GE
Grid Solutions

Kelman™ DGA 900 Plus

Transformer Monitoring System

Installation & Commissioning Manual

Building a world that works

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Contents

List of Tables and Figures

Related Documents

Ref#	Title
MA-024	DGA 900 Installation Manual
MA-025	DGA 900 Operator Guide
MA-040	DGA 900 Plus - Operator Guide

Abbreviations & Definitions

Abbreviation	Meaning
HFCT	High Frequency Current Transformer
HMI	Human Machine Interface
HV	High Voltage
LOTO	Lock Out, Tag Out procedure
LV	Low Voltage
OLTC	On Load Tap Changer
PD	Partial Discharge
RTD	Resistive Temperature Detectors

1 INTRODUCTION

1.1 Product Overview

The Kelman™ DGA 900 Plus (the product) builds on the existing multi-gas online DGA 900 system with additional monitoring capabilities and a series of data models to provide a complete transformer monitoring solution. This flexible offering combines the latest technology and a range of options via a modular and retrofittable architecture. The product uses additional sensors and electronic cards to gather and process key transformer operational data. The latest firmware is embedded with intelligent algorithms that utilise this data to determine incipient transformer faults early. Other important transformer characteristics are also monitored and together this delivers an integrated and comprehensive assessment of transformer health. Depending on the options chosen, the product offers the following capabilities:

- Thermal models
- Cooling status
- OLTC monitoring
- Bushing monitoring & Partial Discharge (PD) detection
- Perception Fleet software

1.2 Scope

This manual must be read in conjunction with the standard DGA 900 manuals as listed in the Related Documents section above. The standard 'DGA 900 Installation Manual' provides important pre-installation considerations and core installation details that must be read prior to installation in order to prepare the site and obtain the necessary equipment in advance of the installation.

This product contains additional sensors, electronic cards and firmware to provide a rich monitoring and modelling feature set as described in the respective Operator Guides. Principally, this manual describes the Hub module and all hardware installation tasks that are unique to the 'Plus' designation pertaining to thermal models, cooling status, OLTC monitoring, bushing and partial discharge monitoring, such as bushing adaptor connections, temperature sensors, CTs, related wiring details and preparatory tasks. This manual also describes essential configuration operations and first start-up procedures that must be done in the HMI as part of the commissioning phase. To configure and generate all the data models, including setting alarms, refer to the 'MA-040 – DGA 900 Plus – Operator Guide'. For all other aspects of the installation, particularly regarding the Analysis module including standard requirements and safety statements, refer to the standard DGA 900 Installation Manual.

The 'DGA 900 Plus' manuals build on the standard 'DGA 900' manuals referenced in the Related Documents table above, and together they form the comprehensive 'DGA 900 Plus' documentation set. Collectively the manuals examine installation for all options including mounting, plumbing, power, electronics and communications, and comprehensive use of the HMI for configuration, communications, alarm settings, calculations and error notifications to avail of all monitoring and modelling functionality.

2 SAFETY

2.1 Symbols

The meaning of symbols used on the Kelman™ DGA 900 Plus:

Caution. Refer to the Installation Manual / Operator Guide to prevent death, injury, equipment damage or loss of data.

Electrical Hazard. Risk of electric shock.

Primary Protective Earth connection.

Hot surfaces may be present.

The meaning of symbols used in this manual:

WARNING A procedure, practice, or condition could cause death or serious injury and/or significant equipment damage.

A procedure, practice, or condition could cause minor injury, equipment damage or loss of data.

Electrical Hazard: Risk of electric shock.

2.2 Safety Statements

The following safety statements must be observed:

The customer and installer are responsible for ensuring that all local regulations and site policies are complied with concerning safe working practices.

The minimum ambient temperature for installation and service activities is −10 °C..

If the equipment is installed or used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

If working at height, third parties must have received appropriate training for working at height prior to work commencing. This includes, but is not limited to, 'Working at height' and 'Using Mobile Elevated Working Platforms' training.

If working at a height greater than 4 feet (1.2 metres) or at a height greater than that stipulated by national or site regulatory requirements, it is the responsibility of the installer to ensure that planned work complies with those requirements.

The installer shall also ensure that any third-party equipment, such as an approved platform, scaffold or lift is suitable and safe before commencing work. *Ladders or improvised platforms do not meet GE service engineer requirements.*

Do not open the cabinet during inclement weather.

Before commencing any installation or maintenance work, ensure that the product is disconnected from the mains supply via the external switch or circuit breaker.

Once installed, this product may have more than one source of electrical supply. Disconnect all supplies at their source before accessing the cabinet for servicing. Follow the site lockout-tagout (LOTO) procedure.

Ensure all power sources, including relays, are de-energised as stipulated by lockout-tagout (LOTO) requirements before performing any maintenance work inside the product.

The product is operated with the door shut under normal use. The door shall be kept locked and should only be opened for service access by suitably qualified and authorised service personnel. During service access, hazardous voltages are accessible

Only GE-trained and certified personnel may commission GE Kelman products. Commissioning tasks include making any connections and/or performing any work within the module, or performing tasks such as purging the oil circuit between the transformer and the product, and/or all first start-up procedures relating to equipment or firmware/software.

WARNING: All procedures in this manual must be followed. Any deviation could cause irreversible damage to the transformer being monitored and/or the product, and could lead to property damage, personal injury and/or death.

Bushing monitoring falls outside the scope of UL61010-1 and CSA C22.2 No. 61010-1 and has not been evaluated. When these products are installed in the United States and Canada, use of bushing monitoring voids the UL listing / certification of the product.

3 TECHNICAL SPECIFICATIONS

The product meets the following technical specification as outlined in Table 3-1.

Table 3-1: Measurements & Operating Specifications

BUSHING & PD MEASUREMENTS	
Input current measuring range	2 mA – 200 mA rms, 1% of reading
Relative phase angle accuracy	0.01 deg of angle
Maximum number of PD measured	200 pulses per cycle (50 to 60 Hz)
Measurement category for signal inputs	CAT III. 5 V AC rms, 200 mA; on each phase
Maximum bushing temperature at bushing adaptor	90 °C (194 °F)
ENVIRONMENTAL	
Unit operating temperature	−40 °C to 55 °C (−22 °F to 131 °F)
Bushing adaptor operating temperature	−40 °C to 90 °C (−40 °F to 194 °F) at bushing tapping point
Storage temperature	0 °C to 45 °C (−32 °F to 113 °F)
Altitude	Up to 2000 m (6500 ft) above sea level
Atmospheric pressure	Up to 1050 mbar
Operating humidity	10 – 95% RH non-condensing
Enclosure*1	IP56, NEMA 3RX
Bushing adaptors	IP66
Weight *2	Analysis module: 33.4 kg (73.6 lb) Hub module: 22.2 kg (48.9 lb) 2 m PCC cable: 0.8 kg (1.83 lb) Product weight: 56.4 kg (124.33 lb) Bushing adaptor (each): 0.350 g (0.8 lb)
Pollution degree	2
POWER	
	Nominal input voltage range: 100-250 V DC 4 A 100-240 V AC, 50/60 Hz, 4 A Input voltage range: 90-264 V AC 90-275 V DC AC frequency range: 45-65 Hz
Single phase Alarm Relays: NO and NC provided*3	10 A 250 V AC, 10 A 30 V DC, 0.3 A 110 V DC, 0.12 A 220 V DC
Over Voltage Category	II
Fuses *4	10 A 600 V AC/DC EATON KLM-10 DC distribution fuses – Schurter Series SPT 250V DC 8 or 6.3 A
Coin cells	Panasonic CR2450 3 V 620 mAh
TOP OIL TEMPERATURE SENSOR (Bushing Monitor)	
Operating Voltage	12 V DC
Communication	CAN bus
TOP OIL TEMPERATURE SENSOR (Models)	
Communication	4-20 mA

[*1] Note: It is possible for a small amount of condensation to form on the inner surface of the Analysis enclosure. This occurs under certain environmental conditions and does not affect the performance or reliability of the product.

[*2] Note: The weight depends on the order specification. The stated weight is for a base product without packaging and excludes options such as a mounting stand. Check the shipping document for the exact packaged weight.

[*3] Note: Maximum DC breaking capacity for a resistive load.

[*4] Note: Use only the approved and recommended fuse to ensure continued fire protection and compliance.

4 COMPLIANCE

The product is designed to meet the following type tests as listed in Table 4-1.

Table 4-1: Type Tests

CATEGORY	STANDARD	Performance Criteria	TEST
EMC Emissions EN 61326-1:2006	CISPR 11	A	Radiated & Conducted Emissions
	FCC Part 15	Meets the requirements of A	Radiated & Conducted Emissions
	EN 61000-3-2	A	Harmonic Current Emissions Limits
EMC Immunity EN 61326-1:2006 IEC 61000-6-5: 2015	EN 61000-4-2	B	Electrostatic Discharge
	EN 61000-4-3	A	Electromagnetic Field Immunity
	EN 61000-4-4	B	Electrical Fast Transients
	EN 61000-4-5	B	Surge Immunity
	EN 61000-4-6	A	Conducted RF Immunity
	EN 61000-4-8	A	Magnetic Field Immunity
	EN 61000-4-11	B, C	Voltage Dips & Interruptions
	IEC 61000-4-16	A	Mains frequency voltage
	IEC61000-4-17	A	Ripple on DC power supply
	IEC61000-4-18	B	Damped oscillatory wave
	EN 60255-5	5 kV, 2 kV & 500 V DC	Impulse, Dielectric & Insulation resistance testing
Environmental Tests	IEC 60068-2-1	−40 °C	Cold
	IEC 60068-2-2	55 °C	Dry Heat
	IEC 60068-2-6	10 – 500 Hz, 0.5 g operation 10 – 500 Hz, 1 g endurance	Vibration
	IEC 6IEC0068-2-30	55 °C, 95% RH	Damp Heat
	IEC60068-2-6		Vibration (sinusoidal)
	IEC60068-2-27		Vibration (bump, shock)
	EN 60529	IP56	Degree of Protection
Safety	IEC 61010-1		2010
	EN 61010-1		2010
	UL61010-1[*5]		
	CSA C22.2 No. 61010-1[*5]		

[*5] Note: Bushing monitoring falls outside the scope of UL61010-1 and CSA C22.2 No. 61010-1 and cannot be included in any third-party certification for North America.

5 TRANSFORMER MONITORING SYSTEM (TMS)

A fully integrated TMS is illustrated in Figure 5-1. In addition to the analytics performed on dissolved gases, the DGA 900 Plus accepts multiple inputs from an array of sensors.

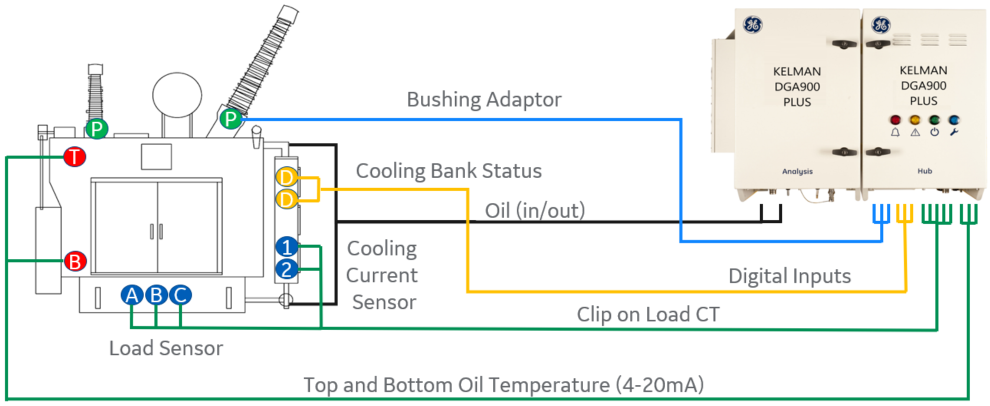


Figure 5-1: TMS inputs overview

These sensors gather operational data on the internal workings of a transformer that allow the DGA 900 Plus to:

- produce thermal models on key aspects of a transformer's condition
- monitor and model the cooling status of fans and pumps
- monitor the condition of the OLTC mechanism
- monitor 3/6 bushings

These capabilities are delivered by several TMS option packs that are installed in the Hub module and are field retrofittable. Each pack has dedicated PCB card options and are supplied with the relevant sensors (unless otherwise stated). These cards receive the sensor data and process it according to advanced algorithms. Some interdependencies do exist between the various cards with some inputs and outputs feeding into other models as illustrated by the relationship schematic shown in Figure 5-2.

Note: Consult with your GE representative to ensure that the correct option pack(s) are part of your installation.

Figure 5-2 illustrates the dataflow, inputs and relationships between the various option packs.

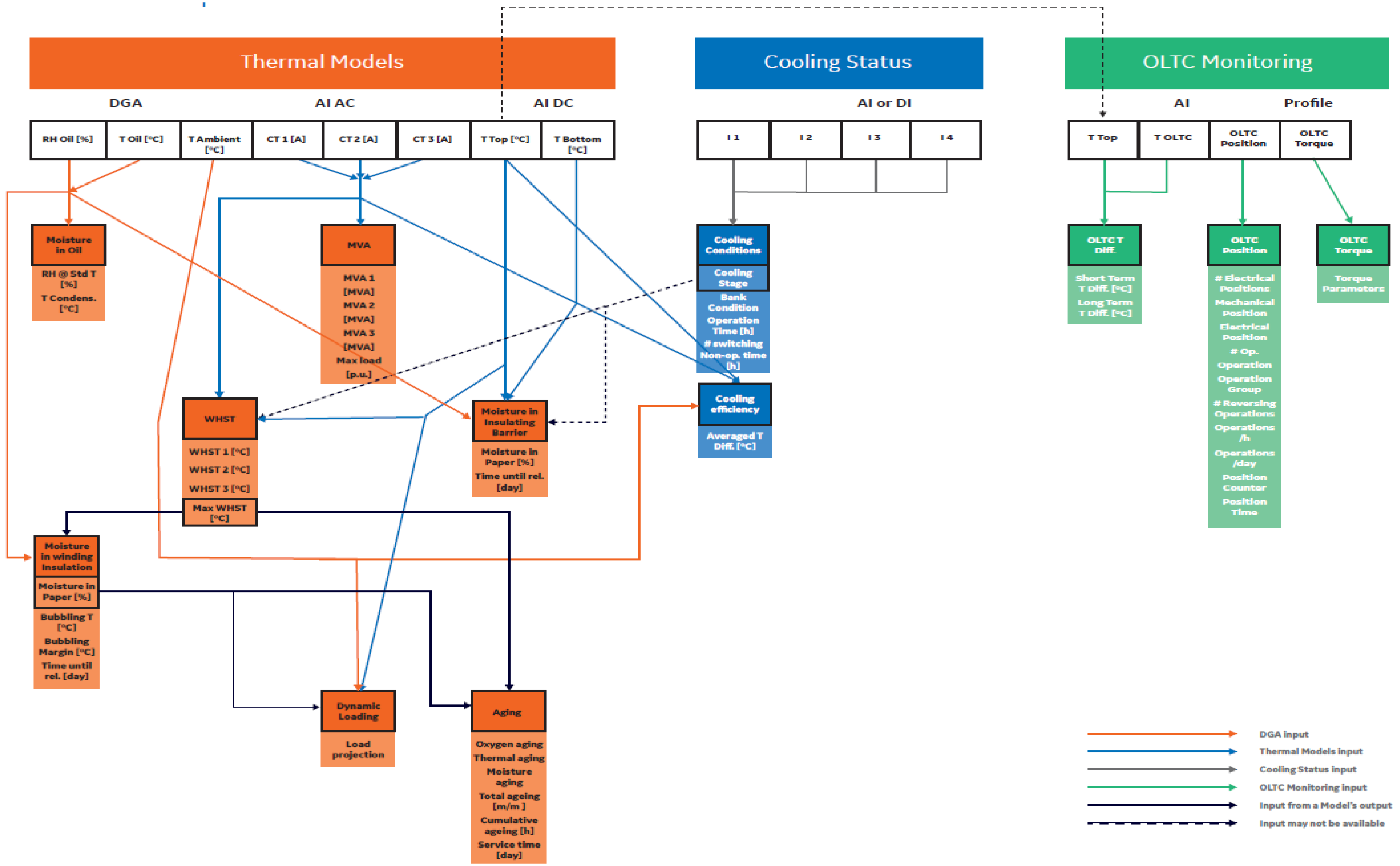


Figure 5-2: Option packs dataflow

5.1 TMS Options

The Hub module has four PCB slots as shown in Figure 5-3. From left to right, the first slot houses the Controller PCB as described in the standard DGA 900 Installation manual. Depending on the chosen combination of options, the other three slots as highlighted house the I/O cards for the additional analogue and digital inputs related to the additional modelling and monitoring capabilities.

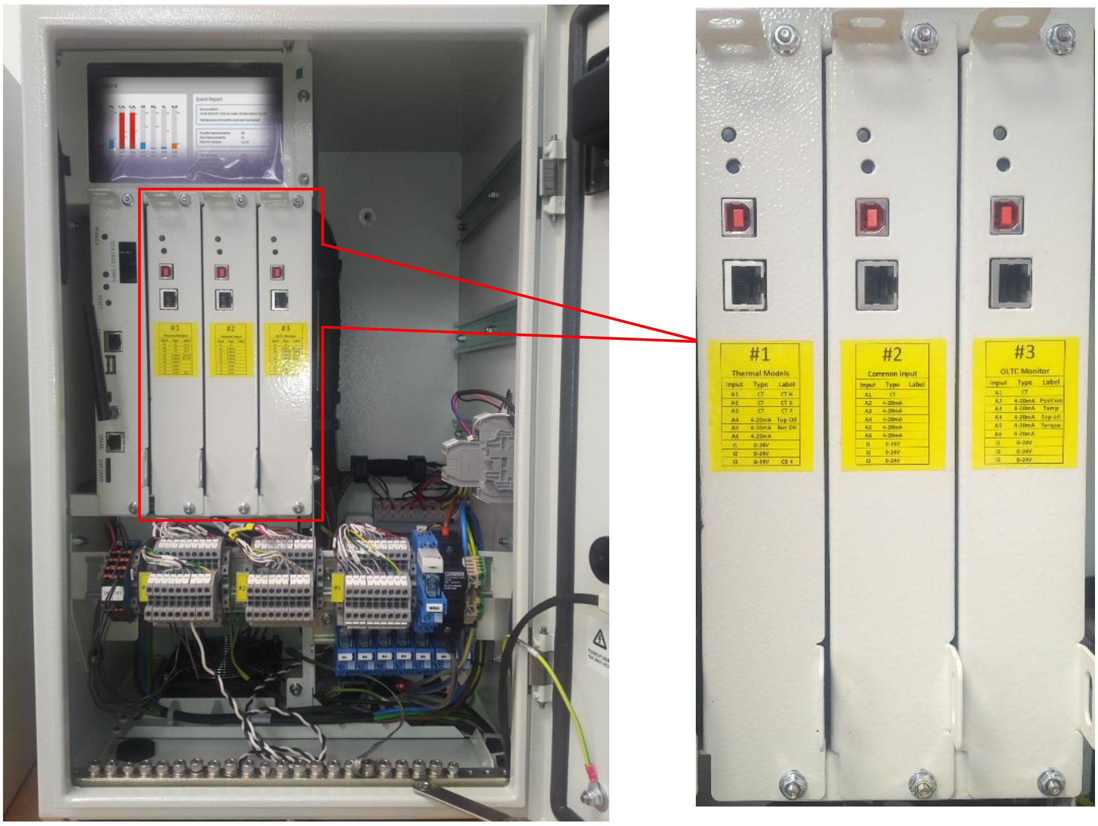


Figure 5-3: Hub module PCB faceplates

The four available card options are:

1. Thermal Models Card Option #1:
2. Cooling Status Monitor
3. OLTC Monitor
4. Bushing Monitor

The system can host up to any three of the above four card options.

Table 5-1 lists all the permutations for the four cards in the three slots.

Table 5-1: DGA 900 Plus card options

Slot 1	Slot 2	Slot 3
Default Card	-	-
Thermal Models	-	-
Thermal Models	Cooling Status	-
Default Card	-	Bushing Monitor
Thermal Models	-	Bushing Monitor
Thermal Models	Cooling Status	Bushing Monitor
Default Card	OLTC Monitor	Bushing Monitor
Default Card	OLTC Monitor	-
Thermal Models	OLTC Monitor	-
Thermal Models	OLTC Monitor	Bushing Monitor
Thermal Models	Cooling Status	OLTC Monitor

The default card refers to the DGA 900 I/O PCB card as described in the standard DGA 900 Installation Manual.

The required sensors must be installed as per the standard common input sensors (4-20 mA, RTD and/or CT). The I/O PCB has six analogue inputs as standard (five of which are customer configurable) and three digital inputs. The final configuration for each board is different depending on the option packs chosen. A label on the PCB faceplate indicates the final configuration. All sensors are supplied as part of the package (unless otherwise requested/stated).

The product is supplied with factory default settings for all parameters, e.g. alarm thresholds. For optimal performance, specific settings are required for each installation and for the OLTC and Bushings monitors, precise commissioning steps must be followed as defined in Section 10.3 and Section 10.4 respectively. For all other operational details relating to the software interface for configuration, bushing settings, data readings and alarms, refer to the 'MA-040 – DGA 900 Plus – Operator Guide'.

Note: The Analysis module is dedicated to dissolved gas analysis as outlined in 'MA-024 - DGA 900 Installation Manual' & 'MA-025 - DGA 900 Operator Guide'.

6 CARD OPTION #1: THERMAL MODELS

The thermal card option generates the base models relating to thermal and moisture readings. It integrates data from the existing DGA analysis (for moisture and ambient temperature) and accepts inputs from two 4-20 mA inputs to obtain top- and bottom -oil temperatures (see Section 6.3) and up to three split core CT sensors for transformer load (see Section 6.4).

6.1 Sensor Input Configuration

Table 6-1 lists the types of inputs used by the Thermal Models.

Table 6-1: Thermal Models inputs

Input	Label	Sensor Type
AIN 1	CT H/H/A/H	CT
AIN 2	CT X/X1/B/C	CT
AIN 3	CT Y/X2/C/Y	CT
AIN 4	Top Oil Temperature	4-20 mA
AIN 5	Bottom Oil Temperature	4-20 mA
AIN 6	*spare*	None / CT / 4-20 mA / RTD
DIN 1	*spare*	12-24 V
DIN 2	*spare*	12-24 V
DIN 3	*spare*	12-24 V

Note: The default range for the Thermal CTs is 0-5 A. Other ranges are available on request with advance notice.

Thermal Models requires the installation and wiring of up to three CTs and two temperature sensors provided with the Thermal Models pack. These are to be wired as shown in Figure 6-1 and in accordance with the 'MA-024 – DGA 900 Installation Manual'.

The Top Oil Temperature sensor should be installed in a vertical position on one of the long sides of the transformer, typically between 20-30 cm from the top, and horizontally in the middle. The Bottom Oil Temperature sensor should be installed as per the Top Oil Temperature sensor, but 20-30 cm from the bottom.

6.2 Wiring

The wiring for the Thermal Models is shown in Figure 6-1. Wetting terminals accept up to 14 24 V DC connections with a cable cross section of 0.14 mm² to 2.5 mm², AWG: 14 – 26.

