TRANSFORMER SERVICE

CoreTec™ 4v2

Enabling open digital monitoring for transformers

General specifications

Name of manufacturer	Hitachi ABB Power Grids
Model	CoreTec 4
Type	Electronic transformer monitoring system
Color front panel and optional cabinet	RAL7035 (Hitachi ABB Power Grids standard)
Location of manufacturing site	Canada
Standard warranty	3 years full part and labor coverage
Maintenance	Solid state maintenance free – expected lifetime 15 years Built in self-diagnostics ensure correct operation
Consumables	Consumable free operation
Data storage	5 year data storage in nonvolatile flash memory
Real time clock	Super capacitor power backup for 1 week Network synchronized through SNTP protocol
Firmware upgrades	Upload through USB key or Ethernet connection
Manufacturers quality certification	ISO 9001:2015 certified by SGS
Manufacturers environmental certification	ISO 14001:2015 certified by SGS

Warranty statement

The CoreTec™ 4 electronic transformer monitoring system comes with a full 3-year warranty against any manufacturing defects, malfunctions including software bugs or parts wear. If any of the above should occur Hitachi ABB Power Grids will repair or replace the defective unit and restore it to operation according to published specifications, this is the only remedy that will be offered to the customer.

Maintenance statement

The CoreTec™ 4 is designed for an effective lifetime of 15 years and requires no recalibration and no consumables, however this does not constitute a warranty that no repairs will be required to maintain correct operation over 15 years. Hitachi ABB Power Grids also commits to keeping the necessary spare parts to repair or replace any CoreTec™ 4 monitoring system for a period of at least 10 years from the date of purchase.

Functional specifications

Thermal model	Calculates the hottest temperature of the winding, the hot-spot, using either IEC60076-7 (2018-01) or IEEE C57.91-2011	Required sensors - PT100 or oil temperature indicator for Top oil temperature - Current clamp for current load
Aging calculation	Calculates transformer insulation aging based on hot-spot temperature according to IEC60076-7 (2018-01) or IEEE C57.91-2011 Calculated every minute and averaged over 1 hour. Total aging is calculated by accumulating aging hours	Required sensors - PT100 or oil temperature indicator for Top oil temperature - Current clamp for current load
Maximum short-term load	Calculates allowable maximum load for 5 min, 15 min, 30 min, 1 hour and 2 hours given the maximum allowed top oil temperature and maximum allowed hot spot temperature according to IEC60076-7 (2018-01) or IEEE C57.91-2011	Required sensors - PT100 or oil temperature indicator for Top oil temperature - PT100 for ambient temperature - Current clamp for current load
Maximum continuous load	Calculates allowable maximum continuous load given the maximum allowed top oil temperature and maximum allowed hot spot temperature. Calculates the hot spot temperature rate of change per hour every 15 minutes. Algorithm will generate alarms when - Hot spot temperature will be exceeded in the next five minutes - Hot spot temperature is exceeded All calculations based on IEC60076-7 (2018-01)	Required sensors - PT100 or oil temperature indicator for Top oil temperature - PT100 for ambient temperature - Current clamp for current load

Load ratio	Calculate percentage load and actual MVA for transformer in real time	Required sensors - Current clamp for current load
Cooling efficiency	Trend radiator inlet and outlet temperatures and raise alarm if outlet temperature goes above preset threshold	Required sensors - PT100 for oil inlet temperature - PT100 for oil outlet temperature
Cooling control	Calculates cooling demand and control the fans based on cooling demand. Cooling demand logic is based on IEC 354 1991-09 and IEEE Std C57.91-1995 Standards. - Algorithm reduces short on-off cycles. - Control up to 6 cooling banks independently - Automatic bank rotation for even wear - Automatic bank excersize - Track run time for maintenance recomendations	Required sensors - PT100 or oil temperature indicator for top oil temperature - PT100 for ambient temperature - Current clamp for current load - Up to 6 dry contact relays for cool-ing banks Optional - Up to 6 digital inputs for feedback
Moisture Calculation	Calculate moisture in paper from moisture in oil data using T.V. Oommen's curves, IEEE C57.106-2002 and IEC60422, 2013-01 standards	Required sensors - Online moisture sensor such as CoreSense™ or CoreSense™ M10 DGA sensors - PT100 or oil temperature indicator for top oil temperature
Bubbling temperature calculation	Calculate the bubbling temperature according to the IEEE C57.91-2011 standard	Required sensors - Online moisture sensor such as CoreSense™ or CoreSense™ M10 DGA sensors - PT100 or oil temperature indicator for Top oil temperature - Current clamp for current load
DGA Gas level and gas trend analysis	Raise warnings and alarms when gas and/or moisture levels and/or trends exceed the recom-mended limits in IEEE C57.104-2019, IEEE C57.106-2015 and IEC60599 ed3.0b	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10
DGA analysis by IEC gas ratios	Compute gas ratios C2H2/C2H4, CH4/H2, C2H4/C2H6 to determine likely fault mechanism. The ratio of CO/CO2 is used to determine paper insultation degradation scenarios. O2/N2 ratio is used as an indication of oxidation processes and tank leaks. C2H2/H2 ratio is used as an indication of OLTC oil contamination in the main tank. The algorithm provides a 3D visualization of the gas ratios. Fault mechanism are: - Partial discharge - Low energy discharge - High energy discharge - Thermal fault <300°C - Thermal fault 300°C to 700°C - Thermal fault >700°C	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10
DGA analysis by Rogers ratios	Compute gas ratios C2H2/C2H4, CH4/H2, C2H4/C2H6 to determine likely fault mechanism. The algo-rithm provides a 3D visualization of the gas ratios.	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10

