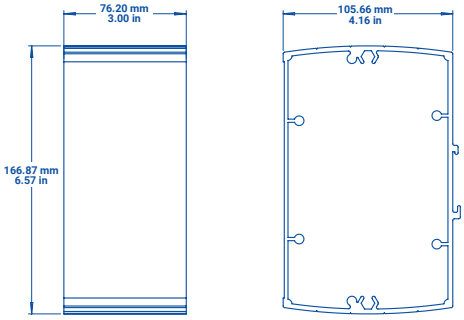
	**OLTC/LTC Motor Current Monitoring**	Provides early indication of OLTC/LTC drive or OLTC/LTC motor problems by monitoring the OLTC/LTC motor current and voltage and alarming on any unexpected deviation.
	**Dual CT+**	Two current inputs can monitor transformer load, fan current, pump current, fault counting, harmonic content of current waveforms or other AC current signals.
	**Dual PT100 RTDs**	Two, three-wire RTD inputs can monitor top oil, bottom oil, ambient, OLTC/LTC temp, main tank temp, cooler inlet/outlet or any other temperature.
	**AC+ Input**	Measures AC Volts and AC Current and calculates Watts and VARS.
	**RS-232**	Connection to a modem or other serial device can be made using this EIA232 compatible connection.
	**RS-485**	Connection to SCADA or other serial devices can be either two-wire or four-wire with this EIA485 compatible connection.
	**Serial Fiber Optic**	Serial connections to SCADA are supported using this port, compatible with multimode 50/100 & 62.5/125mm and ST Connectors.
	**DC Analog**	Two DC analog signals can be monitored with ranges of 0-1mA, 4-20mA, & 0-10VDC.

Product Specifications

Mounting	35mm (1.37in.) DIN rail	
Connection Type	Numbered terminal blocks (removable)	
Operating Temperature	-40°C to 80°C (-40°F to 176°F)	
Humidity	Up to 95% non-condensing	
Power Supply Module	DC Input: 48 VDC minimum to 275 V DC maximum, all tolerances included, 50 W	
	AC Input: 60 V RMS minimum to 265 V RMS maximum, all tolerances included, 47 - 63 Hz, 50W	
	DC Output: 24 VDC nominal unregulated (can vary 18 - 32 V DC) 0.5 A	
Power Input	275 VDC / 265 VAC rms maximum, 47 - 63 Hz	IEC 60664 Over-voltage Category II
Power Output	32VDC maximum	IEC 60664 Over-voltage Category I
Digital Inputs	125 VDC / 125 VAC rms maximum, 47 - 63 Hz	IEC 60664 Over-voltage Category I
Digital Outputs	125 VDC / 250 VAC rms maximum, 47 - 63 Hz	IEC 60664 Over-voltage Category I
Motor Energy Input	300 VAC rms maximum, 47 - 63 Hz	IEC 60664 Over-voltage Category I
VT Inputs	150 VAC rms maximum, 47 - 63 Hz	IEC 60664 Over-voltage Category I
Analog Inputs (other)	24 VDC maximum	IEC 60664 Over-voltage Category I
Analog Outputs	24 VDC maximum	IEC 60664 Over-voltage Category I
Communications	24 VDC maximum	IEC 60664 Over-voltage Category I

2" Module





3" Module

DYNAMIC RATINGS

An ISO 9001, ISO 14001, ISO 27001, ISO 45001 Certified Company.

Americas
+1 262 746-1230
sales.us@dynamicratings.com

Asia Pacific
+61 3 8544-0700
sales.asia@dynamicratings.com

Europe/ Africa
+44 1617 681111
sales.eu@dynamicratings.com

www.dynamicratings.com

Request a quote from your regional office.