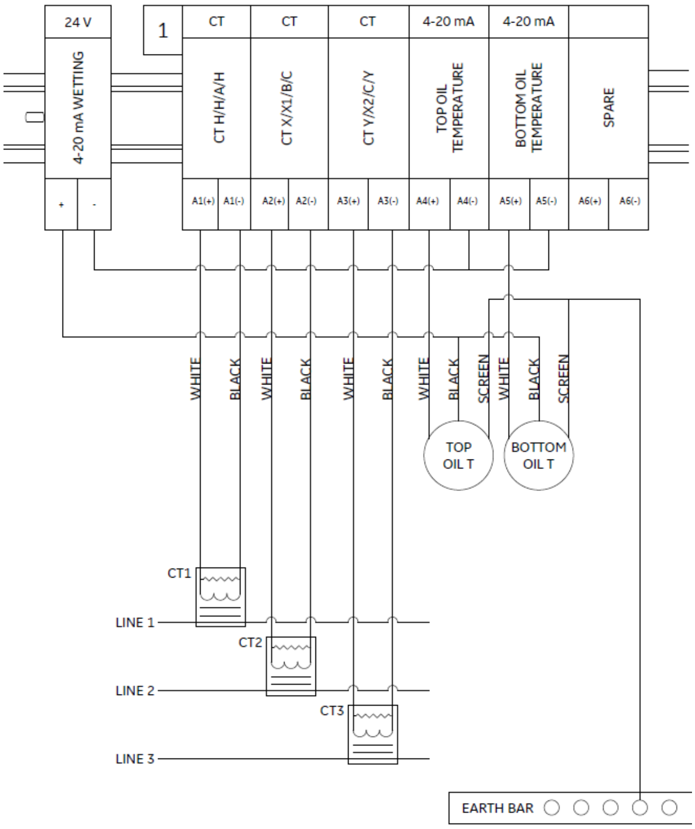


Figure 6-1: Thermal Models wiring

Figure 6-2 to Figure 6-4 below show the temperature sensors and CT in detail.

6.3 Temperature Sensors

The temperature sensors measure the top and bottom oil temperatures of the main tank and the OLTC temperature. An example is shown in Figure 6-1 and comprises of a self-contained PT100 with a built-in 4-20 mA transmitter which is powered from the monitoring unit and provides a 4-20 mA output that is read by the analogue input card. The temperature sensor is enclosed in a plastic weatherproof housing and magnetically mounts to the side wall of the transformer main tank or the OLTC side wall.

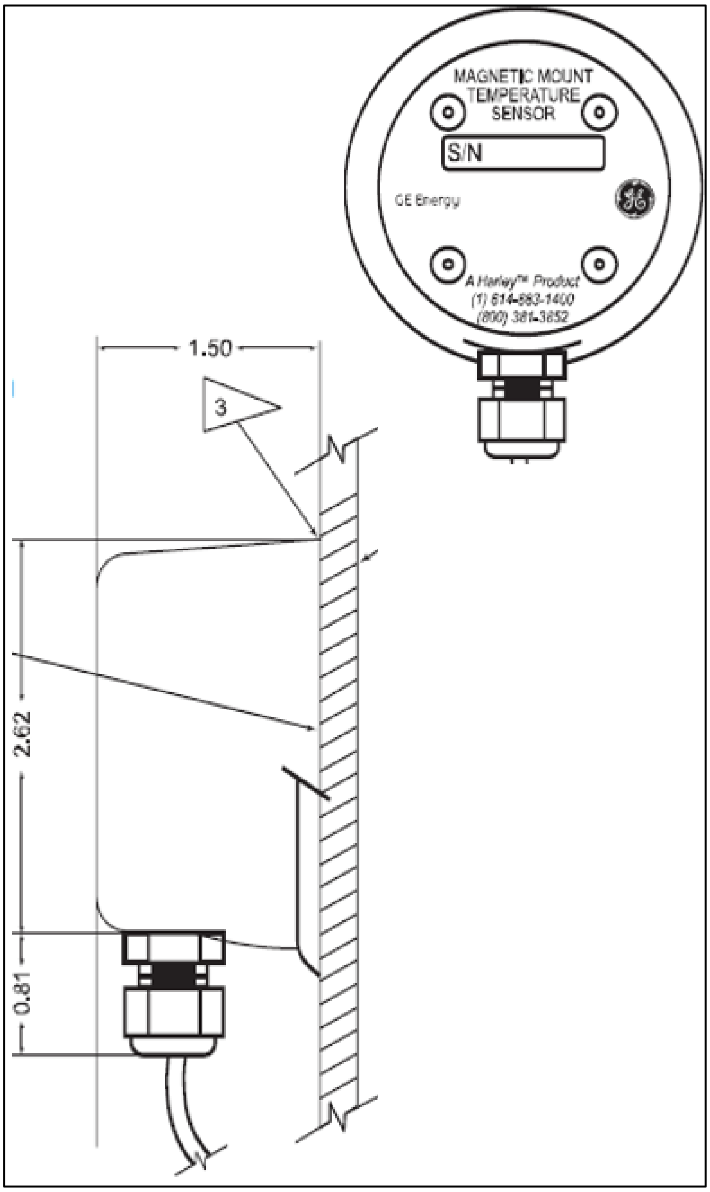


Figure 6-2: Magnetic mount temperature sensor

The oil temperature sensor specification is shown in Table 6-2.

Table 6-2: Oil temperature sensor specification

Item	Value
Enclosure	Plastic
Output	4-20 mA
Wiring	12 m (40 ft) twisted, shielded pair 22 AWG & thermal compound
Operating temperature	−40 °C to 150 °C (−40 °F to 302 °F)
Size	5.7 × 4.7 cm (2.25 × 1.87 in.)
Weight	230g (8 oz) excluding wire 300 g (11 oz) including wire
Power Requirements	24 V DC

Note: The cable length provided with the temperature sensor is 40 feet (approx. 12 metres).

An overview to the fitting of a magnetic mount temperature sensor to the tank wall is shown in Figure 6-3.

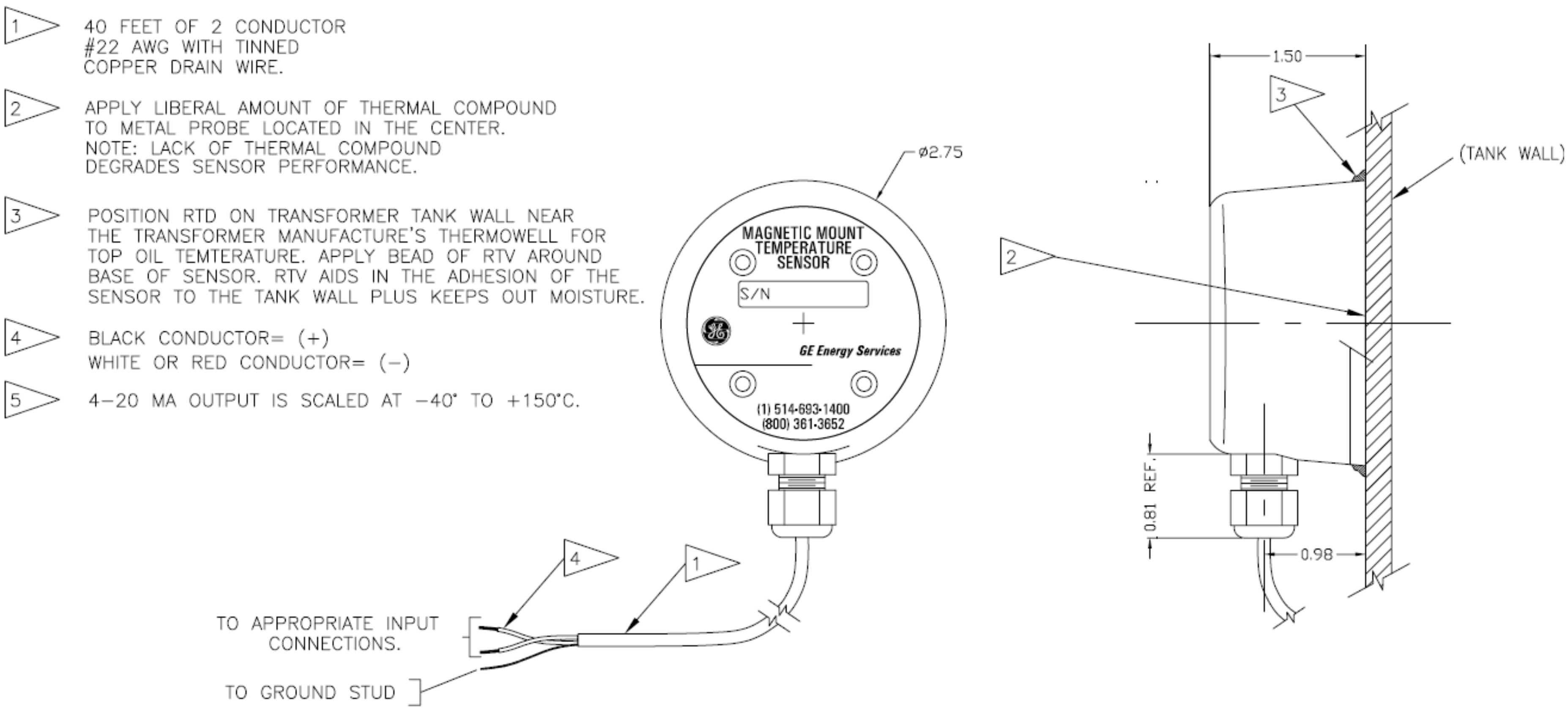


Figure 6-3: Magnetic mount temperature sensor – installation overview

6.4 CT Sensors

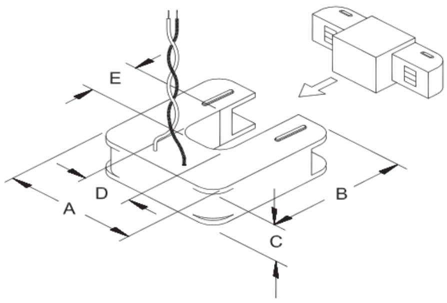
The split core CT as shown in Figure 6-4 clamps over a cable, snapping around the centre conductor to measure the current passing through. The CT provides a voltage that is proportional to the measured current.

Figure 6-4: Split core CT

CT dimensions are listed in Table 6-3.

Table 6-3: CT dimensions

Dim.	in	mm
A	2.000	50.80
B	2.100	53.34
C	0.610	15.49
D	0.750	19.05
E	0.750	19.05



CT specifications are listed inTable 6-4.

Table 6-4: CT specifications

Item	Value
Opening	0.75 in / 1.905 cm ID
Connections	8 ft / 2.4 Meter Twisted Cable 20 AWG*
Input	200 Amp
Output	0.333 Volt at rated current Linearity accuracy ± 1%
Accuracy	10% to 130% of rated current
Phase angle	< 2 degrees (valid for 70 A or higher)
Operates	30 Hz to 1,000 Hz
Maximum Voltage	600 V (on bare conductor)
Compliance	UL recognized, CE, and RoHS compliant
Operating temperature	−20 °C to 110 °C

*Note: The supplied 8 ft (2.4 metres) cable can be extended to 33 feet (10 metres).

The load CT that is shipped with the DGA 900 Plus is rated up to 5 Amps and the cooling CT is rated up to 30 Amps. Alternative CTs are available as listed in Table 6-5, but must be selected and notified prior to shipping.

Table 6-5: CT options

Part #	Rating
SCT-0750-005	**5 Amp**
SCT-0750-000	10 Amp
SCT-0750-000	**30 Amp**
SCT-0750-000	50 Amp
SCT-0750-000	70 Amp
SCT-0750-000	100 Amp
SCT-0750-000	150 Amp
SCT-0750-000	200 Amp

7 CARD OPTION #2: COOLING STATUS MONITOR

The cooling card option monitors up to four cooling bank units (pumps, fans etc). This card requires the Thermal Models option as described in Section 6 and improves the accuracy of the Thermal Models.

The cooling card uses a CT to monitor the current drawn by each cooling bank. Alternatively, a digital input can be used for each cooling bank to monitor the On/Off status.

Note: The four CTs or four digital inputs can be configured to monitor up to four cooling banks, but not both.

7.1 Sensor Input Configuration

Table 7-1 lists the types of inputs used by the Cooling Status models.

Table 7-1: Cooling Status inputs

Input	Label	Sensor Type
AIN 7	spare	CT
AIN 8	Cooling bank 1	CT
AIN 9	Cooling bank 2	CT
AIN 10	Cooling bank 3	CT
AIN 11	Cooling bank 4	CT
AIN 12	spare	None / CT / 4-20 mA / RTD
DIN 4	Cooling bank 1	12-24 V
DIN 5	Cooling bank 2	12-24 V
DIN 6	Cooling bank 3	12-24 V

Note: The default range for the Cooling CTs is 0-30 A. Other ranges are available on request in advance.

Cooling Status requires the wiring of up to four cooling banks using either analogue or digital inputs. These are to be wired as shown in Figure 7-1 (analogue inputs) or Figure 7-2 (digital inputs).

If installing CTs (analogue input), each CT must be clipped around one of the conductors feeding a cooling bank (fan set, pump, etc). It should not be installed to monitor a group of units that can be switched on/off independently of each other.

7.2 Wiring

The cooling banks wiring is shown in Figure 7-1 and Figure 7-2. The Cooling Status monitors up to four cooling banks using analogue inputs (as shown in Figure 7-1) or using digital inputs (as shown in Figure 7-2). Refer to Section 6.4 for more information on the CTs.

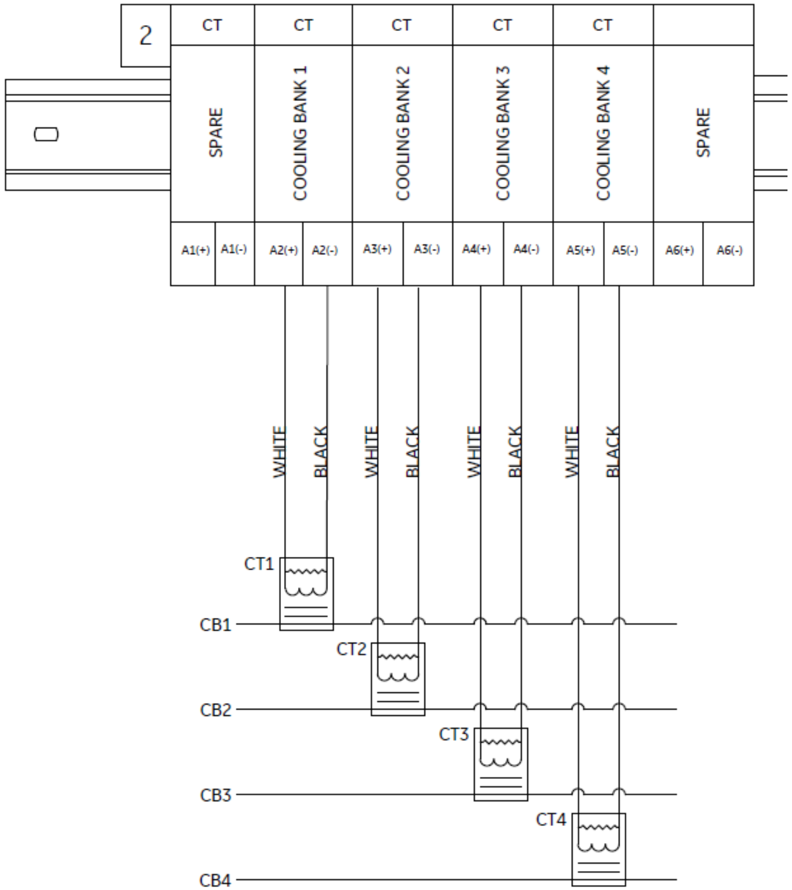


Figure 7-1: Cooling Banks – analogue inputs & CTs

The digital inputs for the cooling status and thermal models wiring are shown in Figure 7-2. Digital inputs are polarised, and the positive supply must be connected to the D+. Maximum current is 25 mA. Maximum voltage is 24 V.

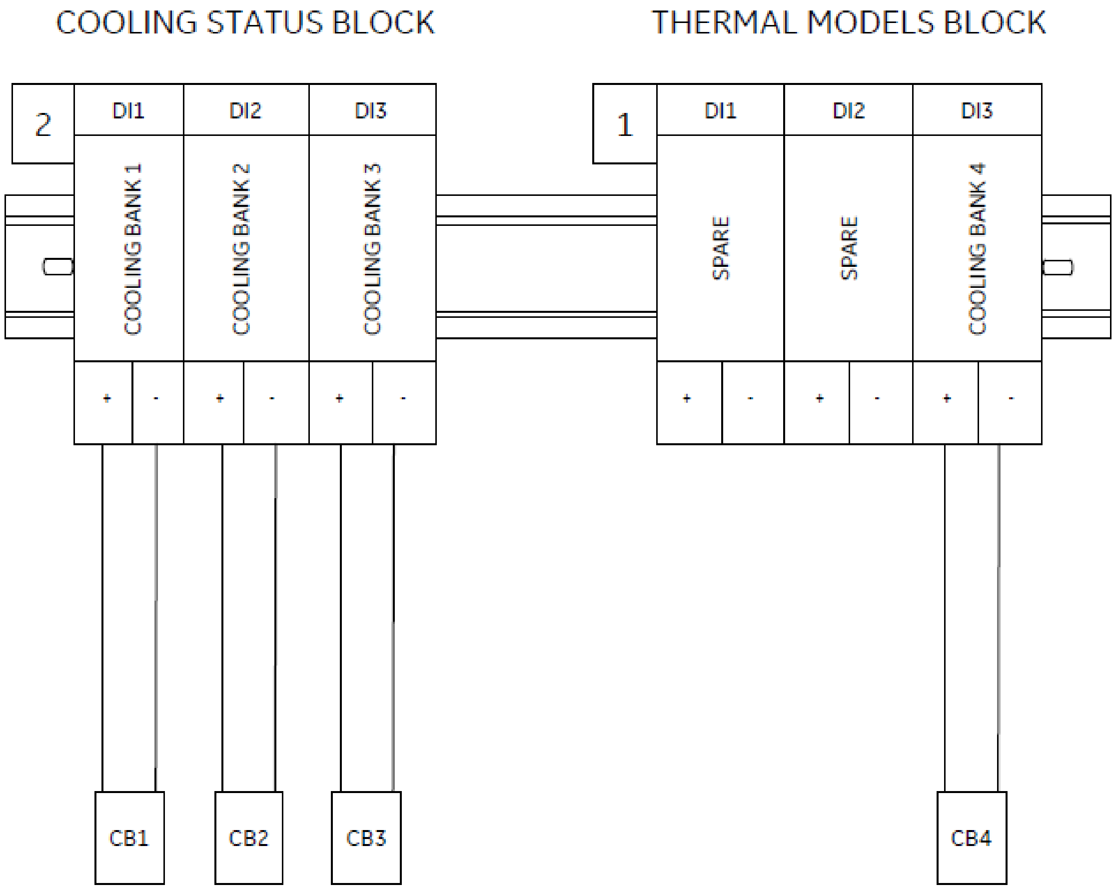


Figure 7-2: Cooling Banks – digital inputs (25 mA max & 24 V max)

8 CARD OPTION #3: OLTC MONITOR

The OLTC card option is designed to monitor one OLTC and integrates data from several sources. The OLTC tap position is monitored by either measuring the resistance of the OLTC resistor wheel or by an available 4-20 mA current loop. Two 4-20 mA current loop temperature sensors provide the transformer main tank top oil temperature and the OLTC temperature. An active power consumption converter measures power drawn by the OLTC motor and supplies this data as a 4-20 mA input to the monitor.

DGA 900 Plus products with an OLTC card enabled must undergo OLTC commissioning as detailed in Section 10.3. The installation and commissioning of the OLTC monitor must be performed on a non-energised transformer.

After installing the Motor Power Converter, the OLTC Tap Position and OLTC Torque models must be left disabled (refer to 'Section 6.4: Models Activation and Status' in the 'MA-040 – DGA 900 Plus – Operator Guide') until commissioning is successfully completed.

8.1 Sensor Input Configuration

Table 8-1 lists all the inputs available to the OLTC Monitor. See Section 8.1.2.1 for wiring installation details.

Table 8-1: OLTC Monitor inputs

Input	Label	Sensor Type
AIN 13	spare	CT
AIN 14	OLTC Position	4-20 mA / RTD
AIN 15	OLTC Temperature	4-20 mA
AIN 16	Top Oil Temperature	4-20 mA
AIN 17	OLTC Torque	4-20 mA
AIN 18	spare	None / CT / 4-20 mA / RTD
DIN 7	spare	12-24 V
DIN 8	spare	12-24 V
DIN 9	spare	12-24 V

Note: The top oil temperature sensor must not be installed if a thermal card top-oil temperature is already available (from Option 1 Thermal Models as described in Section 6).

8.1.1 Tap Position Sensor

The tap position input comes from a customer-supplied potentiometer or other 4-20 mA sensor capable of supplying a position input.

8.1.2 Motor Torque Measurement

Measurement of the OLTC motor torque depends on whether there is a three phase or single-phase motor circuit.

The OLTC Monitor requires the wiring of two temperature sensors, a tap position tracker and a Motor Torque Converter. If the Thermal Models is also installed, the Top Oil Temperature is already available and the Top Oil Temperature sensor for the OLTC Monitor must not be installed.

The OLTC Temperature sensor must be installed on a surface whose other side is in contact with the OLTC oil.

The tap position input can be provided either from a resistor wheel (10 Ω per tap change) or from a 4-20 mA current loop. The OLTC Monitor wiring is shown in Figure 8-1.

8.1.2.1 Wiring (three phase)

The OLTC motor torque requires the installation of an active power measuring converter (AD-LU 410, herein referred to as the Power Converter) to provide the monitor with a 4-20 mA input. See Section 8.2 for more details.

The transformer must be de-energised and grounded before starting the installation of the OLTC Monitor.

It is recommended that the Motor Torque Converter is installed in the OLTC motor cabinet housing as per the wiring shown in Figure 8-5. The Motor Torque Converter requires a power supply of 20-253 V DC or 30-253 V AC (50-60Hz).

The 4-20 mA output must be connected to the product as shown in Figure 8-1. It is recommended to use a shielded pair 22 AWG.

Once the Motor Torque Converter has been installed and connected to the product, both the Motor Torque converter and the product must be switched on to validate and commission the input signals from the OLTC Position and OLTC Motor Torque Converter (whilst the transformer remains de-energised).

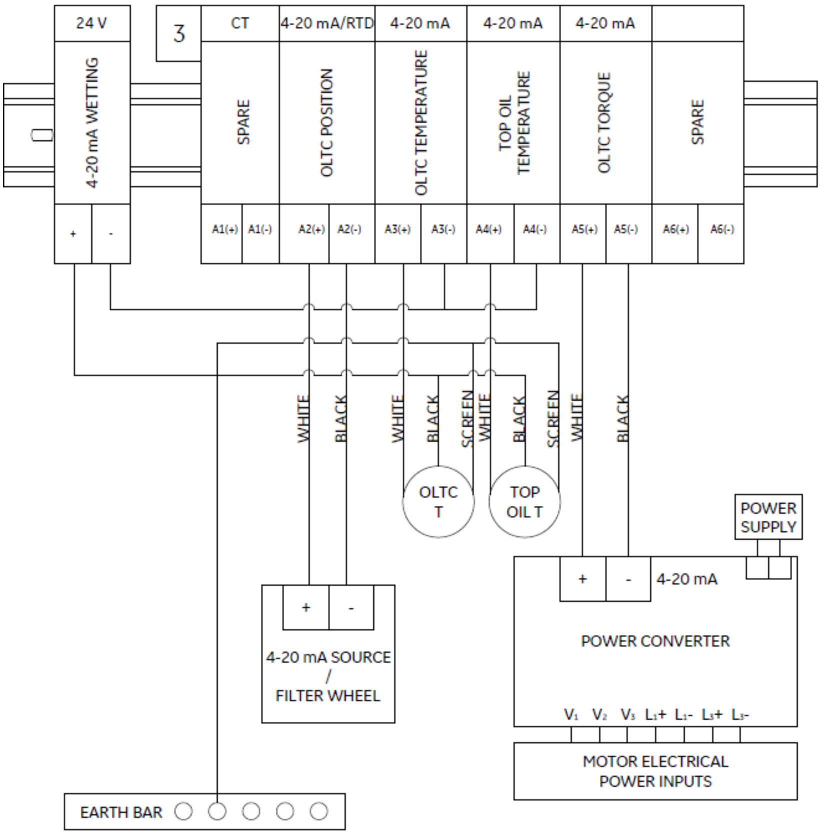


Figure 8-1: OLTC Monitor wiring – three phase

Note: Top oil temperature isn't installed if the top oil temperature of the thermal card is available.