Case	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6	Suggested fault diagnosis
0	< 0.1	0.1 to 1.0	< 1.0	Unit normal
1	< 0.1	< 0.1	< 1.0	Low-energy density arcing-PD
2	0.1 to 3.0	0.1 to 1.0	> 3.0	Arcing-Bigh-energy discharge
3	< 0.1	0.1 to 1.0	1.0 to 3.0	Low temperature thermal
4	< 0.1	> 1.0	1.0 to 3.0	Thermal < 700°C
5	< 0.1	> 1.0	> 3.0	Thermal > 700°C

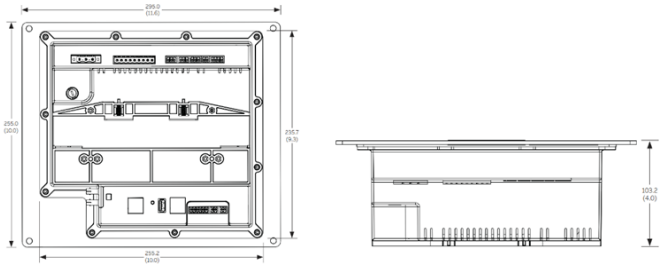
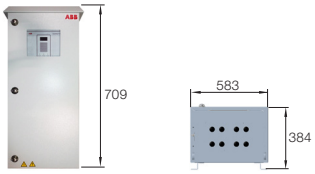
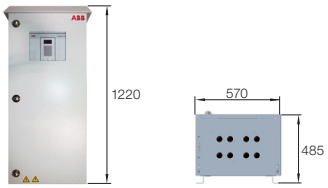
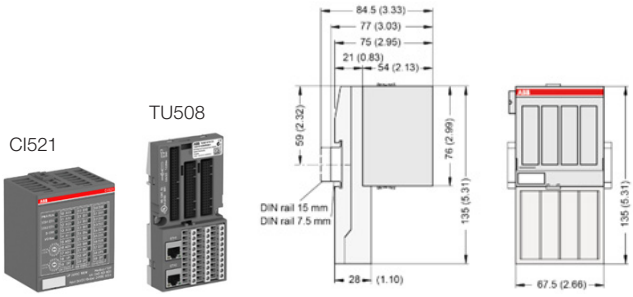
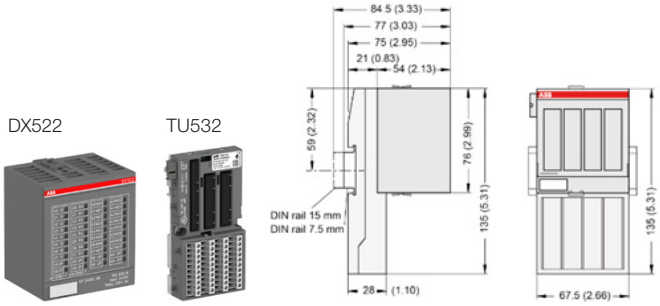
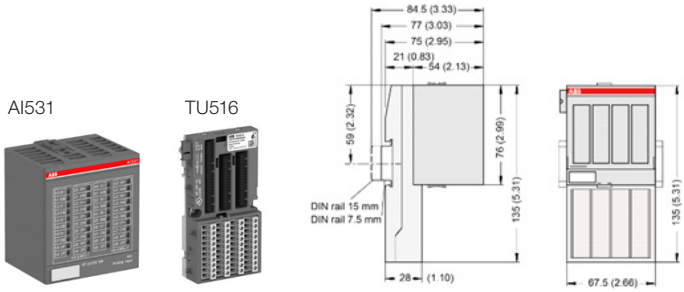
DGA analysis by Duval triangle 1	Compute the relative percentage of CH4, C2H2, C2H4 laid out on a triangle they allow to predict the most likely of: - Partial discharge - Low energy discharge - High energy discharge - Thermal fault <300°C - Thermal fault 300°C to 700°C - Thermal fault >700°C - Discharge or thermal fault	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10
DGA analysis by Duval triangle 4	Compute the relative percentage of H2, CH4, C2H6 laid out on a triangle to get more precise diag-nosis of low energy faults: - Partial discharge - Stray gassing of oil at <200°C - Possible hotspot with paper carbonization at >300°C - Overheating <250°C - Undetermined	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10