Note: See Section 8.2 for the Power converter wiring.

8.1.2.2 Wiring (single phase AC only)

The OLTC motor torque requires the installation of a loop-powered split core CT to provide the product with a 4-20 mA input. Figure 8-2 shows the wiring plan and the 4-20 mA output connected to the product.

Note: Contact GE for specific details on the implementation. The installation position within the motor circuit does depend on the configuration, for example, if DC braking is deployed.

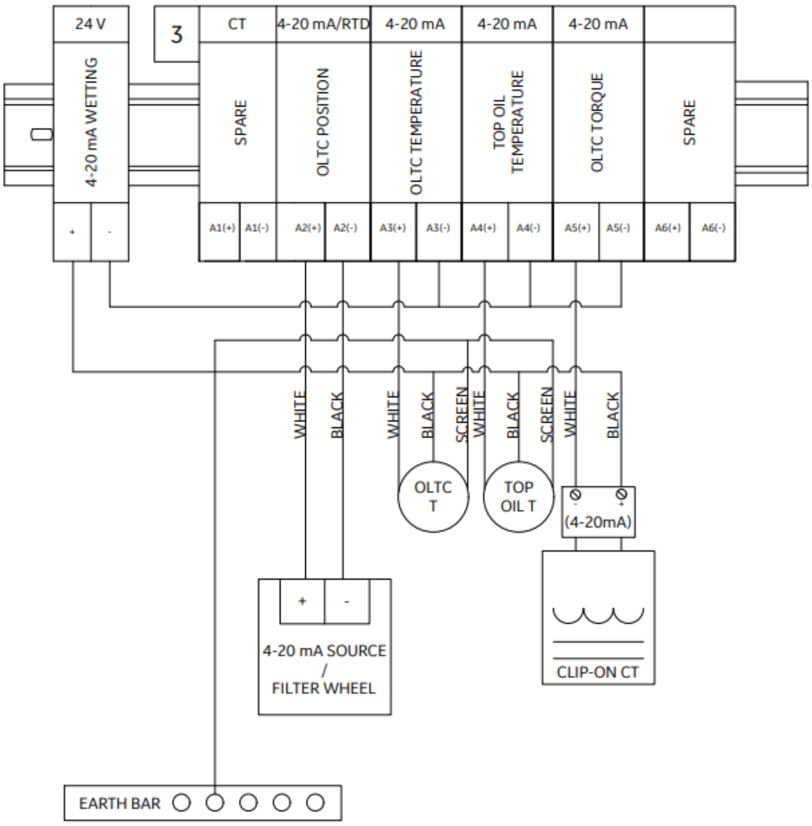


Figure 8-2: OLTC Monitor wiring – single phase

8.1.2.2.1 CT Specification

Response Time: <160 ms

Primary Nominal Current range: > Motor Nominal Current Consumption

8.2 Motor Power Converter

The active power measuring converter module as shown in Figure 8-3 is wired in line with the OLTC motor in the relevant control cabinet and provides a 4-20 mA output.

Figure 8-3: Power Converter

The specification and dimensions for the Power Converter are shown in Figure 8-4.

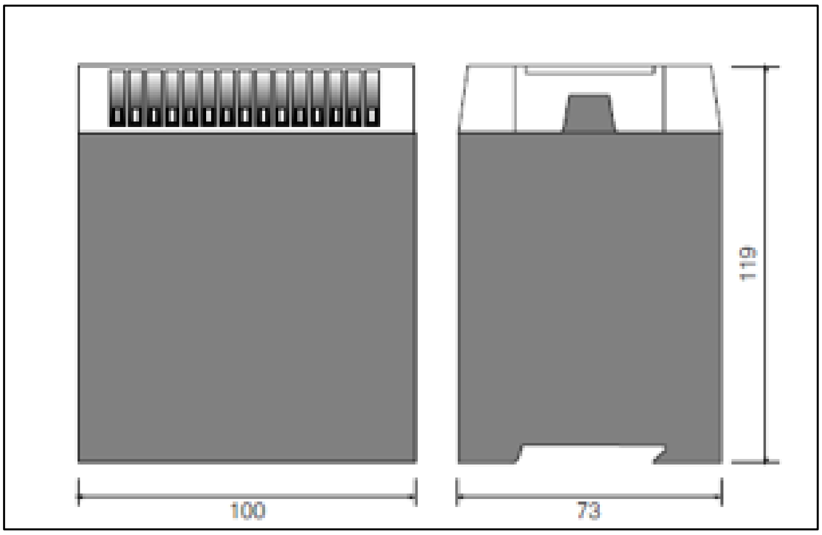


Figure 8-4: Power Converter – specifications & dimensions

The connection point of the tap changer power converter is typically located in the OLTC control cabinet close to the motor.

Note: The wiring of the tap changer motor drive must be extended to accommodate the Power converter.

To connect the power converter to the OLTC motor, use the wiring diagram shown in Figure 8-5. To connect the power converter in the OLTC to the DGA 900 Hub module, use standard twisted pair cable for the 4-20 mA input.

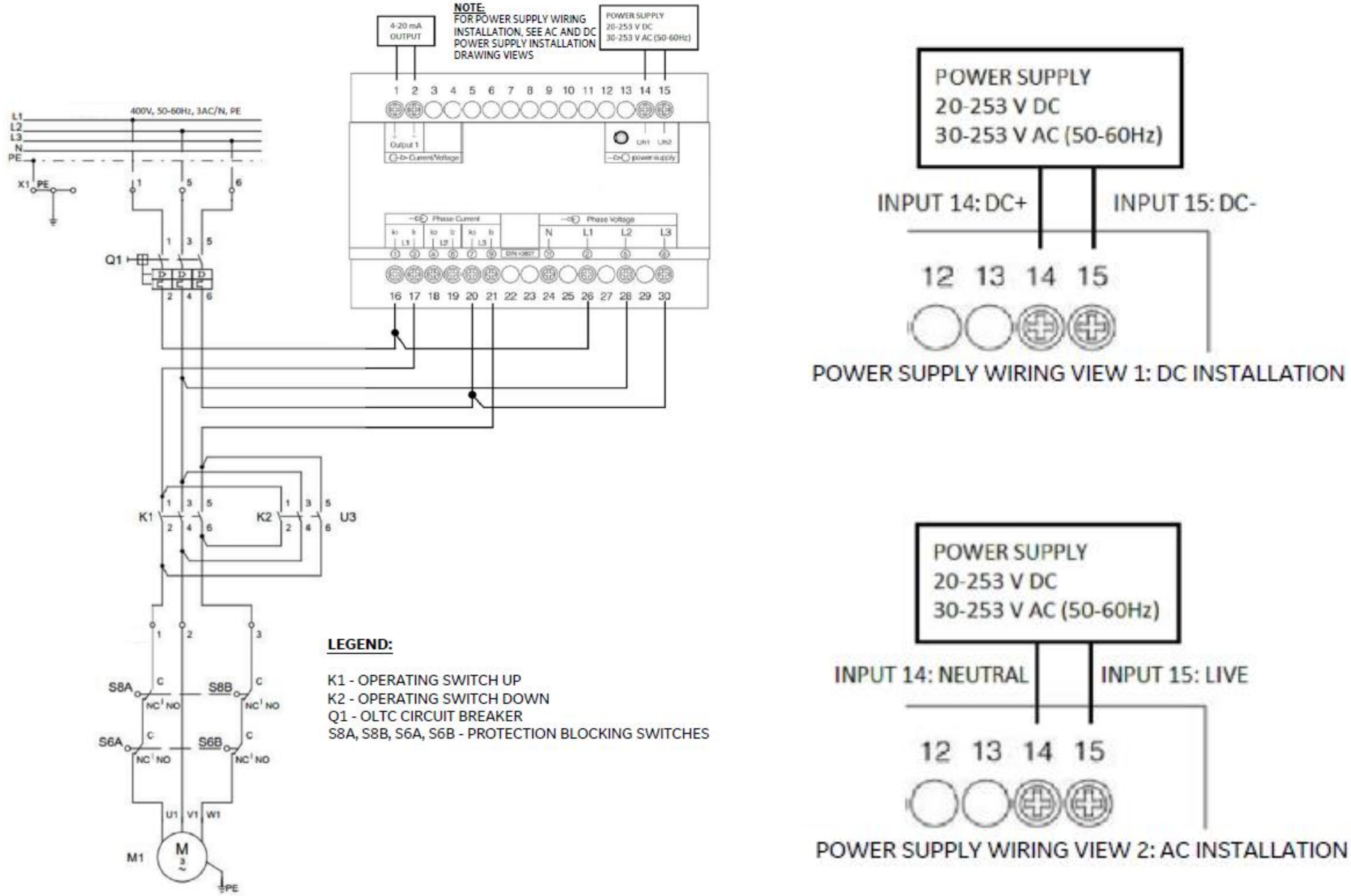


Figure 8-5: Power Converter – wiring example

After installing the Motor Power Converter, the OLTC Tap Position and OLTC Torque models must be left disabled (refer to ‘Section 6.4: Models Activation and Status’ in the ‘MA-040 – DGA 900 Plus – Operator Guide’) until commissioning is successfully completed.

9 CARD OPTION #4: BUSHING & PD MONITOR

The Bushing & PD card:

- measures the condition of transformer bushings (through changes in Capacitance and Power Factor) for one or two sets of three bushings in a single three-phase transformer, or three single-phase transformers.
- detects any Partial Discharges (PD) activity in the transformer main tank (measured as high frequency pulses).

This option uses the following adaptors and sensors:

- Three Bushing Adaptors (Primary input) connected to the tapping point of the bushings being monitored.
- (Optional) Three Bushing Adaptors (Secondary input) connected to the tapping point of a second set of bushings being monitored.
- Three High Frequency Current Transformer (HFCT) sensors at the transformer(s) neutral (if applicable).
- Three magnetically-mounted temperature sensors (MMTS) mounted on the transformer tank(s) to measure the transformer top oil temperature (if applicable).

All commissioning details are found in Section 10.4. Refer to the 'MA-040 – DGA 900 Plus – Operator Guide' for all other operational details relating to the software interface for configuration, bushing settings, data readings and alarms.

Note: A complete list of parts and tools required for the Bushing & PD monitor installation is given in Appendix A.

9.1 Installation Layout

WARNING: Do not attempt to install the product unless the transformer is de-energised and switched off.

WARNING: Ensure that the HV and LV bushings are grounded before installation of the product.

The product should not be mounted where it may interfere with the transformer cooling system or maintenance activities.

Contact GE Technical Support before mounting the product directly on the transformer.

See Section 7 of the standard MA-024 DGA 900 Installation Manual for further guidance on mounting and location advice.

Figure 9-1 illustrates the general installation layout of a DGA 900 Plus with the required connections for a single transformer.

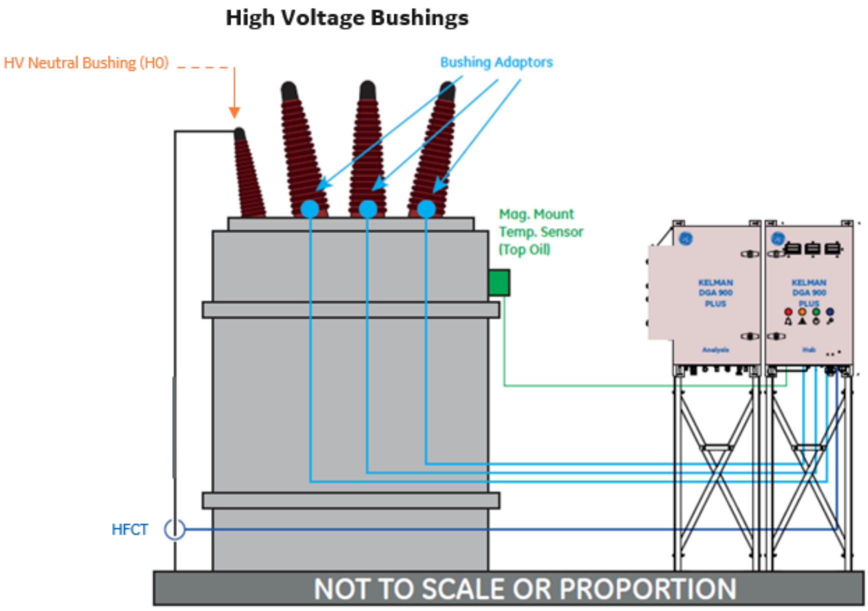


Figure 9-1: General installation layout – single transformer

Figure 9-2 illustrates the general installation layout of a DGA 900 Plus with the required connections for a bank of three single phase transformers.

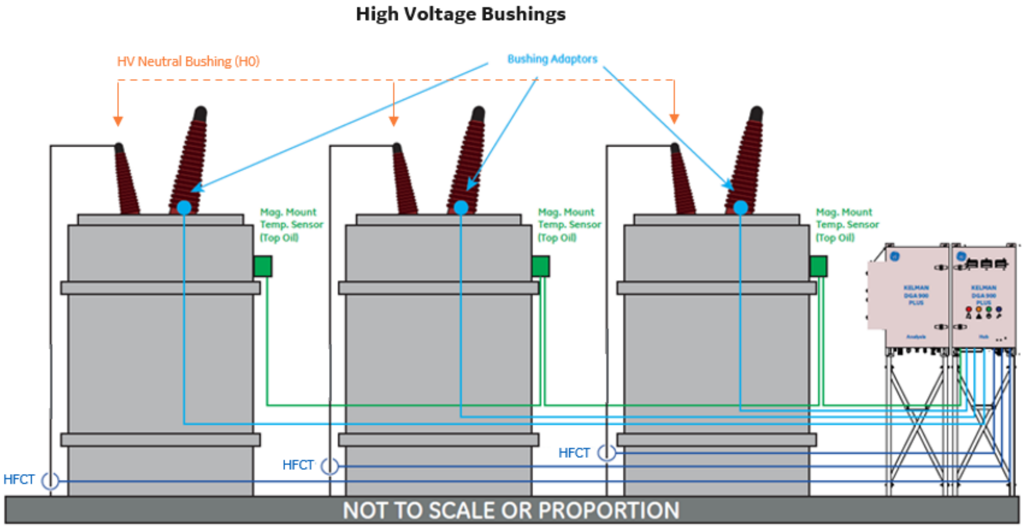


Figure 9-2: General installation layout – bank of 3 single phase transformers

9.2 Inside the Hub Module

The Hub module as shown in Figure 9-3 contains all the connectivity required for monitoring bushings & PD.

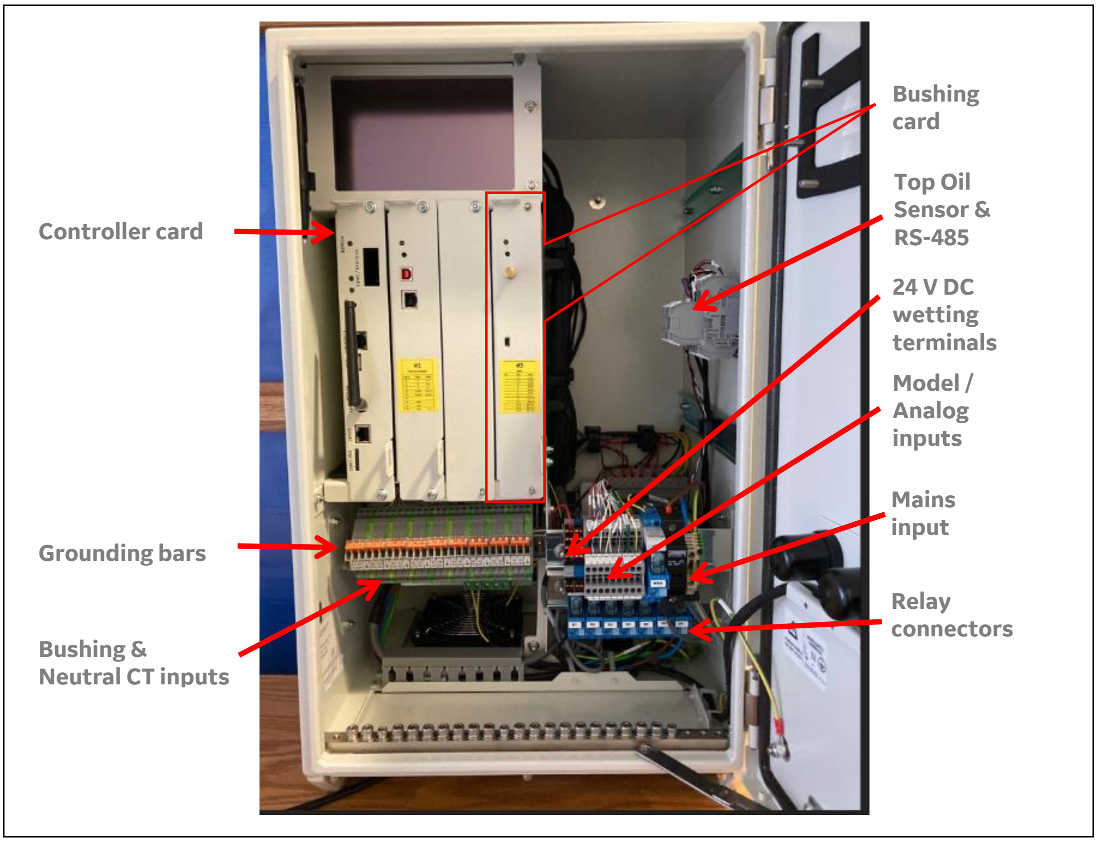


Figure 9-3: Hub module

Typically, the Bushing Monitor card is installed in slot 3 as shown in Figure 9-40, but the card locations are interchangeable. See Section 0 for more general information on the other available card options and their configuration.

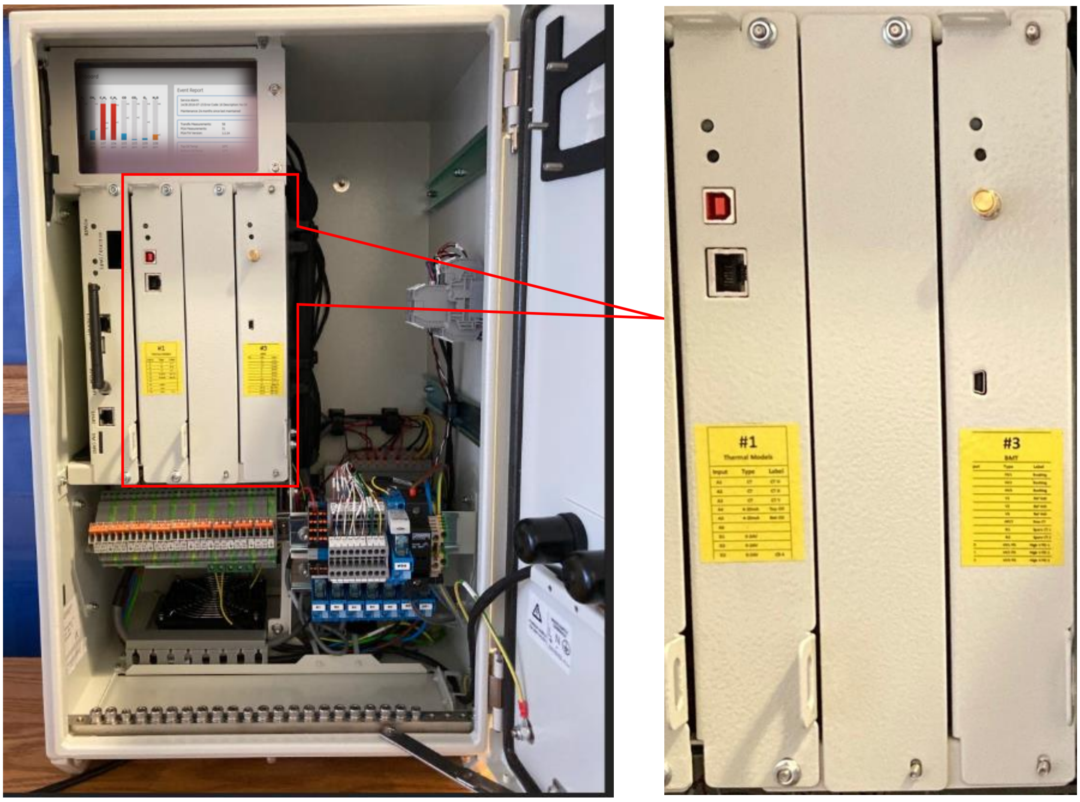


Figure 9-4: Hub module with Thermal Models and Bushing Monitor cards

9.3 Power & Communications

If possible, pre-install the power supply and communications cable connections from the intended product location to their sources. See Section 9.1 for the general installation layout.

A suitable circuit meeting the technical specification requirements must be available for the product at the time of installation. Installation must be done in accordance with local wiring regulations.

An external circuit breaker must be installed on the AC / DC source near to the product and within easy reach of the operator. It should be clearly labelled as the disconnecting device for the product.

Fuses and circuit breakers must be installed in accordance with the local and/or national wiring regulations.

Only use cables rated at 75 °C minimum for the installation.

ALL cables entering the cabinet should have at least 150 mm (6 in.) of excess length to allow for cable strain relief.

The outer sheath of the mains supply cable should continue into the equipment as far as possible so that reinforced insulation is maintained between the operator and mains supply.

The mains supply should be connected so that the protective earth wire should be the last wire to take the strain and break free in the event of the cord being pulled out of the cabinet. Tighten the cable gland to secure the cable.

9.4 Bushing Adaptors

Bushing Adaptors are supplied pre-assembled. An overview to the installation process is as follows:

- A pre-installation check is performed.
- A Bushing Adaptor circuit integrity test is performed.
- Conductive grease is applied to thread (threaded Bushing Adaptor only).
- The whole Bushing Adaptor is screwed into the bushing tapping point.
- The top cover of the Bushing Adaptor is removed leaving the body in place as illustrated in Figure 9-5.
- The cabling is attached through the top cover and O-ring.
- The top cover of the Bushing Adaptor is re-attached as illustrated in Figure 9-6.

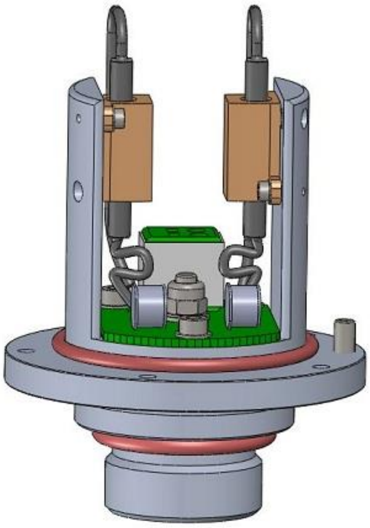


Figure 9-5: Bushing Adaptor – without top cover

Figure 9-6: Bushing Adaptor – with top cover

The rubber O-rings must not be contaminated with grease during the assembly process.

Both ends of the coaxial cables for the Bushing Adaptor and Neutral CT must be prepared and fitted with pin terminals as described in Section 9.4.1.1.

All coaxial cables from the Bushing Adaptors to the product cabinet *must* be run inside a protective electrically grounded metal conduit. See Appendix A.3 for recommended conduit and fittings.

If working at heights is required during the product installation, it is the responsibility of the installer to ensure that:

- planned work complies with national and site regulatory requirements.
- third-party equipment is suitable and safe before commencing work.
- third parties have received appropriate training for working at height. This includes, but is not limited to, 'Working at height' and 'Using Mobile Elevated Working Platforms'.

9.4.1 Bushing Adaptor Cables

All coaxial cables from the Bushing Adaptors to the product cabinet must be run inside a protective electrically grounded metal conduit.

All installation activity should take place in ambient temperatures greater than −10 °C (14 °F) to prevent damage to connectors and cabling because they may become brittle at extreme low temperatures.

When installing conduit to Bushing Adaptors, ensure that the conduit drops away from the Bushing Adaptor body.

Details of recommended conduit and fittings are listed in Appendix A.

All Bushing Adaptors and Neutral CT cables are routed into the Hub module. Each of these coaxial cables must be properly identified using cable markers provided with the installation kit (see Appendix A) as follows:

- Cable for Primary input from phase A Bushing Adaptor: P1
- Cable for Primary input from phase B Bushing Adaptor: P2
- Cable for Primary input from phase C Bushing Adaptor: P3
- Cable for Secondary input (if available) from phase A Bushing Adaptor: S1
- Cable for Secondary input (if available) from phase B Bushing Adaptor: S2
- Cable for Secondary input (if available) from phase C Bushing Adaptor: S3
- Cable from Neutral CT (three phase or single-phase A, if available): N1
- Cable from Neutral CT single phase B (if available): N2
- Cable from Neutral CT single phase C (if available): N3

9.4.1.1 Connecting Coaxial Cables

The marked Bushing Adaptor coaxial cables are connected to the corresponding terminals of the grounding switch inside the Hub module, such that the central wire is routed to the core side and the braid shield wire is routed to the shield side.

Follow these steps to connect the coaxial cables:

9.4.1.1.1 Routing the Coaxial Cables

1. Route the coaxial cables through the metal conduits from each Bushing Adaptor to the product cabinet as required.
2. On the cabinet side, the coaxial cables must be routed though the connector fittings at the bottom of the cabinet. Each cable can be up to 100 m and must be identified with cable markers.
3. All the coaxial cables must be connected to the Bushing Adaptor on one end and to the grounding switch inside the cabinet on the other end.

9.4.1.1.2 Required Materials & Tools

The materials listed in Table 9-1 are shipped with the product and are required for connecting the coaxial cables to the Bushing Adaptors and to the shorting switch.

Table 9-1: GE-supplied materials

Coaxial cable RG-58C/U 150m (500ft)	
Red pin terminals	
Qty	15

Heat shrink $^{3}/_{16}$ in. tubing 60 mm (2.4 in.) Heat shrink ¼ in. tubing 60 mm (2.4 in.)							
Cable markers							
Qty	6	6	8	6	6	6	6

The tool as shown in Table 9-2 is supplied by the customer and is recommended for preparing the coaxial cables.

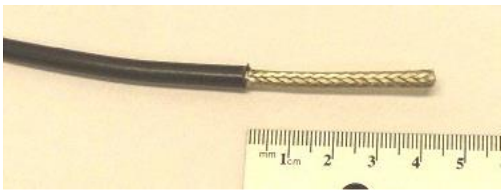
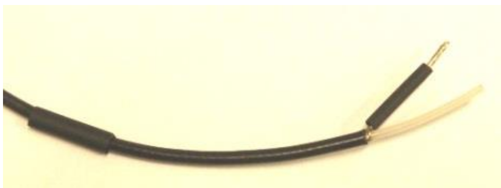
Table 9-2: Customer-supplied tools

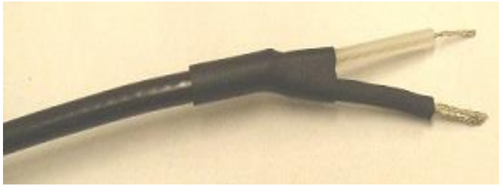
Heat gun	

9.4.1.1.3 Coaxial Cables Preparation

Each coaxial cable must be prepared on both ends (Bushing Adaptor and cabinet) as outlined in Table 9-3.

Table 9-3: Coaxial cable preparation

Steps	Visual
1. Cut the 3/16 in. heat shrink tubing. into pieces approximately 30 mm (1 ¼ in.) long. 2. Cut the ¼ in. heat shrink tubing into pieces approximately 30 mm (1 ¼ in.) long.	
3. Remove approximately 40 mm (1 ½ in.) of the outer jacket from the coaxial cable taking care not to cut the metallic braid.	
4. Un-strand the metallic braid shield and twist it together.	
5. First insert the ¼ in. tubing through the central conductor and shield. 6. Then insert the 3/16 in. tubing through the metallic braid.	

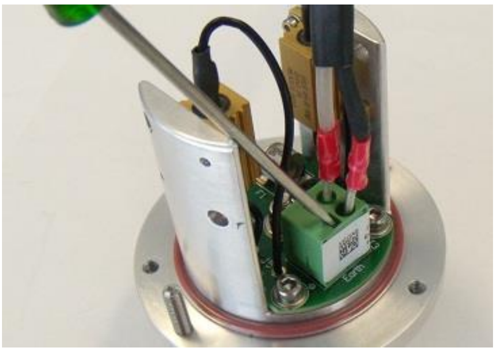
7. Use a heat gun to shrink the 3/16 in. tubing.	 
8. Then, insert the ¼ in. tubing to overlap about 15 mm (0.6 in.) over the metallic braid. 9. Use a heat gun to shrink the ¼ in. tubing. 10. Strip away about 7 mm (¼ in.) of insulation from the central conductor. Twist the strands together.	

9.4.1.1.4 Connecting to the Bushing Adaptor

At the Bushing Adaptor end, the coaxial cables must be terminated with two pin terminals as outlined in Table 9-4.

Table 9-4: Connecting to the Bushing Adaptor

Steps	Visual
1. Select two red pin terminals and the corresponding hand crimp tool.	
2. Insert the central conductor of the coaxial cable into one pin terminal and crimp that terminal. 3. Insert the braid shield into the second pin terminal and crimp that terminal. 4. The terminals must be double crimped (once on the bare wire and once on the insulation). Verify visually and by a pull test on the terminals.	

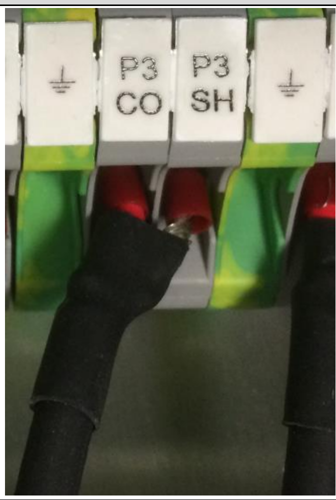
5. Insert the coaxial cable through the connector fitting of the Bushing Adaptor cover. 6. Connect the wires to connector J3 of the Bushing Adaptor board. 7. J3 is a spring-cage type connector. Open the terminal point with a small flat insulated screwdriver. 8. The central white wire must be inserted into the *inner* terminal. 9. The braid shield must be inserted into the *outer* terminal.	
10. A fully connected Bushing Adaptor is shown.	

At the cabinet end, repeat the steps 1-4 above and use the same pins to terminate the cable.

9.4.1.1.5 Connecting to the Grounding Switch

To connect to the grounding switch, follow the steps as outlined in Table 9-5.

Table 9-5: Connecting to the grounding switch

Steps	Visual
The central white wire must be connected to the core (CO) connector. The braid shield must be connected to the shield (SH) connector.	

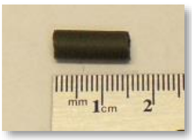
Repeat these steps for all input phases for the Bushing Adaptors and the Neutral CT(s).	

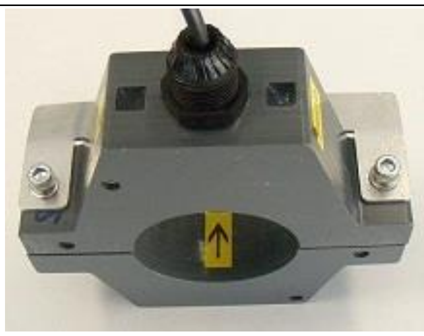
9.4.1.1.6 Connecting to the HFCT

To connect to the HFCT, follow the steps as outlined in Table 9-6.

Note: At the HFCT end, the coaxial cable does not require terminals.

Table 9-6: Connecting to the Neutral CT

Steps	Visual
1. Remove approximately 25 mm (1 in.) of the outer jacket from the coaxial cable (taking care not to cut the metallic braid).	
2. Un-strand the metallic braid shield and twist it together.	
3. Select one piece of heat shrink tubing $^{3}/_{16}$ in., about 15 mm (5/8 in.) long.	
4. Insert the tubing through the metallic braid and heat shrink the tubing. 5. Strip away about 7 mm (¼ in.) of insulation from the central conductor. Twist the strands together.	
6. Remove the connector fitting from the CT. 7. Insert the dome nut, fitting body and seal ring through the coaxial cable as shown.	

8. Connect the cable to the terminals of the HFCT. 9. The central white wire must be connected to the *core* side. 10. The braid shield must be connected to the *shield* side. 11. Tighten the set screws using a hex key wrench (1.5 mm).	
12. Screw the fitting body into the HFCT with the seal ring. Hold the wire to prevent it from twisting. Recommended torque is 3.75 N m (33 lb in). 13. Screw the dome nut tightly into place. Recommended torque is 2.50 N m (22 lb in). 14. The fitting and the nut must be sufficiently tight to prevent water ingress.	 

9.4.2 Install a Bushing Adaptor

The Bushing Adaptors are shipped with a plastic-threaded cap as shown in Figure 9-7.

Figure 9-7: Bushing Adaptor with cap

When removing the original test tap caps from the bushings, first check that they fit the plastic-threaded cap from the new bushing adapter. If it is a good fit, continue with the Bushing Adaptor installation. *If the original test tap cap does not fit the plastic-threaded cap, halt the installation and contact GE Technical Support*.

Note: See Section 9.8 for the test procedure on how to verify the circuit integrity of the Bushing Adaptor.

To install a Bushing Adaptor:

9.4.2.1 Check Bushing ID reference against Bushing Adaptor ID reference.

9.4.2.2 Remove the bushing test tap covers. The customer must retain the tap covers if in the future the bushings are to be decommissioned.

9.4.2.3 Place the O-ring in its seat as shown in Figure 9-6 to form a seal between the bushing adaptor and the tapping point surface.

Note: There are two spare O-rings supplied in the shipping package of each Bushing Adaptor. Store these safely for future use should the Bushing Adaptor need to be re-installed.

9.4.2.4 Apply the conductive grease to the bushing adaptor threads. The high temperature anti-seize carbon conductive grease (supplied with the installation kit) must reach all threads. To start, apply an even amount of grease to the first few threads as shown in Figure 9-8.

Figure 9-8: Bushing Adaptor with initial threads covered in grease

As the bushing adaptor is installed into the tapping point of the bushing, the grease will work its way down ensuring an even coating across all threads as shown in Figure 9-9.

Figure 9-9: Bushing Adaptor with all threads covered in grease

9.4.2.5 Screw the complete Bushing Adaptor into the tapping point of the bushing. First just hand-tighten to prevent thread damage.

9.4.2.6 Tighten the Bushing Adaptor to the required torque defined in the installation drawing (46-XXXX) provided with each Bushing Adaptor. It is important to tighten the Bushing Adaptor in steps of no greater than 20 N m (15 lb ft) until you reach the final torque requirement to minimise mechanical stress.

Note: A suitable torque wrench is specified in Table A-2: GE FSE-supplied items.

9.4.2.7 Finally, check that the resistance between the Bushing Adaptor body and the bushing tapping point remains less than 5 Ω.

9.4.2.8 Remove the Bushing Adaptor top cover.

Note: Suitable tools are specified in Table A-2: GE FSE-supplied items.

9.4.2.9 Install a liquid-tight fitting (as listed in Table A-3: Customer-supplied items) into the Bushing Adaptor top cover. Use a sealing gasket to ensure a liquid tight seal.

Note: The Bushing Adaptor thread for the liquid-tight fitting is ½ in. NPSM as illustrated in Figure 9-10.

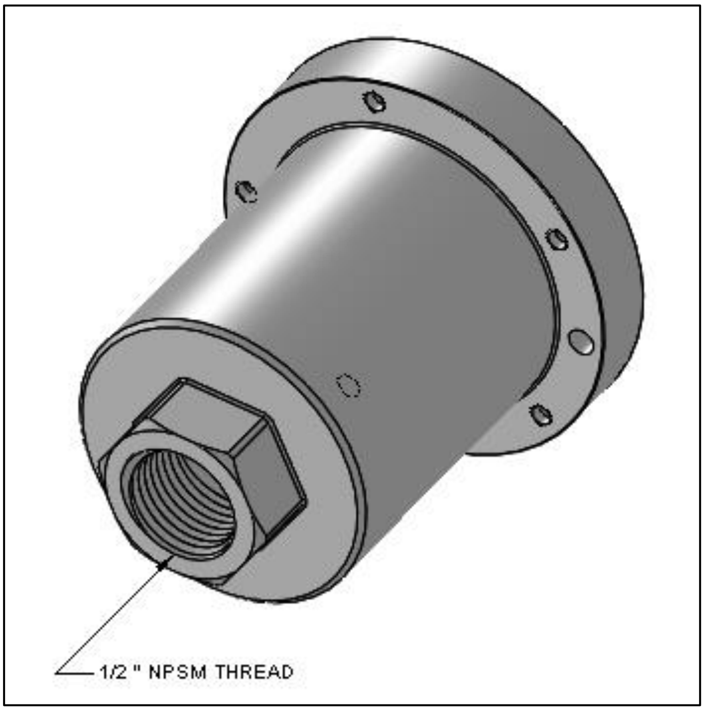


Figure 9-10: Liquid-tight fitting thread

9.4.2.10 Thread the end of the metal liquid tight conduit as well as the coaxial cable into the fitting. Terminate the conduit into the fitting carefully to form a liquid-tight assembly.

9.4.2.11 Place the O-ring in its seat for the cover (see Figure 9-5).

9.4.2.12 Connect the coaxial cable as outlined in Section 9.4.1.1.4.

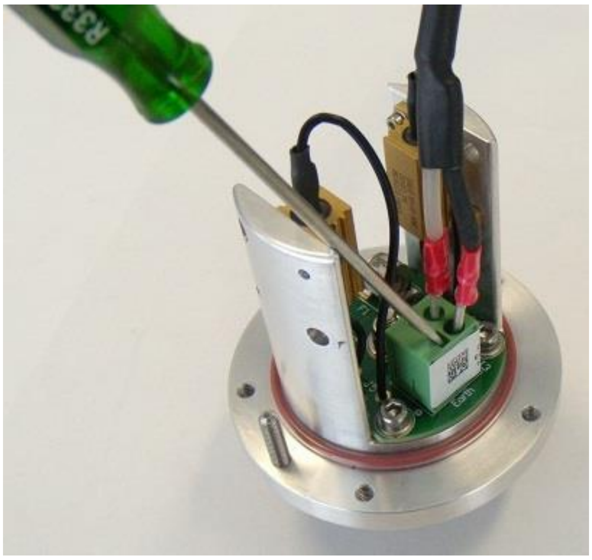


Figure 9-11: Bushing adaptor terminal block

⚠ Ensure that there is no tension or stress on the coaxial cable and that there is adequate cable inside the Bushing Adaptor to allow for strain relief of the coaxial cable.

9.4.2.13 Replace the Bushing Adaptor top cover on its seat and reassemble using the Allen key screws and/or locating keyway.

9.4.2.14 To compress the sealing O-ring evenly, tighten the five screws progressively working across the circle rather than around the circle of screws as illustrated in Figure 9-12. Tighten the screws to the torque specified in the installation drawing (46-XXXX) provided with each Bushing Adaptor.

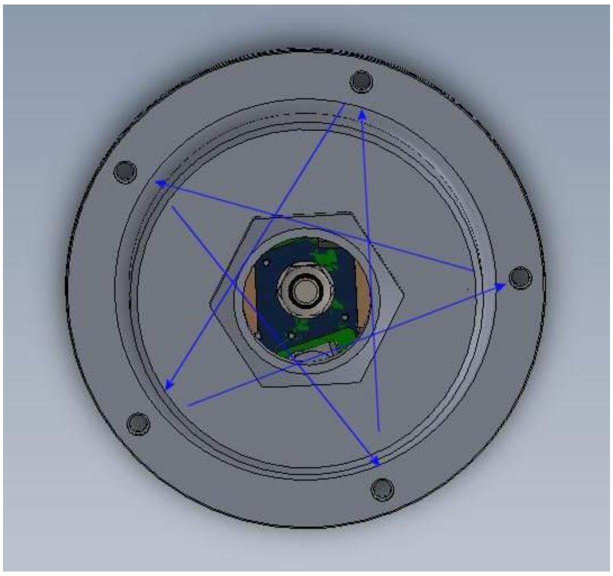


Figure 9-12: Tightening order

WARNING: Ensure that the Bushing Adaptor has been assembled carefully with the liquid tight fitting and conduit to form a liquid tight connection. Water ingress inside the bushing may result in catastrophic failure.

If the cabling is being routed as part of the pre-installation work, then ensure that the phase is properly identified on each coaxial cable.

Ensure that the serial number of the bushing adaptor matches the phase of the bushing to which it is connected. For the bushing mappings, refer to Section 10.3 Configuration in 'MA-040 – DGA 900 Plus – Operator Guide'.

It is crucial that the Bushing Adaptor circuit integrity tests in Section 9.8 are performed for each bushing.

9.5 High Frequency Current Transformer (HFCT)

WARNING: The HFCT must be installed on a ground cable or bar going from the high voltage neutral bushing (typically identified as H0) directly to ground. There must not be any open switches between the path to ground from the neutral bushing while the transformer is energized.

WARNING: If there is a switch on the path to ground from the high voltage neutral bushing as shown in Figure 9-13, the HFCT must **NOT** be installed between the switch and the neutral bushing, because if for any reason the switch is opened there will no longer be a direct path to ground causing a potentially hazardous condition.

WARNING: Prior to any test that requires the removal of the transformer neutral ground, any installed HFCT must first be removed. Replace the Neutral HFCT after the transformer ground has been reconnected.

Preparation of the coaxial cables is outlined in Section 9.4.1.1.3 and 9.4.1.1.6.

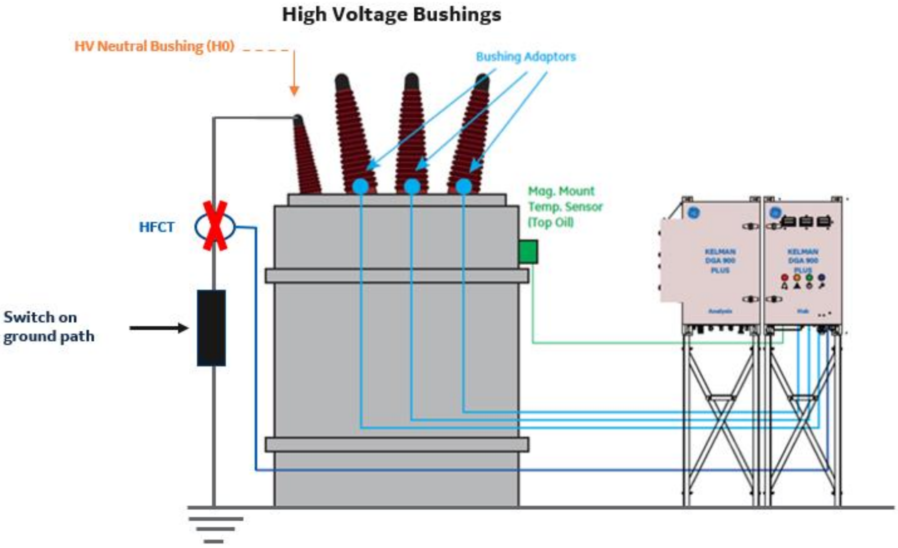


Figure 9-13: HFCT cannot be installed if a switch is on cable from the Neutral Bushing to ground

To minimise noise, the HFCT should be installed as close to the High Voltage Neutral bushing as possible provided there is no switch on path to ground as per the warning above. Figure 9-14 and Figure 9-15 show the correct installation of the HFCT.

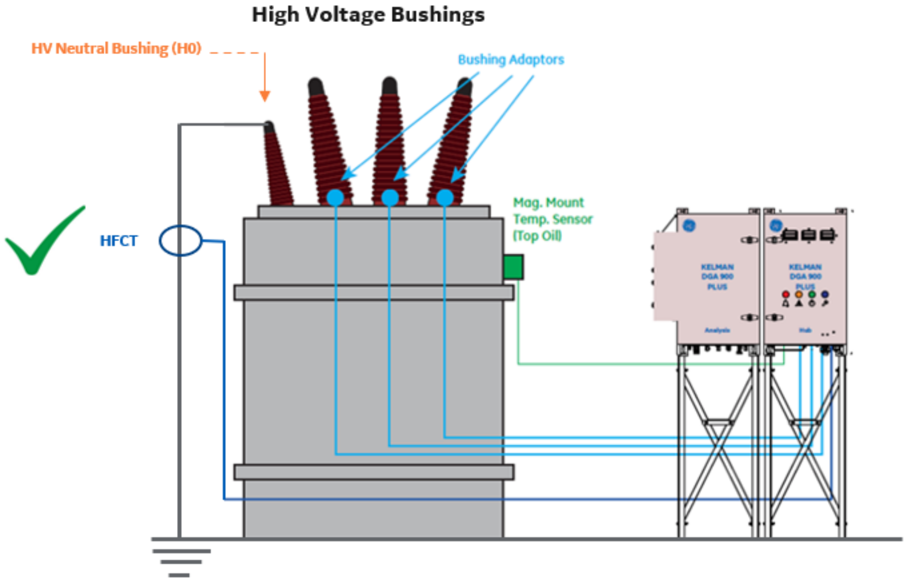


Figure 9-14: HFCT installed on cable from the Neutral Bushing (H0) directly to ground

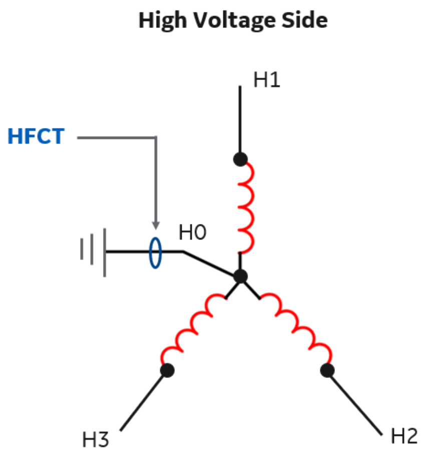


Figure 9-15: Star configuration (Y-Connection)

Similarly, in Figure 9-16, the HFCT can be installed after the switch. However, it should be understood if for any reason the switch is opened, the path to ground will be interrupted and the HFCT will have absolutely no positive affect, resulting in PD diagnostic capabilities being disabled.