DGA analysis by Duval triangle 5	Compute the relative percentage of CH4, C2H4, C2H6 laid out on a triangle to get more precise diagnosis of high energy faults: - Partial discharge - Stray gassing of oil at <200°C - Possible hotspot with paper carbonization at >300°C - Overheating <250°C - Thermal fault 300°C to 700°C - Thermal fault >700°C - Undetermined	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10
DGA Gas level and gas trend analysis for Ester filled transformers	Raise warnings and alarms when gas and/or moisture levels and/or trends exceed the recommended limits in IEEE C57.155-2014 and CIGRE Technical Brochure 443: 2010	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10 with Ester oil capability
DGA Gas level and gas trend analysis for Silicone filled transformers	Raise warnings and alarms when gas and/or moisture levels and/or trends exceed the recommended limits in IEEE C57.146-2005 and CIGRE Technical Brochure 443: 2010	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10 with Silicone oil capability
DGA Gas level and gas trend analysis for OLTC tank gases	Raise warnings and alarms when gas and/or moisture levels and/or trends exceed the recommended limits in IEEE C57.139-2015 and CIGRE Technical Brochure 443: 2010	Required sensors - Online DGA sensor such as CoreSense™ or CoreSense™ M10 connected to OLTC tank
OLTC maintenance tracking	Monitor operational parameters of the On Load Tap Changer: - Number of operations by the OLTC - Date for next maintenance - Maximum number of operations recommend-ed by the manufacturer - Temperature difference between LTC compartment and main tank - Existing Mechanical issues - Dynamic resistance issues - Breakdown voltage - Moisture - Motor drive current Results are shown in a dashboard, for example number of operations per tap position, trends for temperature, moisture, motor drive current The algorithms will raise alarms for: - 75% of max recommended operations - 90% of max recommended operations - Above 100% recommended operations - Recommended maintenance interval in less than 30 days - Difference between OLTC and main tank temperature above recommended limit. - Motor drive current too high - Mechanical issues - Dynamic resistance issues	Required sensors - Position feedback from motor drive - PT100 or oil temperature indicator for Top oil temperature - PT100 or oil temperature indicator for OLTC tank temperature - Current clamp for current load - Current clamp for motor drive cur-rent - Online moisture sensor such as CoreSense™ or CoreSense™ M10 DGA sensors connected to OLTC tank
OLTC contact wear calculation for ABB tap changers	Calculate percent contact wear from OLTC operational parameters. The algorithm will raise alarms for - Time in same position too long - Most worn contact at 80% wear - Most worn contact at 100% wear	Required sensors - Position feedback from motor drive - Current clamp for current load
Bushing monitoring	Monitor the following bushing parameters using either Sum of currents or Voltage reference method for Bushing monitoring: - Capacitance - Dielectric dissipation factor (tanδ and Δtanδ) - Calculated leakage current	Required sensors - Online bushing monitoring system like TX BM - TX BM tap adaptors - TX BM Sensors - TX BM controller

Electrical specifications

Voltage input	100 to 240 VAC (50 to 60 Hz) or 100 to 240 VDC 24 VDC for optional IO modules
Max power consumption	100VA
Max current	0.5A
Line voltage fluctuation	Not to exceed 10% of nominal line voltage
Power cable	Three (3) conductor configuration with Live, Neutral and Earth connections Max current rating 8A Copper-only wire (stranded WITH FERRULE or solid) AWG #18 to AWG #12 90 °C 600V, UL and CSA type Maximum length 15m (50ft) for AWG#12 Maximum length 10m (33ft) for AWG#18
Fuse type	1 × 1.6 A/300 V (5 × 20 mm), slow blow (IEC60127 type T)