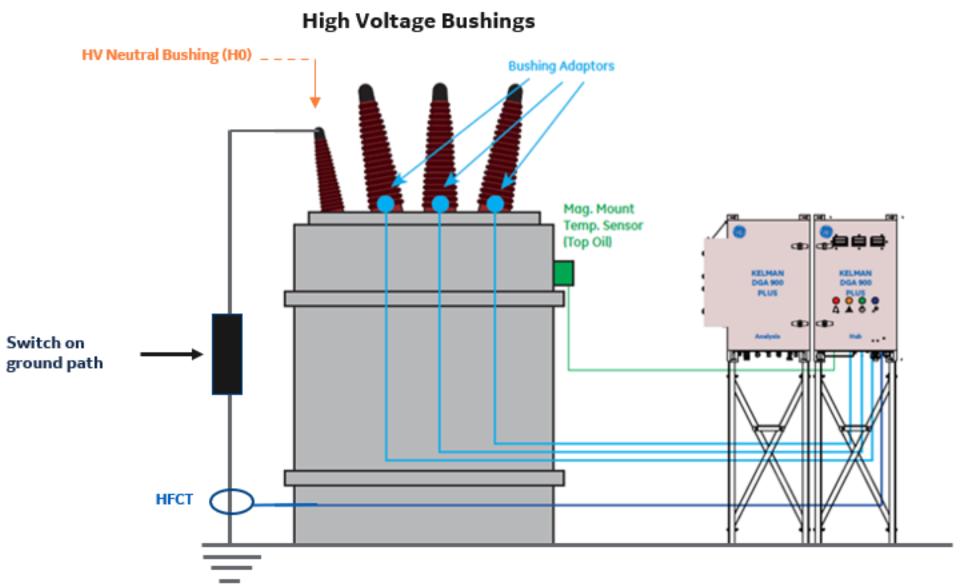


Figure 9-16: HFCT installed after the switch on cable from the Neutral Bushing to ground

The HFCT (if to be fitted) is specific to the transformer connection point (as provided in the pre-installation information). Fit the HFCT clamp to the neutral ground connection. An example is shown in Figure 9-17. Note: The Neutral CT arrow must point towards earth.

Figure 9-17: HFCT – example

As with the Bushing Adaptor cables, the Neutral CT cable should be routed through the conduit to the product cabinet. If the cable routing is carried out as part of a pre-installation activity, mark the cable end to identify it as the appropriate Neutral connection.

9.6 Magnetically Mounted Temperature Sensors

If working at heights is required during the product installation, it is the responsibility of the installer to ensure that:

- planned work complies with national and site regulatory requirements.
- third-party equipment is suitable and safe before commencing work.
- third parties have received appropriate training for working at height. This includes, but is not limited to, 'Working at height' and 'Using Mobile Elevated Working Platforms'.

The Thermal Compound and Silicone Safety Data Sheet guidelines must be followed.

The Magnetically-Mounted Temperature Sensor (MMTS) as shown in Figure 9-18 to Figure 9-20 should be attached at the top of the transformer to allow the top oil temperature to be monitored.

Figure 9-18: MMTS rear view

Figure 9-19: MMTS front view

Figure 9-20: MMTS side view - #1

To install the MMTS on a transformer:

- Apply a liberal amount of thermal compound (Wakefield Engineering Thermal Joint Compound 120 series, GE P/N: CONS01026) on the metal probe located in the centre as shown in Figure 9-18. Note: A lack of thermal compound degrades sensor performance.

- Apply RTV silicon sealant around the edge of the MMTS. This helps keep out moisture and aids in the adhesion. Note: No RTV silicon is supplied with the product.

If installing more than one MMTS, they must be wired in series ensuring that the *last* MMTS on the CANbus line is *MMTS #1*. Keep a record of which MMTS is installed to which single phase transformer so that the product can be commissioned accordingly. See Table 9-7: Results at the end of Section 9. MMTS #1 has a cable gland, a blanking plug and an internally fitted termination resistance on the PCB between H and L.

⚠ At installation, the MMTS should be oriented with the cable gland pointing down as shown in Figure 9-19. This will minimise the risk of water ingress to the sensors.

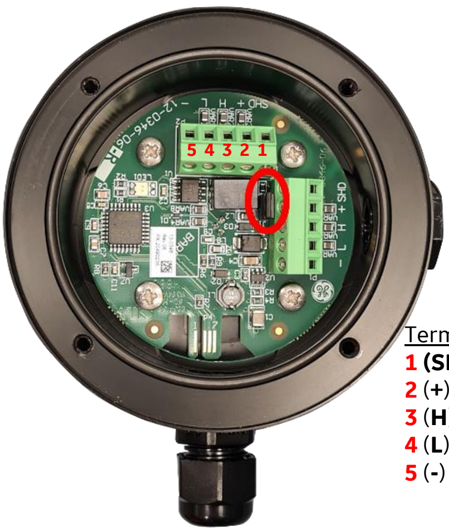
A 20-metre 4-wire CANbus cable (Belden 8729) is supplied with the product to connect the MMTS (see Appendix A).

Note: Additional cabling may have been purchased.

Route the cable from the MMTS(s) to the product cabinet, cutting as required. Figure 9-21 to Figure 9-22 illustrate the terminal connections inside the MMTS. Figure 9-24 shows the CANbus connection inside the cabinet.

Notes:

- The shield is connected to the ground of the CANbus terminal block (see Figure 9-24).
- It is advisable that the cables are run inside a plastic conduit to provide protection against mechanical damage.
- The cable must be properly inserted into the cable gland. The dome nut of the cable gland is torqued to a recommended 1.62 N m (14.4 lb in) using a torque wrench.



Terminal Key
1 (SHD) Shield
2 (**+**) 12 V DC (red)
3 (**H**) CANH (green)
4 (**L**) CANL (white)
5 (**-**) Ground (black)

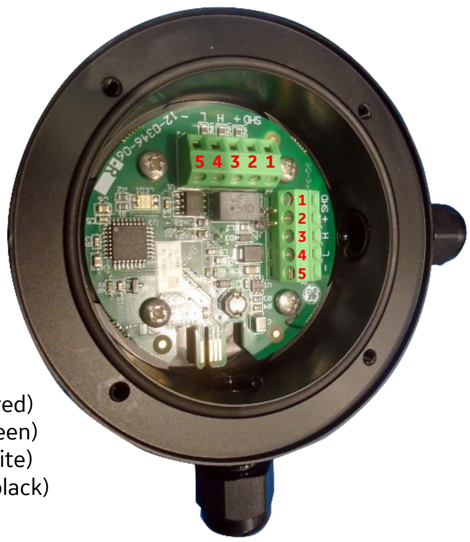


Figure 9-21: MMTS #1 with jumper

Figure 9-22: MMTS #2/3 without jumper

Ensure that the label number of the MMTS matches the phase / transformer to which it is mounted. For top oil mappings, refer to Section 10.1 General Settings in ‘MA-040 – DGA 900 Plus – Operator Guide’.

9.7 Cabinet Connections

Do not open the cabinet during inclement weather.

ALL cables entering the cabinet should have at least 150 mm (6 in.) of excess length to allow for cable strain relief.

Before connecting the Bushing Adaptor coaxial cables to the product cabinet, test that the ground connections have been made correctly. Verify that there is continuity from the shield of each of the Bushing Adaptor cables to the product cabinet ground terminal.

9.7.1 Bushing Adaptors & Neutral CT(s)

An overview of the Bushing Adaptor connections is shown in Figure 9-23. The input terminals for the coaxial cable connections are identified as, P1, P2, P3, S1, S2, S3 & N1, N2, N3 (Core and Shield). See Section 9.4.1 Bushing Adaptor Cables.

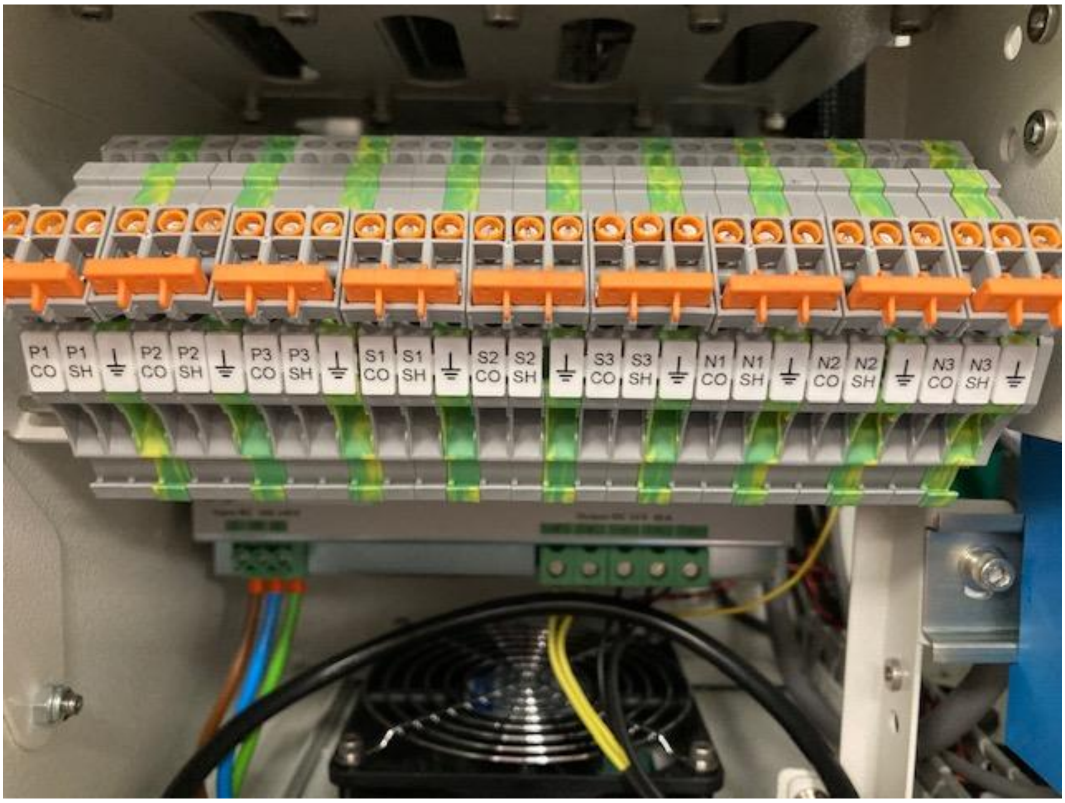


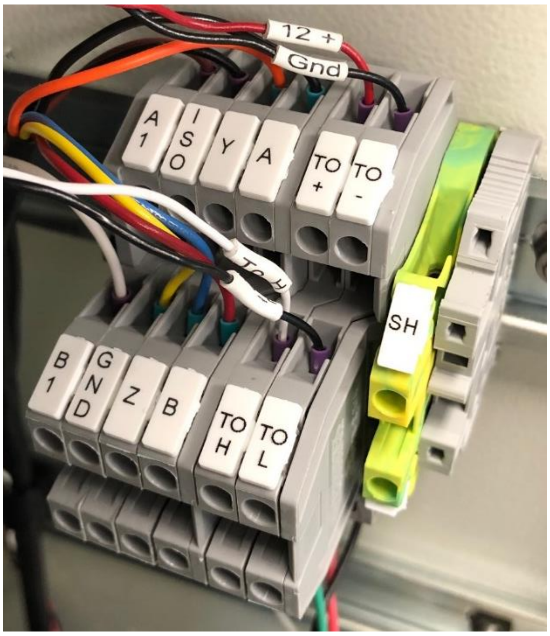
Figure 9-23: Bushing adaptor connections

The *rated* maximum *working* voltage that may be present on each phase is 5 V AC rms and the *rated* maximum current that may be present is 200 mA. The measurement category is CAT III for circuits that can be connected to any coaxial cable connection.

For connection of the Bushing Adaptors as well as the Neutral CT(s) to the grounding switch terminals, see Sections 9.4.1.1.5 and 9.4.1.1.6.

9.7.2 Magnetically-Mounted Temperature Sensors

The MMTS are connected to the CANbus connectors on the DIN rail. See Figure 9-3 for an overview to the key parts of the product and Figure 9-24 below for a more detailed look at the connection points.



Terminal Key
1 **(SHD)** Shield
2 (**+**) 12 V DC (red)
3 (**H**) CANH (green)
4 (**L**) CANL (white)
5 (**-**) Ground (black)

Figure 9-24: CANbus Connection on the DIN rail

Due to the inability to reach the MMTS(s) once the transformer is energised, communication with the sensor must be tested before the transformer is switched on (if power to the product is available). Refer to Section 10.4 'Live Measurement' of the 'MA-040 – DGA 900 Plus – Operator Guide' and check that the Field Sensors Error for Top Oil is not increasing by 1 every second and that the respective temperatures in the Field Sensors are within the expected range.

9.8 Bushing Adaptor Circuit Integrity Test Record

The Bushing Adaptor Circuit Integrity Test is to be performed upon installation, after periodic transformer maintenance or any bushing repair activities.

9.8.1 Required Material

- Antenna Analyser, RigExpert AA-170 model (>170 MHz)
- UHF to BNC adaptor
- Coax cable with BNC connector at one end and clips at the other end as shown in Figure 9-25.

Figure 9-25: Coax BNC to clips cable

- Two small flat screwdrivers or a 2-pin connector and a release key as shown in Figure 9-26.

Figure 9-26: Two-pin connector and release key

- USB cable with type B connector
- PC with AntScope software installed
- 50 Ω wire-through resistor
- Ohmmeter

9.8.2 Test Procedure

The RigExpert handheld antenna analyser is used to verify the electrical connection of the internal Bushing Adaptor. Before commencing the test:

Ensure that the transformer is switched off and properly grounded. The product must not be energised.

Close terminal inputs to isolate the signals from the device as shown in Figure 9-27.

Note: The calibration considers the waveguide between the measuring circuit and the load i.e. adaptor + cable + cable position.

Note: It is important to keep the cable straight between the RigExpert and the Bushing Adaptor during all the measurements.

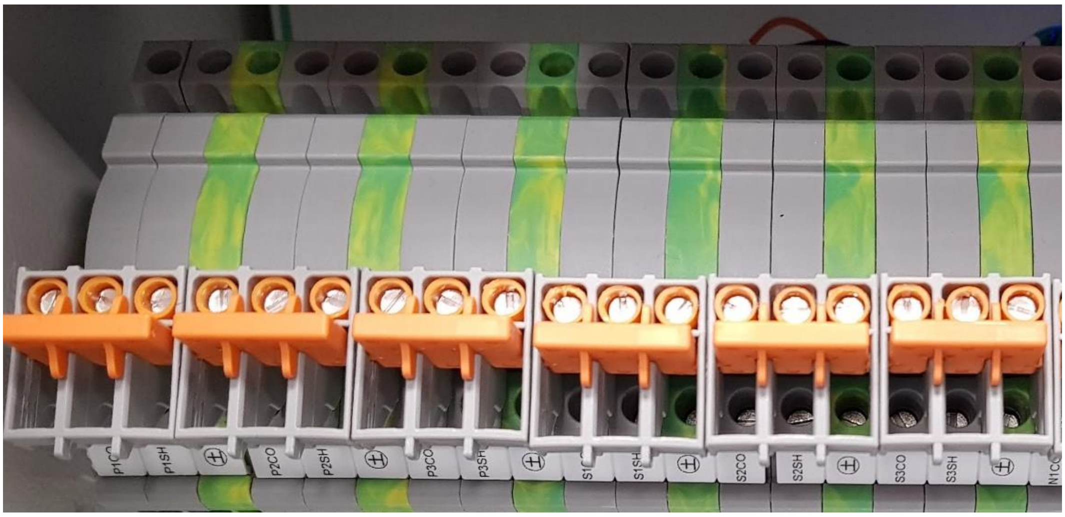


Figure 9-27: Primary and secondary switches closed to isolate signal

9.8.2.1 RigExpert Setup

Follow these steps to calibrate the RigExpert:

1. Create a new folder on the computer. Next create a subfolder for each Bushing Adaptor using its corresponding serial number as the name.

Note: These folders are used to save the data measured by the RigExpert.

2. Connect the RigExpert to the PC via the USB cable.
3. Power on the RigExpert.
4. Open the AntScope software.
5. Select **Configure** and choose **AA-170** as the antenna analyser model for the RigExpert as shown in Figure 9-28.

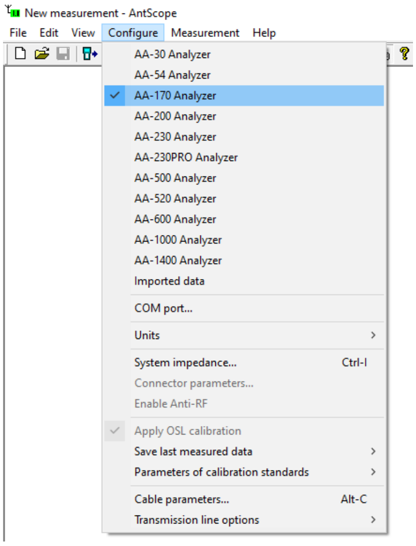


Figure 9-28: AntScope New measurement – Configure > AA-170 Analyzer

6. In Windows File Explorer, create a new folder for the installation of each Bushing Adaptor phase.

9.8.2.2 RigExpert Tests

9.8.2.2.1 Open Circuit Test

1. Place the coaxial cable so that during the calibration and the subsequent measurements minimal movement of the cable will occur. Leave the clips unconnected, i.e. open circuit, as shown in Figure 9-29.

Figure 9-29: Open calibration

2. Select **Measurement** > **Range** to configure the resolution and scan range. Select **Limits** and set the limits from `0` to `50,000` kHz. In the Resolution field, type `100` points and click **OK** as shown in Figure 9-30. A measurement will be triggered.

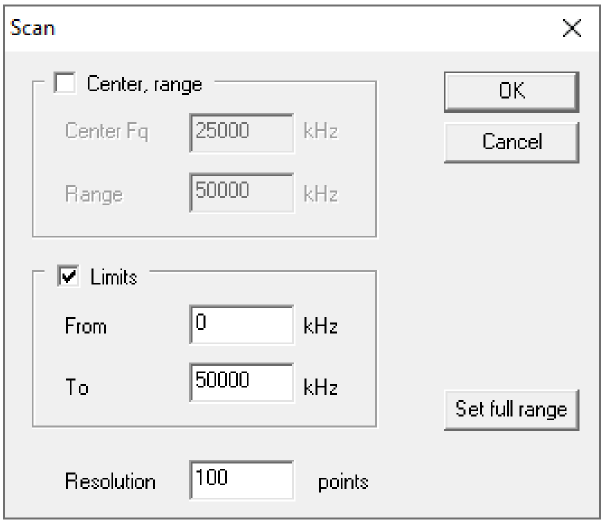


Figure 9-30: Limits scan range

The progress of the scan is displayed on the status bar (bottom left of the AntScope window). Wait until the scan is finished as shown in Figure 9-31.

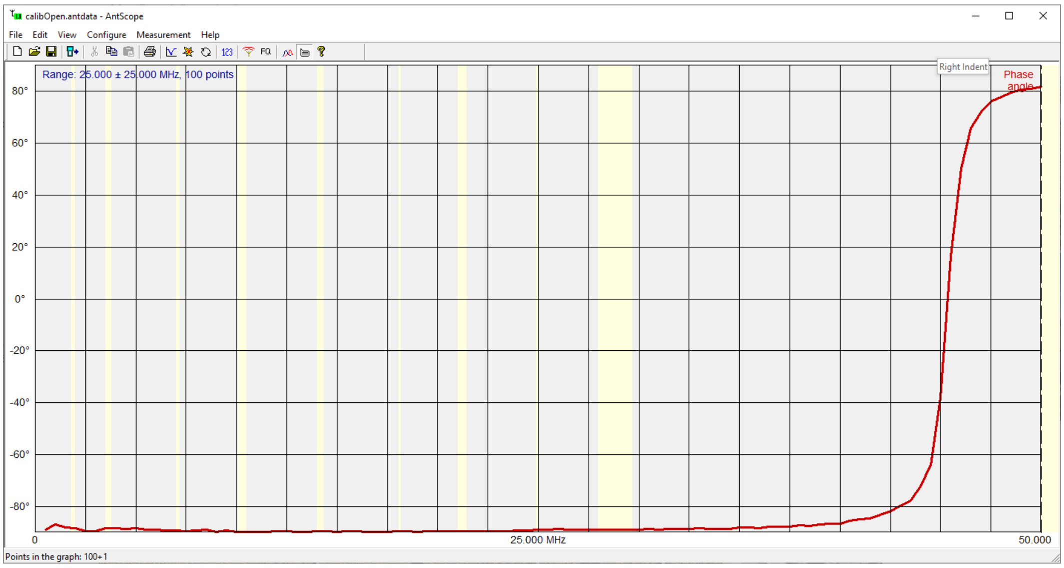


Figure 9-31: AntScope measurement - Open

3. To save the calibration, select **Configure > Save last measured data > as "open" Calibration** as shown in Figure 9-32.

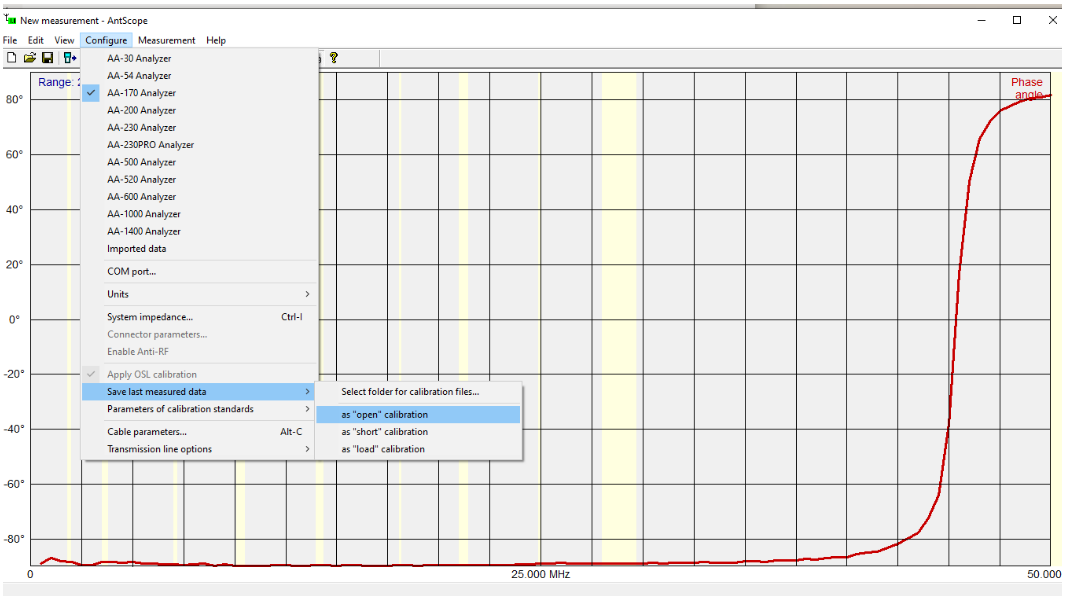


Figure 9-32: Configure > Save last measured data > as "open" calibration

4. Select **File** > **Save As** and type the filename `calibOpen` as shown in Figure 9-33.

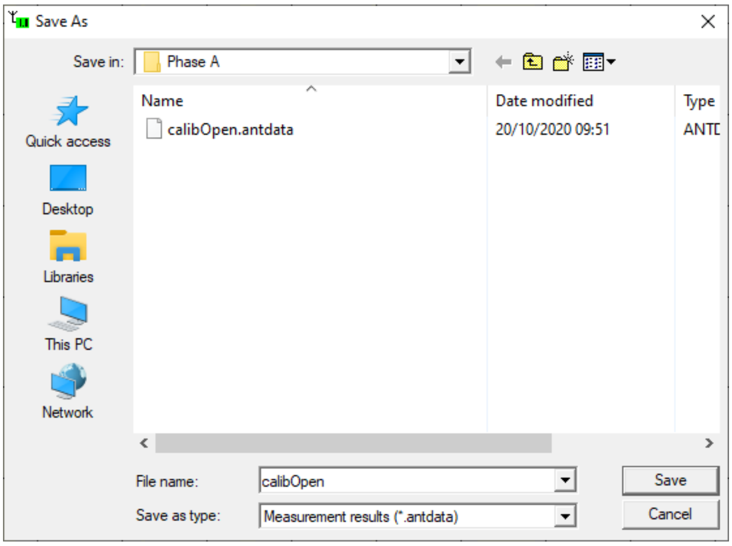


Figure 9-33: Save As "calibOpen"