Mechanical specifications

Dimensions CoreTec™ 4 295 x 255 x 103.2 mm (11.61 x 10.04 x 4 in)	
Weight CoreTec™ 4	1.7 kg (3.7 lbs)
Enclosure CoreTec™ 4	IP20 panel and din rail mount
Dimensions CoreTec™ 4 cabinet S 709 x 583 x 384 mm (27.91 x 22.95 x 15.11 in) IP66 ingress protection	
Dimensions CoreTec™ 4 cabinet L 1220 x 570 x 485 mm (48.03 x 22.44 x 19.09 in) IP66 ingress protection	
Dimensions CI521-Modbus TCP bus module 4AI, 2AO, 8DI, 8DO TU508-Ethernet terminal unit with spring terminals	
Dimensions DX522-Digital input/output module 8DI, 8relays TU532-I/O terminal unit for relay modules	
Dimensions AI531-Analog input/output module 8AI TU516-I/O terminal unit	
AI modules	Individualy configurable as 0...10 V, -10...+10 V, 0/4...20 mA, Pt100/1000, Ni1000 Resolution 12 bits
AO modules	Individualy configurable as -10...+10 V, 0...20 mA, 4...20 mA Resolution 12 bits
IO module sequence	Minimum requirements is CI521 with TU508 Additional modules plug into each other

Communication specifications

Ultrabright easy-to-read LED		Three color-coded LEDs for system, process and uplink status
Local screen		Four-line monochrome display Scrolls through important thermal and DGA parameters
User interface		Local/remote Web based interface using HTTPS over Ethernet TCP/IP Display real time results and historical trends Visualize algorithms Set warning and alarms Configure system
Digital interfaces	RS485 serial port	Integrated 120Ω terminator Full duplex and half duplex supported 24 AWG cable, 1220m (4003ft) maximum length Settings: 9600baud, 8 data bits, 1 stop bit, no parity, no flow con-trol Protocol: Modbus RTU master
	Expansion RJ45 Ethernet	RJ45 100 base-T Ethernet port Dedicated for local modular expansion and service field connection Category 5 cable, 100m (328 ft) maximum length Default IP: HTTPS://192.168.3.20:8081 Protocols: Modbus IP, DNP 3, IEC61850, IEC60870, OPC UA HTTPS secure web server, publishes web HMI over Ethernet
	SCADA RJ45 Ethernet	RJ45 100 base-T Ethernet port Port dedicated for customer network and SCADA connection Cannot be used if optical Ethernet in use Category 5 cable, 100m (328 ft) maximum length Default IP: DHCP dynamic address (fixed address can be config-ured) Integrated DHCP client for IP address assignment Protocols: Modbus IP, DNP 3, IEC61850, IEC60870 HTTPS secure web server, publishes web HMI over Ethernet
	Optical Ethernet	100 base-FX fiber optics Ethernet port Port dedicated for customer network and SCADA connection Cannot be used if SCADA RJ45 Ethernet in use ST-ST full duplex 62.5/125 multi-mode fiber Maximum length 2000m (6562 ft) Default IP: DHCP dynamic address (fixed address can be config-ured) Integrated DHCP client for IP address assignment Protocols: Modbus IP, DNP 3, IEC61850, IEC60870 HTTPS secure web server, publishes web HMI over Ethernet
	USB	USB type A
Analog interfaces	4-20mA outputs	2 analog outputs for publishing values 4 to 20mA, 24v max, 21 mA signal used to indicate error Copper wire AWG #24 to AWG #26 with ferule Maximum recommended distance 400m
	4-20mA inputs	3 analog inputs for reading auxiliary values 4 to 20mA, 24v max, 21 mA signal used to indicate error Copper wire AWG #24 to AWG #26 with ferule Maximum recommended distance 400m
	dry contacts	3 dry contact relays outputs for publishing alarms Copper stranded AWG#18 with ferrule or solid AWG#18 to AWG#14 Output type: normally Closed/Open (SPDT) Rated operational voltage U2 (IEC/EN 60947-01): 250 VAC Switching voltage: min 5V at 100mA, max 400VAC/250VDC Min switching current: 10mA at 10V Rated operational currents (IEC/EN 60947-5-1) AC12 (resistive) 6A AC15 (inductive) 1.5A AC15 (inductive) 3 A DC12 (resistive) 6 A DC13 (inductive) 1 A DC13 (inductive) 0.22 A DC13 (inductive) 0.11 A Max making (inrush) current: 15A at 240VAC Min switching power: 10 mA at 10 V ($AgSnO_2$) Max switching (breaking) power (AC1 [resistive]): 1500VA at 250VAC Contact resistance: 100 mΩ (at 1 A/6 V DC) Rated insulation voltage: 250VAC Rated impulse withstand voltage Uimp Between coils and contacts: 4kV for 1min Between open contacts: 1kV for 1min
I/O expansion blocks	CI521 and TU508	Connects to CoreTec 4 through Ethernet using Modbus IP Provides additional IO: - 8 Digital inputs - 8 Digital outputs - 4 Analog inputs (0-10V, -10-10V, 0-20mA, 4-20mA using 12 bits, RTD: PT100, PT1000, Ni1000 ± 0.1°C) - 2 Analog outputs (-10-10V, 0-20mA, 4-20mA using 12 bits)
	AI531 and TU516	Connects to CI521 Provides additional IO: - 8 Analog inputs (0-10V, -10-10V, 0-20mA, 4-20mA using 12 bits, RTD: PT100, PT1000, Ni1000 ± 0.1°C)
	DX522 and TU532	Connects to CI521 Provides additional IO: - 8 Digital inputs - 8 Dry contact relay outputs