9.8.2.2.2 Short Circuit Test

1. Connect the clips to each other as shown in Figure 9-34.

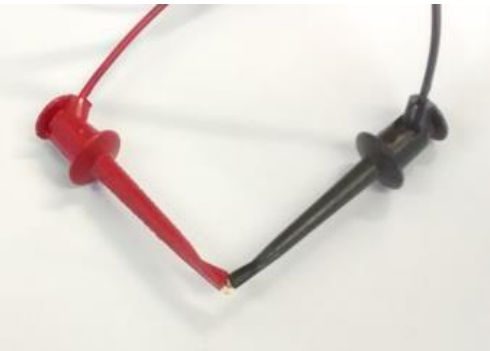


Figure 9-34: Short calibration

2. Click the 'Start/Stop Measurement' button  to start a measurement as shown in Figure 9-35.

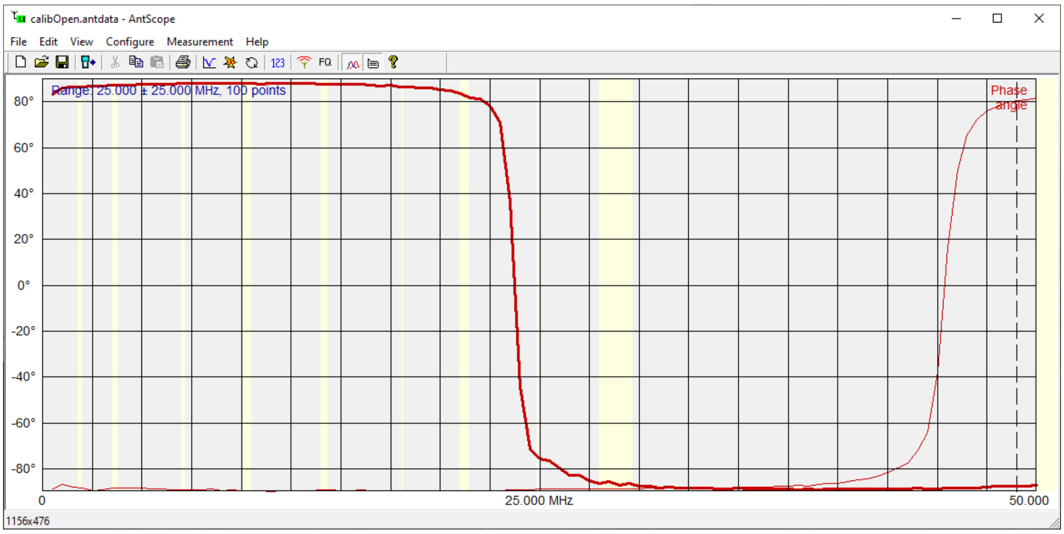


Figure 9-35: AntScope measurement - Short

3. Select **Configure > Save last measured data > as "short" calibration** as shown in Figure 9-36.

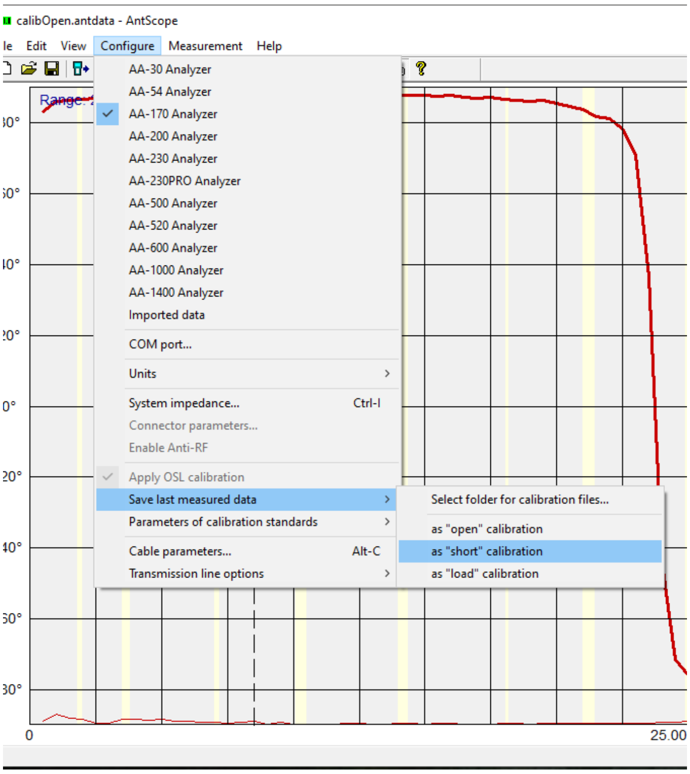


Figure 9-36: Configure > Save last measured data > as "short" calibration

4. Select **File > Save As** and type the filename `calibShort` as shown in Figure 9-37.

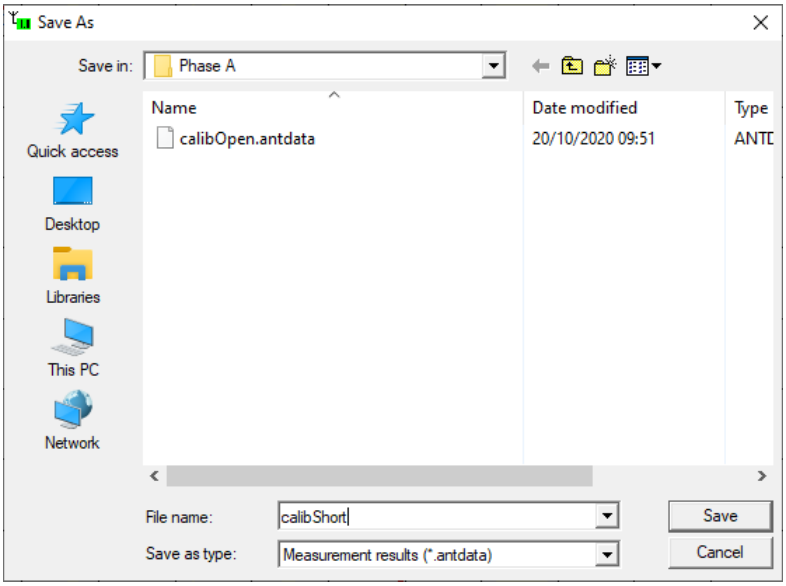


Figure 9-37: Save As "calibShort"

9.8.2.2.3 Load Test

1. Connect the 50 Ω resistor across the clips as shown in Figure 9-38.

Figure 9-38: Load calibration

2. Click the 'Start/Stop Measurement' button  to start a measurement as shown in Figure 9-39.

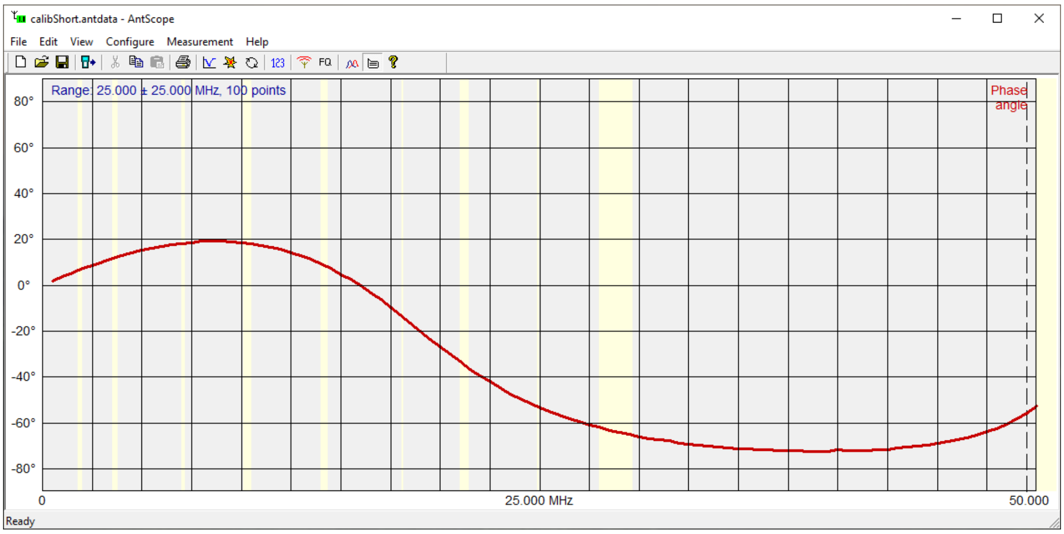


Figure 9-39: AntScope measurement - Load

3. Select **Configure > Save last measured data > as "load" calibration** as shown in Figure 9-40.

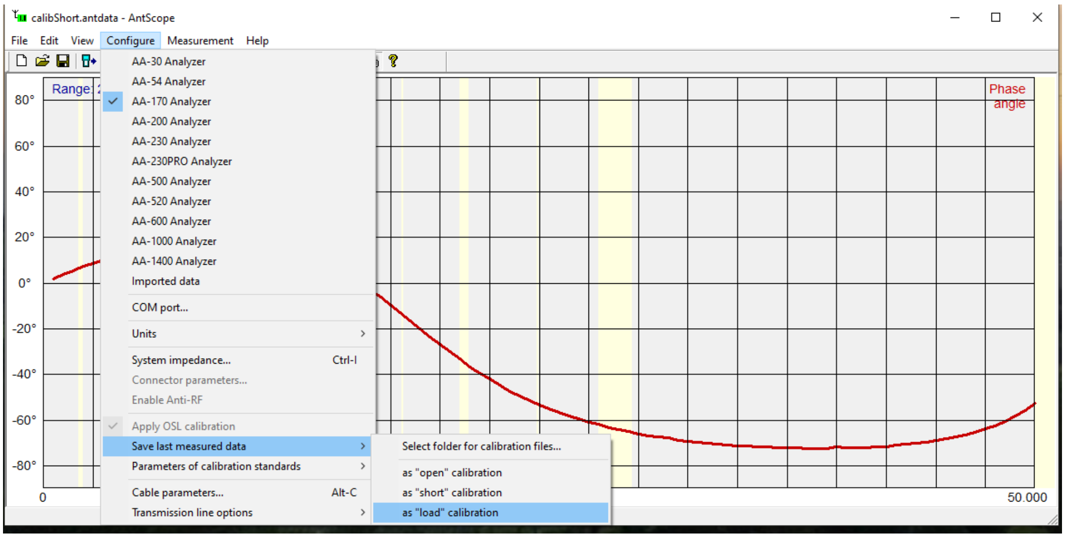


Figure 9-40: Configure > Save last measured data > as “load” calibration

4. Select **File > Save As** and type the filename `calibLoad` as shown in Figure 9-41 to save the data in the folder created in Section 9.8.2.1 for this Bushing Adaptor.

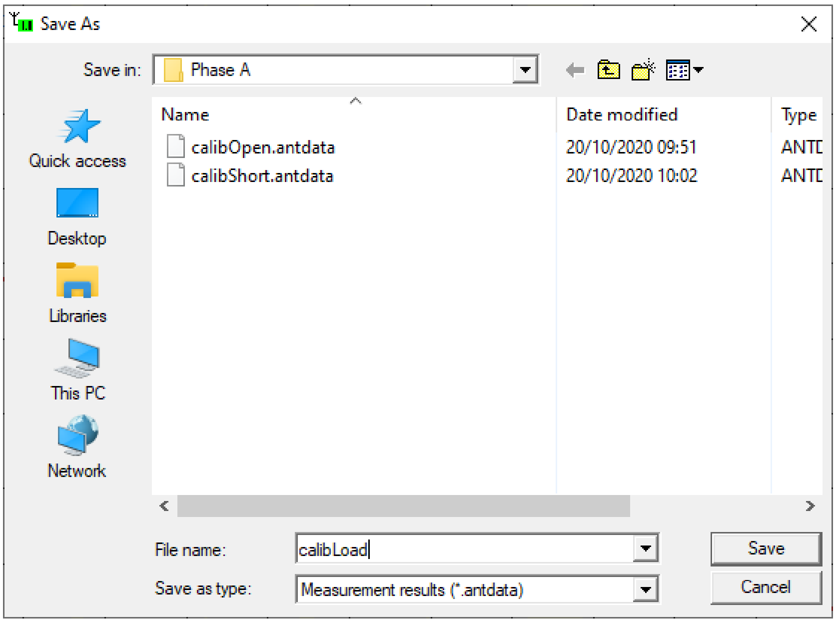


Figure 9-41: Save As “calibLoad”

9.8.2.2.4 Adaptor-only Test

1. Connect the clips to the Bushing Adaptor using the short cables in the adaptor’s connector as shown in Figure 9-42.

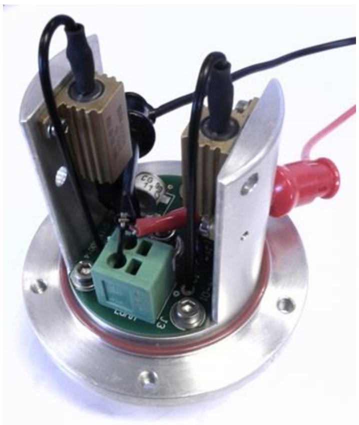


Figure 9-42: Bushing adaptor measurement

2. Click the 'Start/Stop Measurement' button  to start a measurement as shown in Figure 9-43.

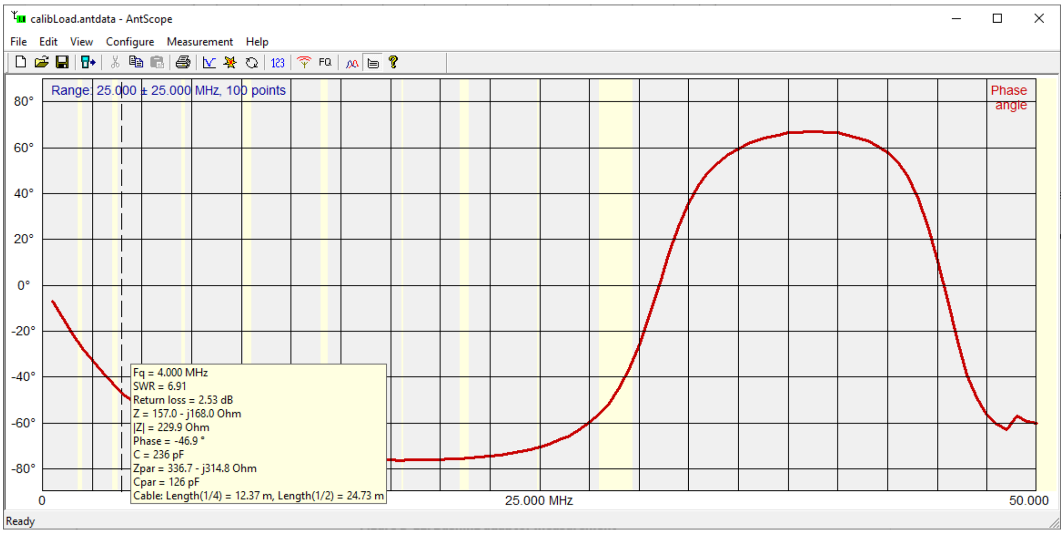


Figure 9-43: AntScope measurement - AdaptorOnly

3. Select **File > Save As** and type the filename `AdaptorOnly` as shown in Figure 9-44.

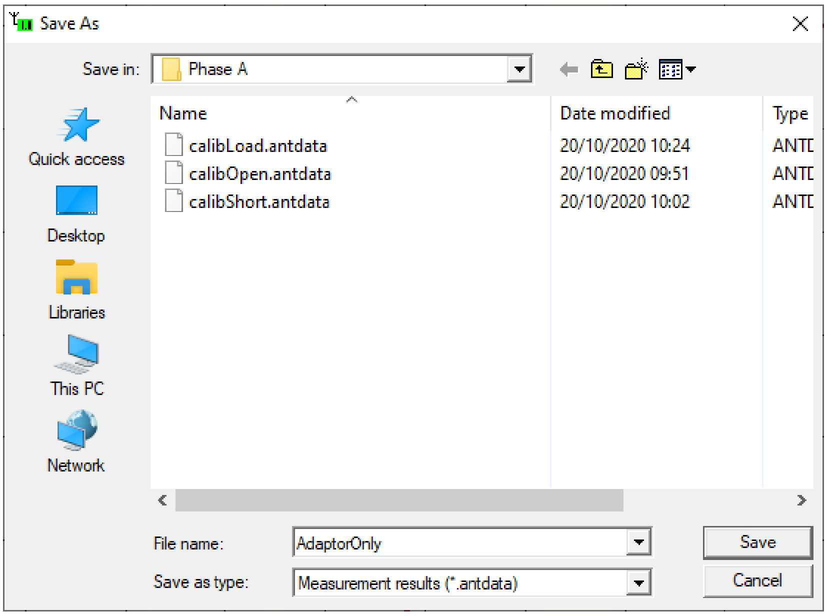


Figure 9-44: Save As "AdaptorOnly"

9.8.2.2.5 Adaptor Installed

1. Connect the Bushing Adaptor to the bushing tapping point as outlined in Section 9.4 Bushing Adaptors.
2. Click the 'Start/Stop Measurement' button  to start a measurement as shown in Figure 9-43.
3. Select **File > Save As** and type the filename `AdaptorInstalled` as shown in Figure 9-45.

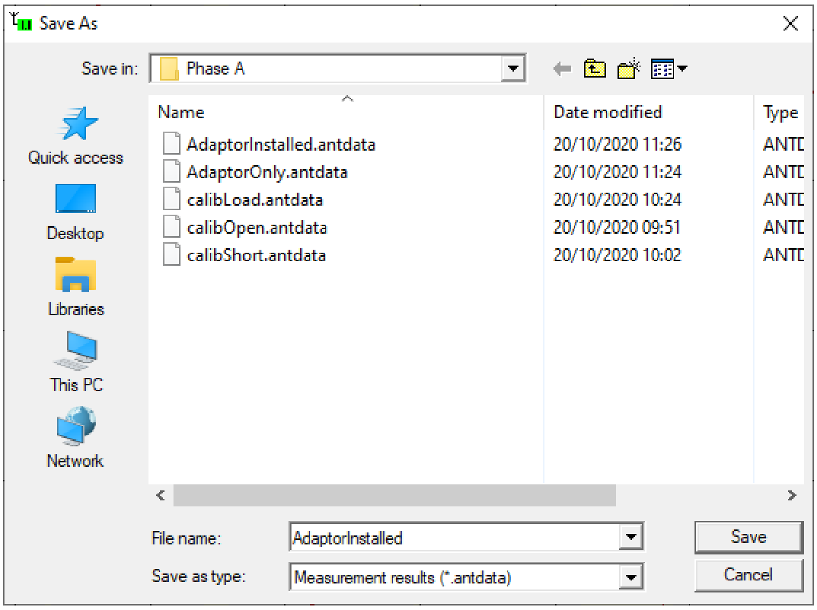


Figure 9-45: Save As "AdaptorInstalled"

4. Click the 'Show Previous' button  to compare the waveforms of both sets of data on the graph (the previous scan as well as the latest scan) as shown in Figure 9-46.

The internal pin of the Bushing Adaptor must make electrical contact with the bushing tapping point for a phase change to occur as demonstrated in the example shown in

Figure 9-46. Without electrical contact, the installation must be aborted, and the original test tap covers refitted.

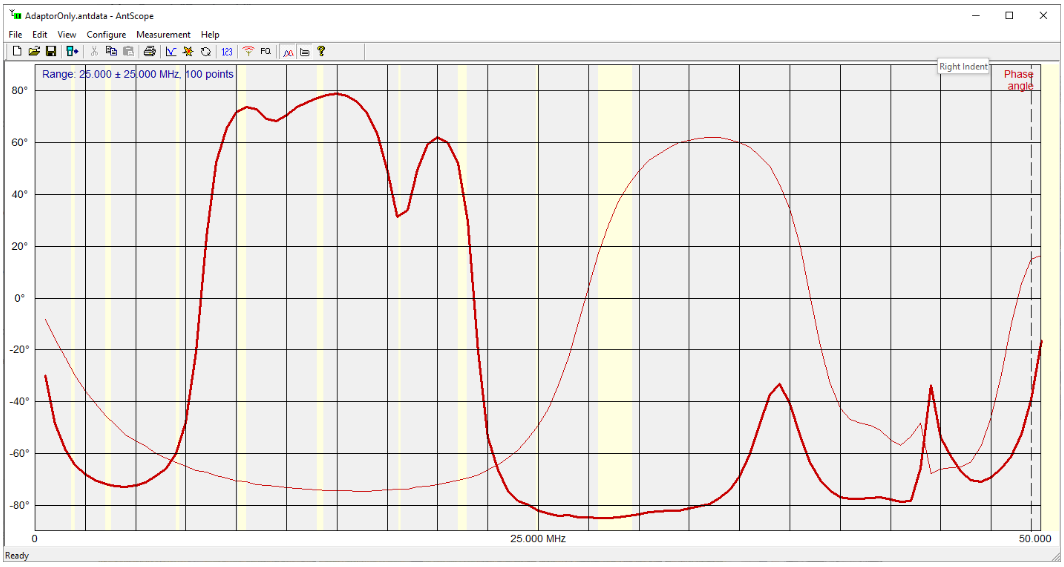


Figure 9-46: AntScope measurement - AdaptorInstalled

5. Move the cursor over −45° or as close as possible as shown in Figure 9-47. The Cpar (Capacitance parallel) will be the bushing capacitance stated on the nameplate (± 5%) or the last measured nominal value. In this example, the value is 550 pF as shown in Figure 9-47.

Figure 9-47: AntScope measurement – AdaptorInstalled (with Cpar measurement)

6. Repeat all the RigExpert test steps in Section 9.8.2.2 for each Bushing Adaptor installation on the transformer.

9.8.2.3 Bushing Nameplate Information

Record the bushing manufacturer nameplate information in Table 9-7: Results. For each bushing record the:

- Serial Number
- PF%
- C1

- C2
- Temperature

If possible, photograph the bushing nameplates. The bushing nameplate images must be stored with the field service installation report and the antenna analyser data.

Also record the following items in Table 9-7: Results:

- Bushing Adaptor ID.
- Phase that each MMTS has been fitted to during a three single phase installation.

9.8.2.4 Continuity Tests

Complete the following tests for each bushing installed and record the measurements in Table 9-7: Results

Before commencing the tests, ensure that the Hub and Analysis enclosures are earthed.

9.8.2.4.1 Shield to Ground Resistance Test

For each Bushing Adaptor input, test the continuity (resistance) between the coaxial cable shield and the ground terminal inside the cabinet as shown in Figure 9-48. It should be less than 5 Ω.

Record this measurement in Table 9-7: Results.

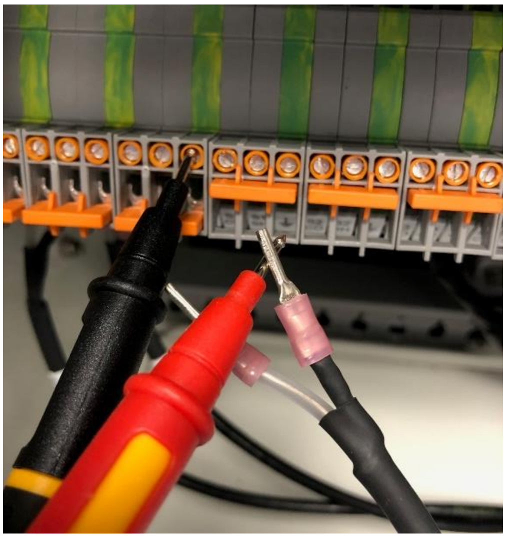


Figure 9-48: Resistance between cable shield and ground

9.8.2.4.2 Coaxial Cable Core and Shield Resistance Test

For each Bushing Adaptor, measure the resistance between the coaxial cable core and the shield as shown in Figure 9-49.