Environmental specifications

Operating ambient temperature	-40°C to +60°C (-40°F to +140°F) -60°C with retrofit cabinet and cabinet heater
Operating electronics temperature	-40°C to +80°C (-40°F to +176°F)
Cold start min temperature	-40°C (-40°F)
Survival temperature	-60°C to +100°C (-76°F to +212°F)
Shipping/storage temperature	-40°C to +70°C (-40°F to +158°F)
Operating ambient humidity	5% to 95% RH noncondensing
Operating altitude	-610m to 3000m (-2001ft to 9843ft)
Pollution degree	4 (outdoor use), 2 (internal)

Certifications

European approval (electrical safety)	CE mark
North American approval (electrical safety)	cCSAus mark
Electrical safety – with US and Canadian deviations	IEC/EN 61010
Electrical safety – International deviations	CBScheme
Cybersecurity	Compliant with cybersecurity standards IEC62443-4-1, IEC62443-4-2 and IEEE 1676 compliance IEC62351 part 8 secure role-based access control
FCC part 15 – with Canadian equivalent	FCC
Ingress protection	IP20 panel and DIN rail mount With retrofit cabinet: IP66 – IEC/EN 60529 NEMA 4X – NEMA standard 250 Class C4 – ISO12944-2 Option for Class C5M
Directive limiting use of heavy metals	ROHS 2011/65/EU ROHS – China
Electronics recycling directive	WEEE 2012/19/EU
Hazardous chemicals directive	REACH EC1907/2006
Regulation on substances that deplete ozone layer	EC2037/2000
Ordinance on the Use of Particularly Dangerous Substances, Preparations, and Articles	SR814.81
Regulations on chemicals threatening health and environment from Union of European rail industries	UNIFE
Regulation on persistent organic pollutants	EC850/2004
Electrical equipment for measurement, control and laboratory use	IEC61326-1 Industrial levels, class A equipment & industrial locations
Electromagnetic immunity	IEC/EN 61000-6-2
Emission standard for industrial environments	IEC/EN 61000-6-4
Electrostatic discharge immunity	IEC/EN 61000-4-2 level 4 (8kV contact, 15kV through air)
Radiated, radio-frequency, electromagnetic field immunity	IEC/EN 61000-4-3
Electrical fast transient/burst immunity	IEC/EN 61000-4-4
Surge immunity	IEC/EN 61000-4-5
Immunity to conducted disturbances, induced by radio-frequency fields	IEC/EN 61000-4-6
Power frequency magnetic field immunity	IEC/EN 61000-4-8
Pulsed magnetic field immunity	IEC/EN 61000-4-9
Damped oscillatory magnetic field	IEC/EN 61000-4-10
Voltage dips, short interruptions and voltage variations immunity	IEC/EN 61000-4-11
Ring wave immunity	IEC/EN 61000-4-12
Common mode disturbances 0-150 kHz	IEC/EN 61000-4-16
Harmonics emissions	IEC/EN 61000-3-2
voltages changes, voltage fluctuations and flicker	IEC/EN 61000-3-3
Conducted emissions	EN55011, CISPR 11, conducted group 1 class A
Radiated emissions	EN55011, CISPR 11, radiated group 1 class A
Random vibrations category 4	IEC/EN 60068-2-64
Shock	IEC/EN 60068-2-27
Damp heat cyclic with 95% relative humidity	IEC/EN 60068-2-30
Sinusoidal vibrations	IEC/EN 60068-2-6 Test extended to 150-180Hz range

Hitachi ABB Power Grids Ltd

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