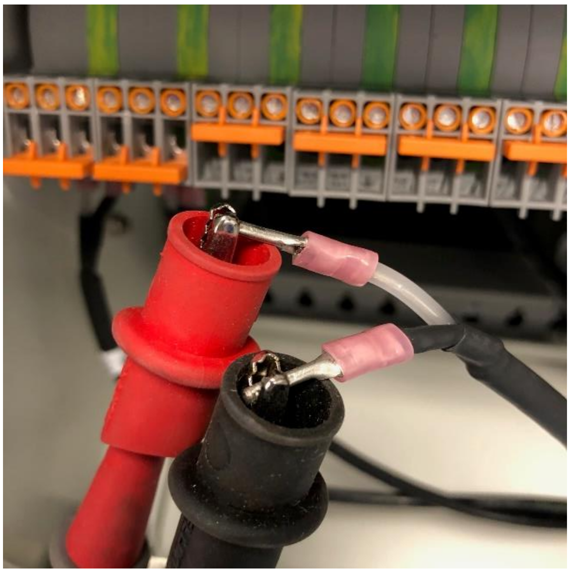


Figure 9-49: Resistance measurement

Record the measurement as [*R1*] in Table 9-7: Results. It should be less than 3000 Ω and within 5% of the Bushing Adaptor input resistance.

To verify the measurement, use the Administrator login and factory password of the month (POTM) to gain access to service mode. In the HMI, select **BMT > Calibration – Bushing Adaptor Calibration Data**.

An example of a load impedance is shown in Figure 9-50.

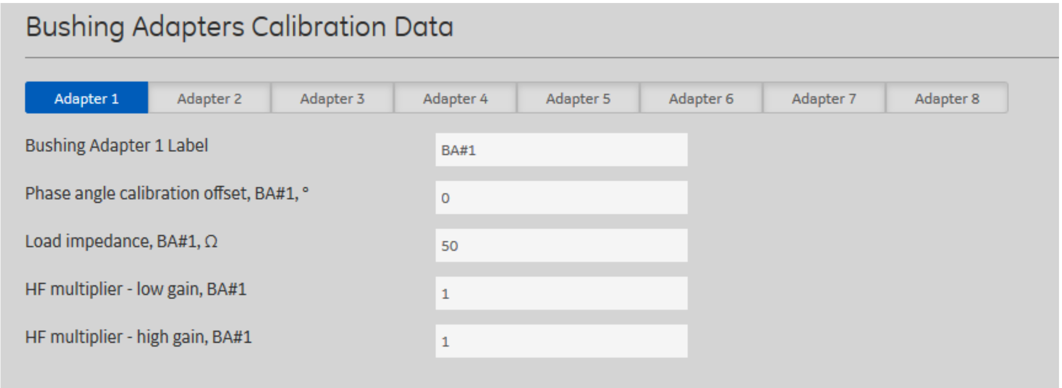


Figure 9-50: Bushing Adaptor Calibration Data

9.8.2.4.3 Input Resistance Test

For each input, measure the resistance at the core and shield terminals as show in Figure 9-51.

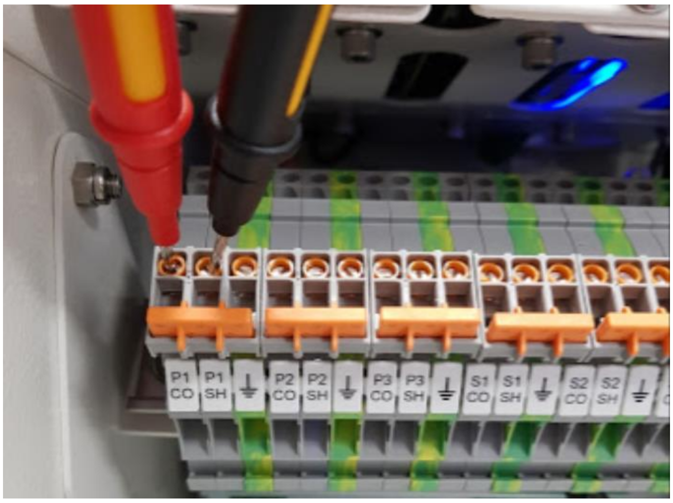
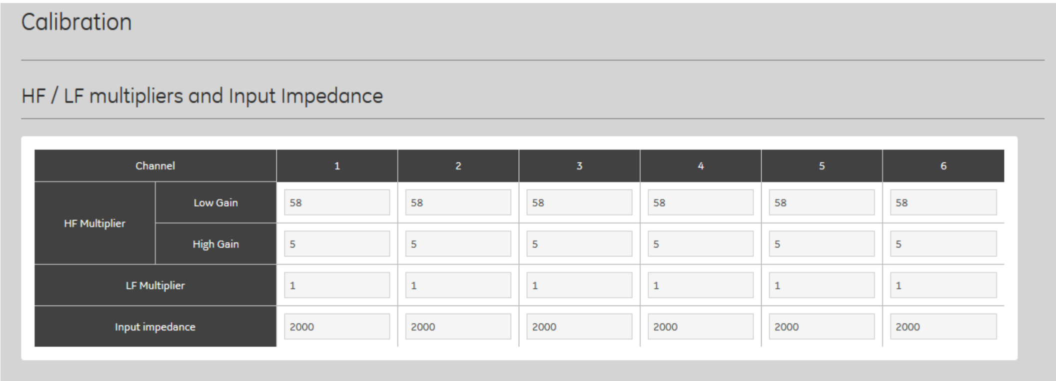


Figure 9-51: R2 resistance measurement

Record the measurement as [*R2*] in Table 9-7: Results. It should be less than 2000 Ω and within 5 % of the input channel impedance.

To verify the measurement, use the Factory Login, Press **BMT > Calibration – HF / LF multipliers and Input Impedance**. An example of input impedance is shown in Figure 9-52.



Calibration

HF / LF multipliers and Input Impedance

Channel		1	2	3	4	5	6
HF Multiplier	Low Gain	58	58	58	58	58	58
	High Gain	5	5	5	5	5	5
LF Multiplier		1	1	1	1	1	1
Input impedance		2000	2000	2000	2000	2000	2000

Figure 9-52: Calibration - Input Impedance

9.8.2.4.4 Total Resistance Test

Reconnect all the coaxial cables.

Retest the resistance across the two screws of the connector for each Bushing Adaptor as shown in Figure 9-53.

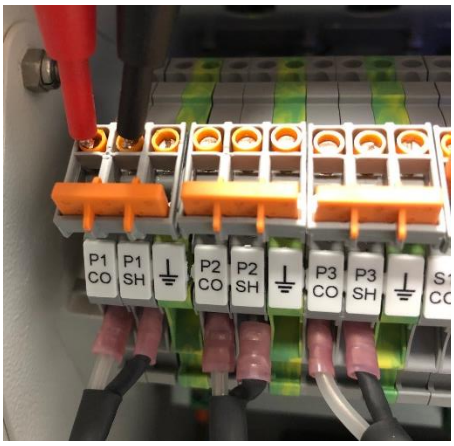


Figure 9-53: R3 total resistance measurement

Ensure that the measurement of [*R3*] is within 5% of the total input resistance [R_{input}] calculated from [*R1*] and [*R2*] for each input.

Note: The total input resistance [R_{input}] is calculated as [R_{input}]=1/(1/[R1] + 1/[R2])

9.8.2.4.5 Input voltage Test

Once the transformer is energised and the grounding switches are in the operational position (i.e. not grounded), measure the voltage drop across the core and the shield at the block terminals of the coaxial cables connected to the Bushing Adaptors as shown in Figure 9-54 and record these voltages in Table 9-7: Results. These voltages must be within 0.9 to 1.4 Vrms.

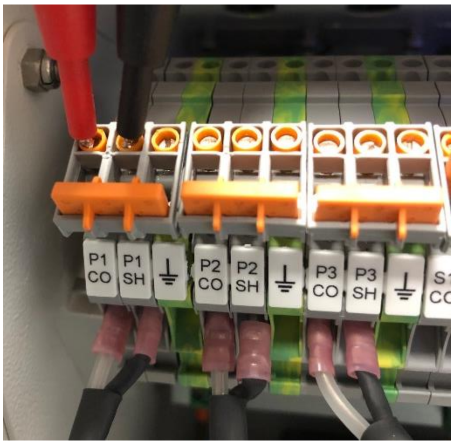


Figure 9-54: Input voltage measurement

Table 9-7: Results

Date: ___________		Primary B (A1) Ser No:	Primary B (B1) Ser No:	Primary C (C1) Ser No:	Primary B (D1) Ser No:	Secondary A (A2) Ser No:	Secondary B (B2) Ser No:	Secondary C (C2) Ser No:	Secondary C (D2) Ser No:
Section	**Description**								
9.8.2.3	**Bushing Adaptor ID**								
9.8.2.3	**Mag Mount Temperature Sensor (MMTS) # (3 single phase install)**								
9.8.2.4.5	**Bushing Adaptor Internal Pin Correctly Installed (Yes / No)**								
9.8.2.3	**Manufacturer Nameplate Power Factor % [PF%]**								
9.8.2.3	**Manufacturer Nameplate Capacitance [C1]**								
9.8.2.3	**Manufacturer Nameplate Capacitance [C2]**								
9.8.2.3	**Manufacturer Nameplate [T]**								
9.8.2.4.1	**Shield to ground resistance Test (<5 Ohm)**								
9.8.2.4.2	**Coaxial cable core and shield resistance Test [R1] (<3000 Ω)**								
9.8.2.4.3	**Input resistance Test [R2] (<2000 Ω)**								
9.8.2.4.4	**Total resistance Test [R3]**								
9.8.2.4.4	**[R3] within 5% of the [R_{input}] (Yes or No)**								
9.8.2.4.5	**(when the transformer is energised) Input voltage Test Expected 0.9 – 1.4 v RMS**								

10 COMMISSIONING & SERVICE

This section details essential operational tasks and all first start-up procedures that need only be performed once as part of the commissioning phase to prepare the product for deployment in the field. Refer to the relevant sections below depending on the installed options.

Note: A familiarity with the interface is assumed. If not, refer to the 'MA-040 – DGA 900 – Plus Operator Guide' for login details and general HMI functionality.

Installation and commissioning must be performed by trained field service engineers only. Resetting certain attributes may lead to data loss if the product is already operational.

Check that all the installed inputs connected to a signal for the thermal, cooling and OLTC cards are reading values within expectations.

After installation, check that the pulled current by every cooling bank unit is within 5% of the value entered in the cooling configuration page. If not, update the values in the Cooling Configuration page to the measured values and let the asset operator know that those values have changed.

At the time of commissioning, reset all models as outlined in this section including parameters, counters and all related model data.

10.1 Factory Settings

Select **Service > Factory** to view the Factory Settings page as shown in Figure 10-1.

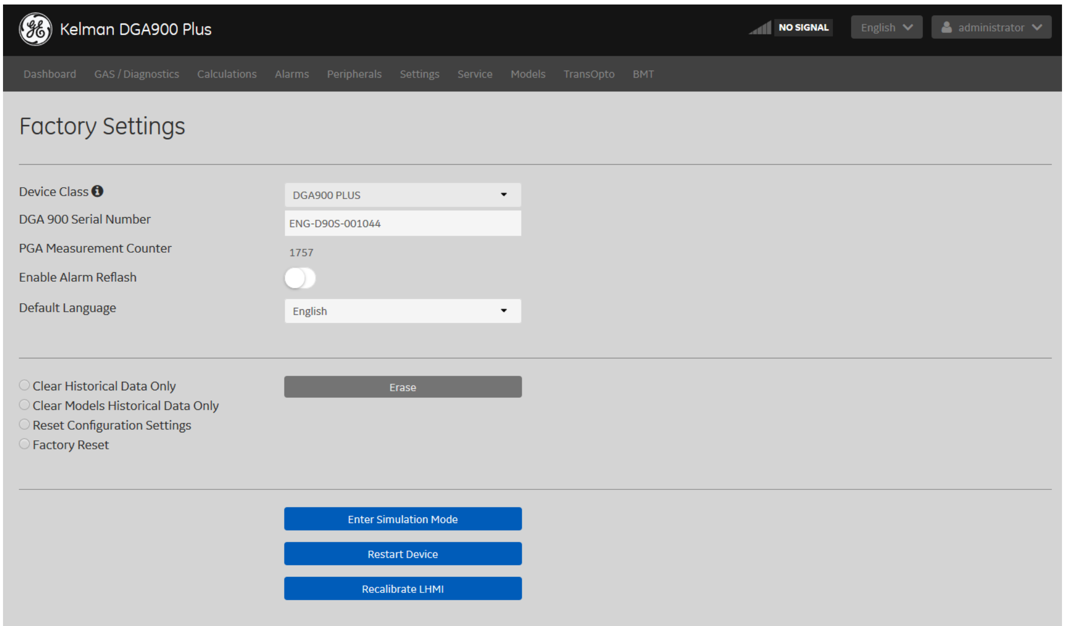


Figure 10-1: Service > Factory Settings

Select **Clear Historical Data Only** to erase all historical data including that associated with models.

The models can be saved, uploaded and downloaded together with the rest of the DGA 900 configuration via the dashboard menu option.

10.2 Models

Sometimes it is necessary to reset a specific model or its parameters due to a change in initial conditions and/or a change in hardware. This section lists those models and the reset options.

Note: Previously stored data is unaffected by a reset.

Select **Service > Models** to view the Models reset page as shown in Figure 10-2.

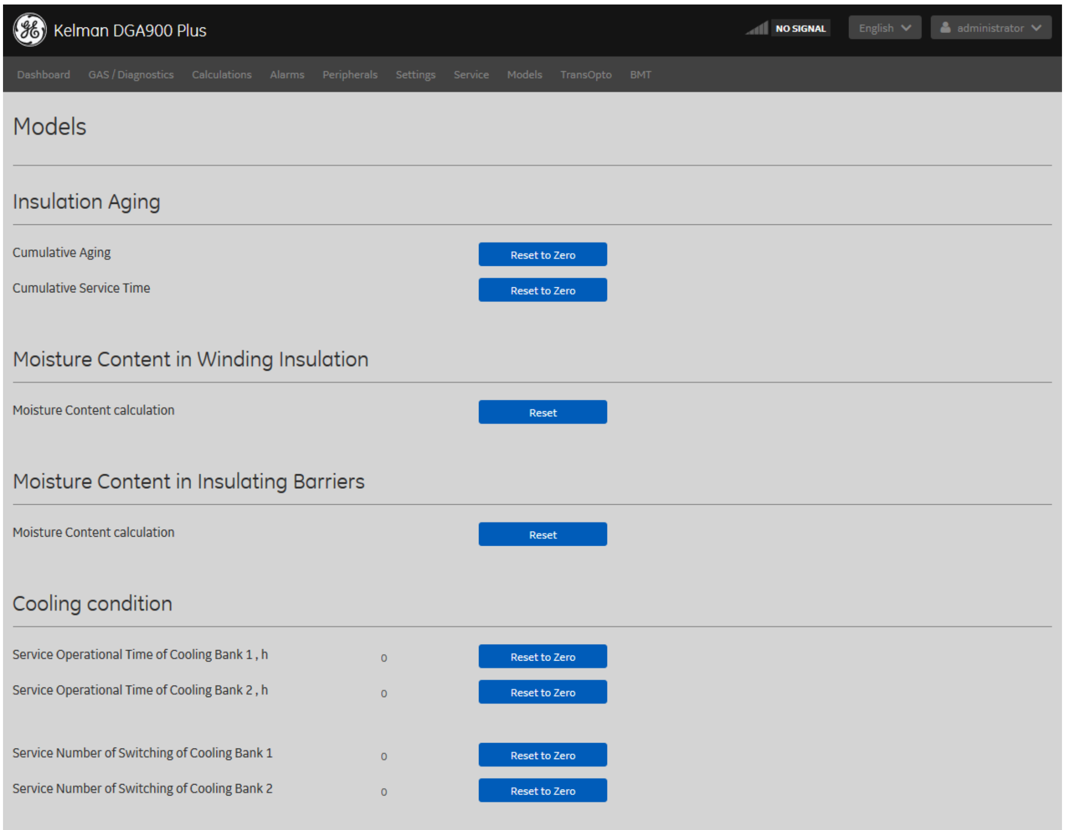


Figure 10-2: Service > Models

Listed below are the models that can be reset.

- Moisture Content in Winding Insulation
- Moisture Content in Insulating Barriers

The outputs of these models are slow changing. If initialised with the wrong input values, it may take a substantial period before these outputs can be considered reliable. Therefore, once the input is considered reliable from the PGA, it is advisable to reset these models.

Click **Reset** to reset the entire model as opposed to the data value of any parameter.

Note: After installation, it is advisable to reset the above two models.

Listed below are the models with parameters that can individually be reset.

- Insulation Aging

- Cooling Condition

  The product supports up to four cooling banks. Each bank can be independently set to zero, and the operational time and switching can also be reset.

Note: After installation, it is advisable to reset all the counters to zero

Note: Before resetting the counters, ensure that the internal time and date are correct. (The internal time can be found on the dashboard home page).

Click **Reset to Zero** to reset the listed parameters to hold a value of zero.

10.3 OLTC Monitor Commissioning

DGA 900 Plus products with an OLTC card enabled must undergo OLTC commissioning to ensure optimal and correct use of the following models:

- OLTC Tap Position Tracking
- OLTC Motor Torque
- OLTC Temperature

Commissioning determines the following:

- Mapping for mechanical position number to analogue input current
- Generation of group calculation parameters
- Limits for OLTC motor torque model alarms

The models require custom parameters unique to each tap changer. These can be found in the customer-specific 'Models Configurator' spreadsheet (available from the GE Service Team). OLTC commissioning requires the A14 (tap position) and A17 (motor torque) inputs.

OLTC monitor installation and commissioning must be performed on a non-energised transformer.

After installing the OLTC Motor Power Converter, the OLTC Tap Position and OLTC Torque models must be left disabled (refer to 'Section 6.4: Models Activation and Status' in the 'MA-040 – DGA 900 Plus – Operator Guide') until commissioning is successfully completed.

Table 10-1lists the OLTC software requirements for commissioning.

Table 10-1: OLTC software requirements

	OLTC Software Requirement
Laptop or computer equipped with the following software:	Perception Desktop
	Microsoft Excel
	Text editor e.g. Notepad (available as default in Windows) or Notepad++
	Latest DGA 900 Plus firmware (installed on the product)

Table 10-2 lists the OLTC commissioning files.

Table 10-2: OLTC files

Source	File	Purpose
Service Team	Commissioning_Document_v1.2	Spreadsheet tool required for autogenerating the OLTC configuration files.
Service Team	Models Configurator	Spreadsheet with reference values to complete calculations.
Service Team / Customer	TapPositionCalibration.cfg	Tap position map (manual mechanical mappings)
Autogenerated	TapPositionCalibration.cfg	output OLTC configuration (tap position map)
Autogenerated	OltcGroups.cfg	output OLTC configuration (sequence groupings)
Autogenerated	OltcRefData.cfg	output OLTC configuration (profile parameter reference per group)

10.3.1 Prerequisite Commissioning Steps

WARNING: The transformer must be de-energised / powered down before beginning the commissioning process.

It is also recommended to perform the following prior to commissioning the product:

- Test Product Connection
- Disable motor torque alarms (if required)

10.3.1.1 Test Product Connection

On the computer, use the Perception software to connect with the DGA 900 Plus and ensure that the downloaded CSV file contains no data.

1. In Perception Desktop, select **File > New Database**.
2. Type a meaningful name for the database e.g. `[DGA900_PLUS_SERIAL_NUMBER]_[DATE & TIME]_COMMISSIONING_[CUSTOMER_NAME]`
3. In the Asset Explorer, right click on the newly created database and select New > DGA 900 Plus.
4. On the Properties tabbed page, enter the connection details.
5. If a successful connection is made, a green tick appears on the DGA 900 Plus icon in the Asset Hierarchy as shown in Figure 10-3.

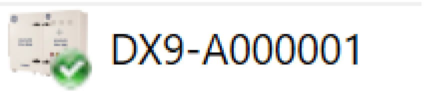


Figure 10-3: Successful connection to DGA 900 Plus

6. Right click the 'DGA 900 Plus' icon and select **Download** from the shortcut menu.
7. On the Properties tabbed page, the Device Connection details should show the State as 'Connected' and actively display the download in progress.

8. Once the download completes, check that the 'Data Table' tab contains no OLTC Tap Position or OLTC Torque data.

10.3.1.2 Disable Motor Torque Alarms (if required)

If the customer has agreed to allow the product to run for a set period in order to gather additional data on which to generate alarms, then the motor torque alarms should be disabled for this period. Otherwise skip this section and proceed to 'Section 10.3.2. Establish Baseline Settings'.

Use the product's HMI to disable all tap position and motor torque alarms. Select **Alarms > OLTC Model Alarms Configuration** as shown in Figure 10-4.

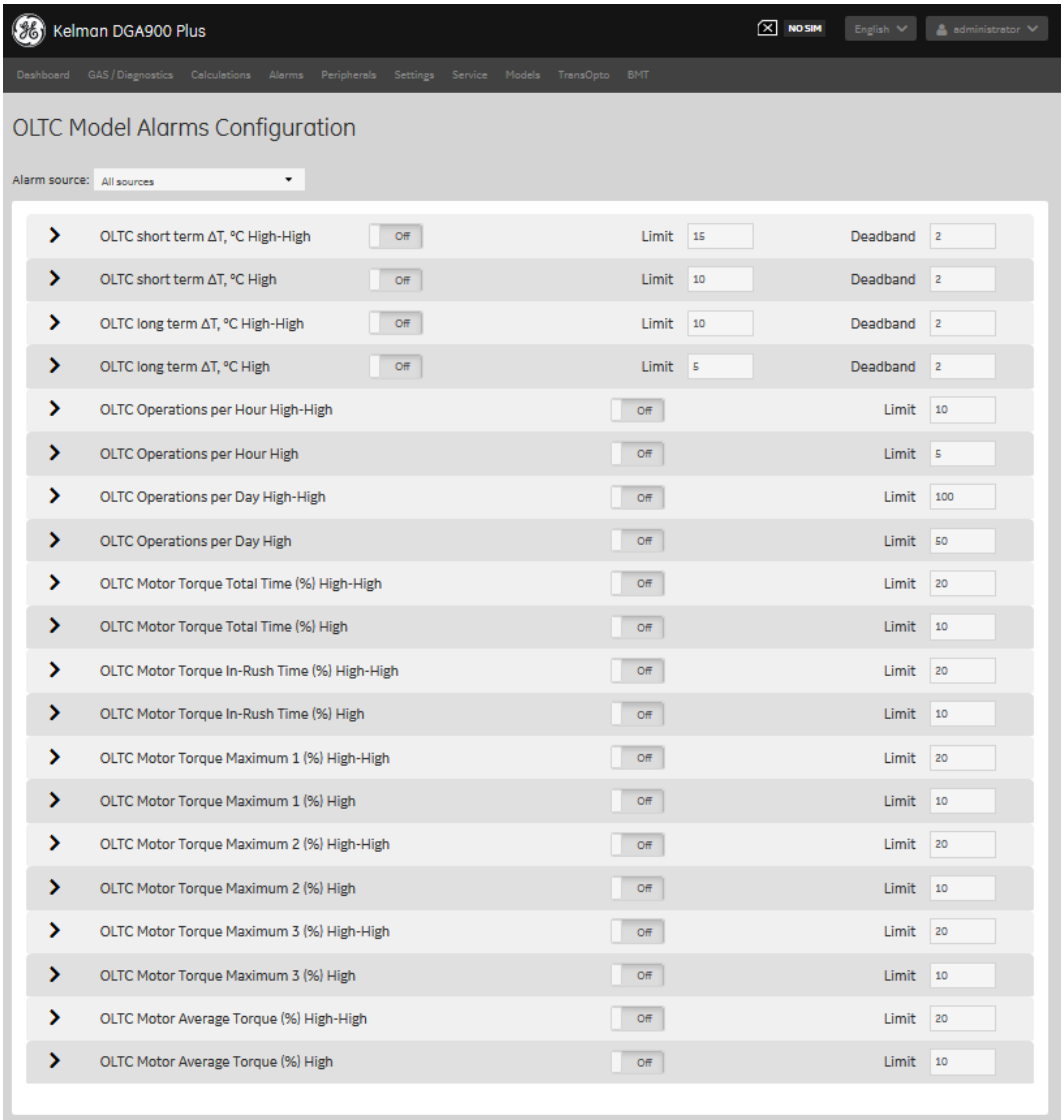


Figure 10-4: OLTC Model Alarms Configuration

In the 'OLTC Model Alarms Configuration' page, perform the following steps:

1. Select **OLTC Motor Torque Total Time (%)** from the Alarm source dropdown menu as shown in Figure 10-5.

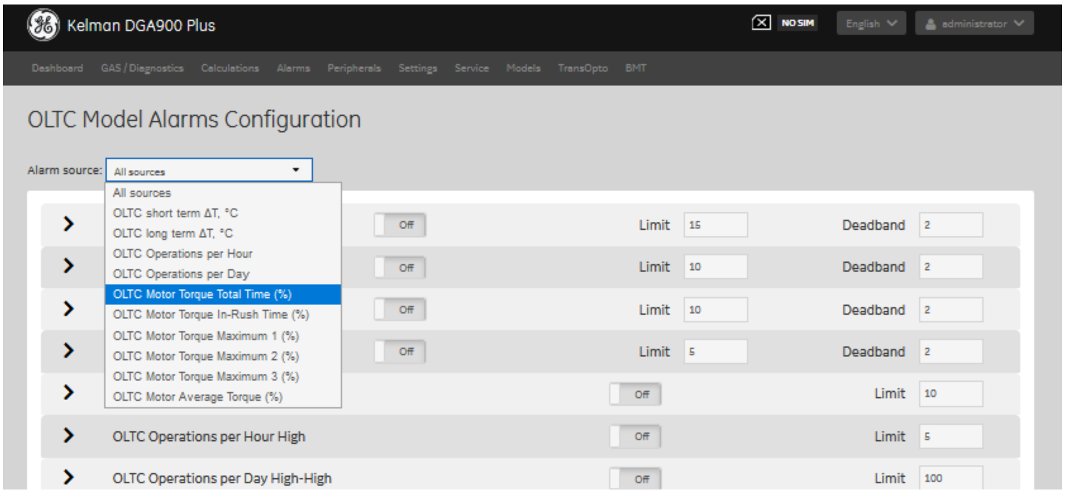


Figure 10-5: OLTC Motor Torque Total Time (%)

2. The adjacent box should list **All limits** as shown in Figure 10-6. If not, select the ‘Alerts’ dropdown menu and choose **All limits**.

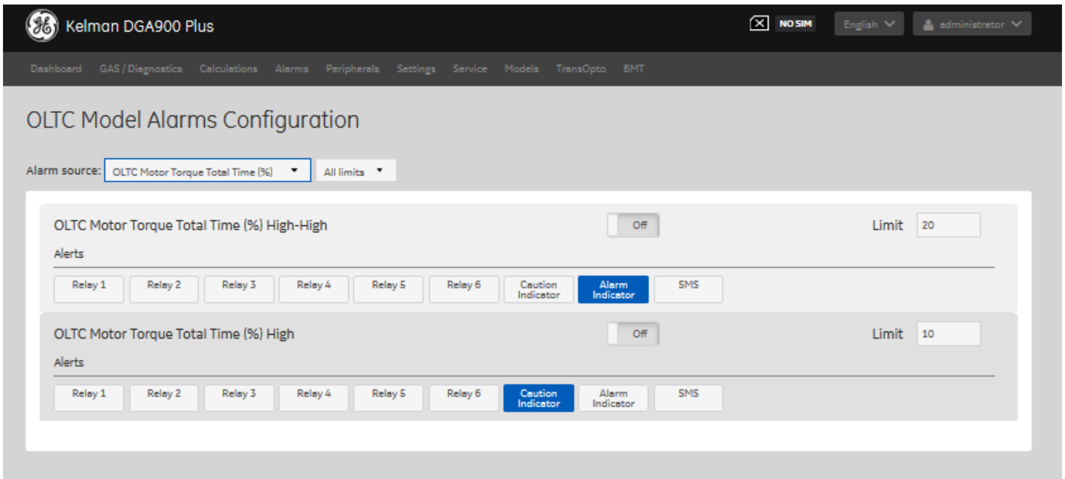


Figure 10-6: OLTC Motor Torque Total Time (%) – Alerts Off

3. For each Alert, use the slider control to slide the Alert to the **Off** position as shown in Figure 10-6.

Now repeat these steps for all remaining alarms (in the same manner as above):

4. Select **OLTC Motor Torque In-Rush Time (%)** from the Alarm source dropdown menu.

5. The adjacent box should list **All limits**. If not, select the ‘Alerts’ dropdown menu and choose **All limits**.

6. For each Alert, use the slider control to slide the Alert to the **Off** position.

7. Select **OLTC Motor Torque Maximum 1 (%)** from the Alarm source dropdown menu.

8. The adjacent box should list **All limits**. If not, select the ‘Alerts’ dropdown menu and choose **All limits**.

9. For each Alert, use the slider control to slide the Alert to the **Off** position.

10. Select **OLTC Motor Torque Maximum 2 (%)** from the Alarm source dropdown menu.

11. The adjacent box should list **All limits**. If not, select the 'Alerts' dropdown menu and choose **All limits**.
12. For each Alert, use the slider control to slide the Alert to the **Off** position.
13. Select '**OLTC Motor Torque Maximum 3 (%)**' from the Alarm source dropdown menu.
14. The adjacent box should list **All limits**. If not, select the 'Alerts' dropdown menu and choose **All limits**.
15. For each Alert, use the slider control to slide the Alert to the **Off** position.
16. Select **OLTC Motor Average Torque (%)** from the Alarm source dropdown menu.
17. The adjacent box should list **All limits**. If not, select the 'Alerts' dropdown menu and choose **All limits**.
18. For each Alert, use the slider control to slide the Alert to the **Off** position.

10.3.2 Establish Baseline Settings

10.3.2.1 Verify Mappings

Use the product's HMI to cycle through all the tap changer positions to build up the mapping. Select **Models > OLTC Tap Position Tracking Configuration**.

1. In the 'OLTC Tap Position Tracking Configuration' section, ensure that the listed parameters, for example as shown in Figure 10-7, match those specified in the 'Models Configurator' spreadsheet.

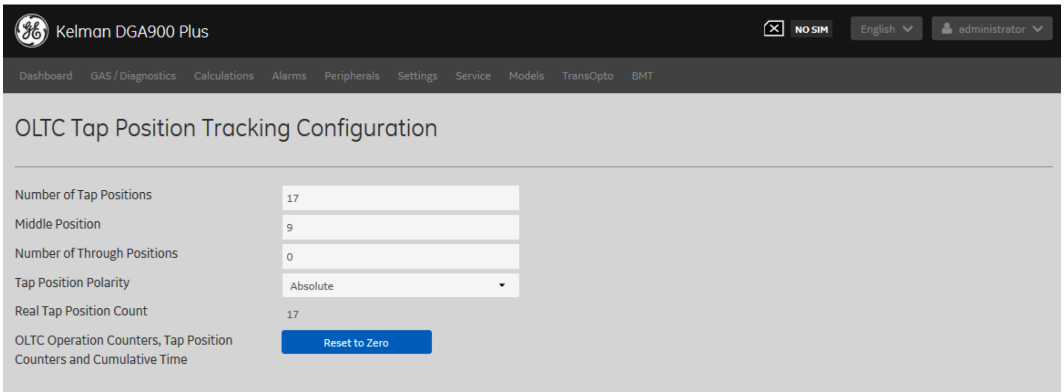


Figure 10-7: OLTC Tap Position Tracking Configuration – parameters

In the 'Configuration Import' section, click into the circle to select the customer-specific tap position map file **TapPositionCalibration.cfg** file, or click-and-drag the **TapPositionCalibration.cfg** file directly from File Explorer into the circle as shown in Figure 10-8, and wait for the import to complete.

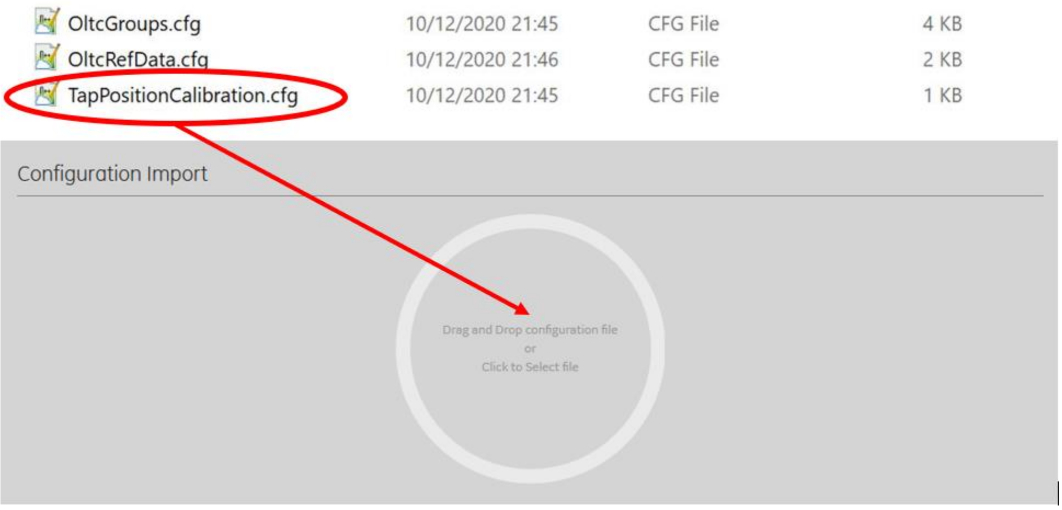


Figure 10-8: Configuration Import – TapPositionCalibration.cfg

Use the product's HMI to verify the sensor parameters and motor torque profile parameters. Select **Models > OLTC Motor Torque Configuration** and ensure that all parameters, for example as shown in Figure 10-9, match those as given by the manufacturer of the torque converter.

Sensor Parameters, 'Minimum Sensor Value' and 'Maximum Sensor Value' must match those of the torque converter (0, 2000 by default). Motor Torque Profile Parameters must be set according to the OLTC Motor nominal power: 'Start Threshold' to be twice the nominal power and 'End Threshold' to be a tenth of the nominal power, e.g. for a 300 W motor, the 'Start Threshold' should be 600 W and the 'End Threshold' should be 30 W. In any case, 'Start Threshold' must be less than the 'Maximum Sensor Value', and the 'End Threshold' must be greater than the 'Minimum Sensor Value'.

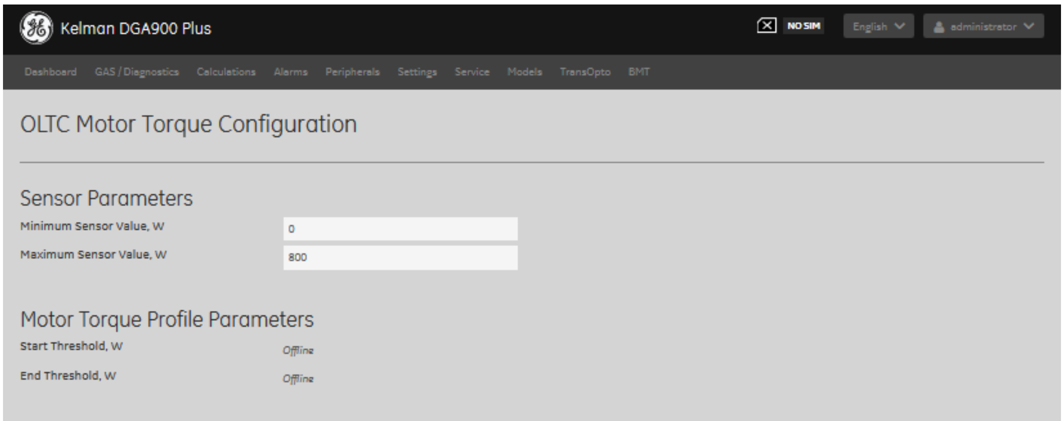


Figure 10-9: OLTC Motor Torque Configuration - parameters

10.3.2.2 Create Tap Positions

Follow these steps to establish a baseline of tap positions by sequencing the motor torque outputs to arrive at the desired tap positions:

1. Move the tap changer to its lowest position.
2. Increase the tap changer position by *one* (i.e. to the next higher position).
3. Decrease the tap changer position by *one* (i.e. returning it to the lowest position).

4. Use the product's HMI, select **Models > OLTC Motor Torque** to verify the parameter values.

   In the OLTC Motor Torque page, ensure that all the parameters display a value (i.e. are not offline). If the parameters read 'Offline', return to Step 1.

5. Increase the tap changer position by *one*. Is this the *highest* position? If *Yes*, then go to Step 9. If *No*, then go to Step 6.

6. Increase the tap changer position by *one*. Is this the *highest* position? If *Yes*, then go to Step 9. If *No*, then go to Step 7.

7. Decrease the tap changer position by *one*.

8. Increase the tap changer position by *one*. Is this the *highest* position? If *Yes*, then go to Step 9. If *No*, then go to Step 6.

9. Decrease the tap changer position by *one*.

10. Increase the tap changer position by *one*.

11. Decrease the tap changer position by *one*. Is this the *lowest* position? If *Yes*, then the tap position sequence is complete. If *No*, then go to Step 11 (i.e. repeat this step until the tap changer is at its lowest position).

Figure 10-10 illustrates an example of tap position movements following this sequence of steps.

Note: The actual number of positions depends on the type of tap changer.

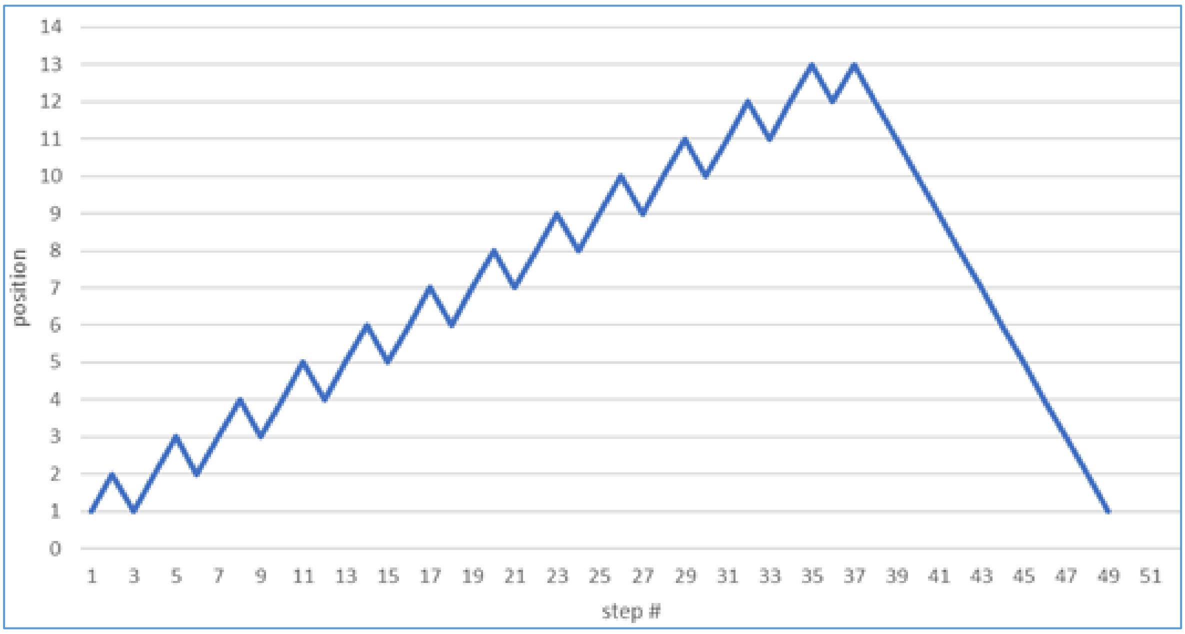


Figure 10-10: Tap position movements — an example

10.3.3 Download DGA 900 Plus data to Perception

The new OLTC data must be downloaded from the DGA 900 Plus. The recommended means to do this is via the Perception Desktop software.

1. Start the Perception Desktop software on a computer.

2. Select **File > New Database**.

3. Type a meaningful name for the database e.g. `[DGA900_PLUS_SERIAL_NUMBER]_[DATE & TIME]_COMMISSIONING_[CUSTOMER_NAME]`

4. In the Asset Explorer, right click on the newly created database and select **New > DGA 900 Plus** as shown in Figure 10-11.

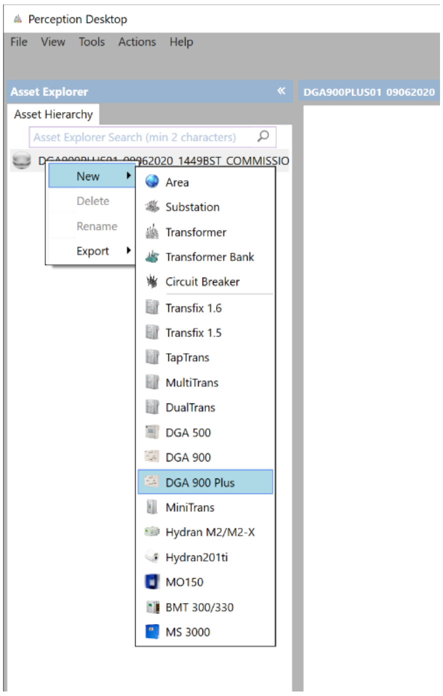


Figure 10-11: New > DGA 900 Plus database

5. On the Properties tabbed page, enter the connection details.

6. If a successful connection is made, a green tick appears on the DGA 900 Plus icon in the Asset Hierarchy.

7. Right click the DGA 900 Plus icon and select **Download** from the shortcut menu.

8. On the Properties tabbed page, the Device Connection details should show the State as 'Connected' and actively display the download in progress.

9. Once the download completes, select the **Data Table** tab.

9. In the Data Table tabbed page, right click in the data area and select **Add/Remove Measurement Points**.

11. Select **Tap Position** and **OLTC Motor Torque** as shown in Figure 10-12.

Note: All other options should be left unchecked.

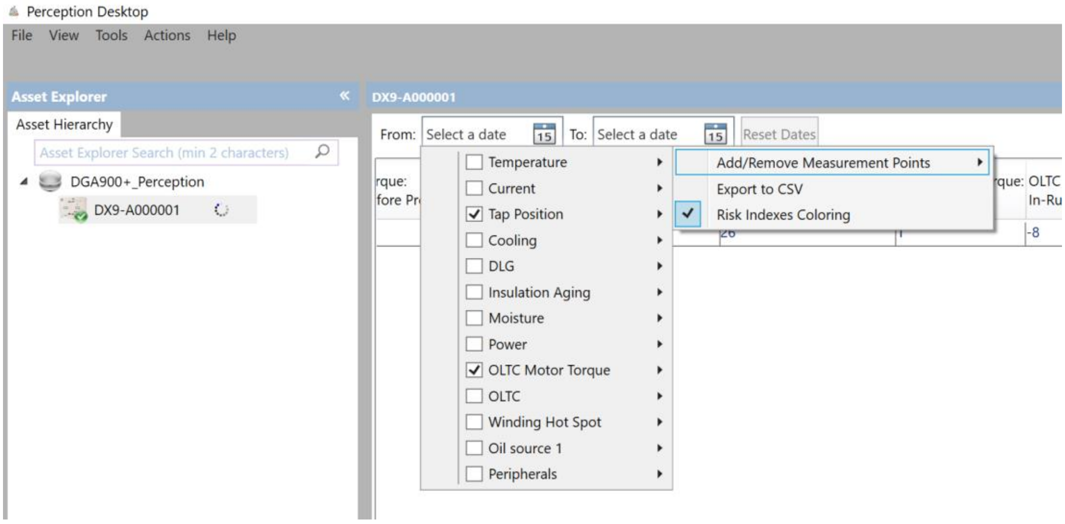


Figure 10-12: Add / Remove Measurements Points > Tap Position & OLTC Motor Torque

12. Right click in the data area and select **Export to CSV**.

13. In the Export to CSV dialog box, browse to an appropriate location, type a suitable filename and click **Save**.

The OLTC data is now saved externally to a CSV file format.

10.3.4 Generate Configuration Files

Use the Excel commissioning tool called 'Commissioning_Document_v1.2' to generate the required OLTC configuration files. The spreadsheet takes the following inputs:

- The tap position movements in the form of raw CSV data (as output by Perception in Section 10.3.3)
- The 'through positions' of the tap changer

This data is used to produce the tap position map and the motor torque configuration files, output in the form of TapPositionCalibration.cfg, OltcGroups.cfg and OltcRefData.cfg. To use the tool, perform the following steps:

1. Start Microsoft Excel and open the Commissioning_Document_v1.2 as shown in Figure 10-13.

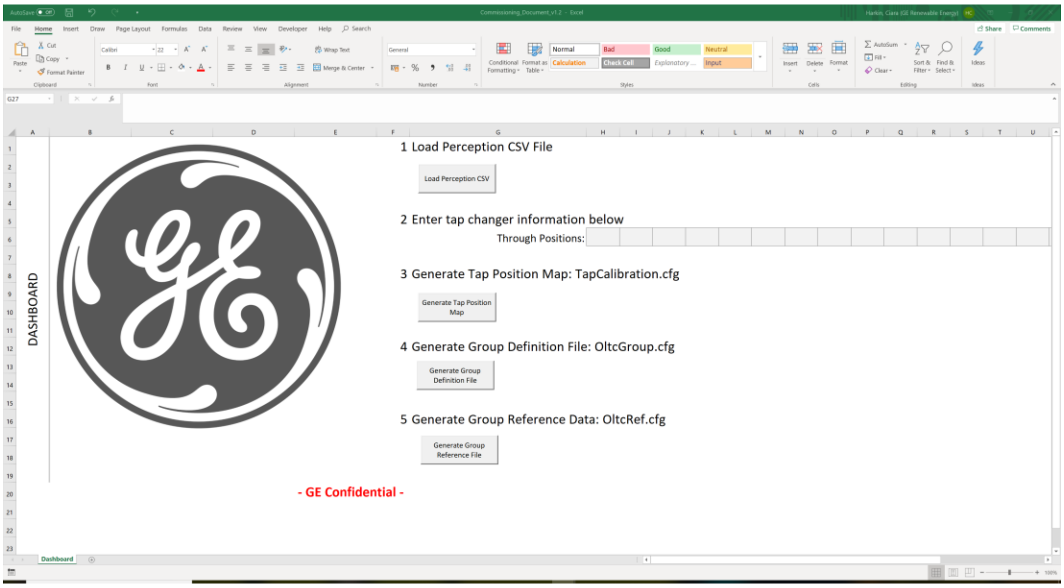


Figure 10-13: Microsoft Excel — Commissioning_Document_v1.2 — Dashboard homepage

2. Click the **Load Perception CSV** button on the sheet.

3. In the dialog box, browse to the location of the Perception CSV file as downloaded in the previous section, select that file and click **Open**.

   A dialog box confirms if the data from the file is successfully accepted by the tool. Click **OK**.

4. Enter the relevant mechanical position number for each 'through position' of the tap changer in the range of cells (H6: AP6).

Note: The information can be obtained from the customer or can be found on the transformer nameplate.

Note: Depending on the transformer configuration, the number of 'through positions' can vary, so not all cells need be filled.

5. If the customer has already provided mapping details of the mechanical positions ('TapPositionCalibration.cfg'), then go to step 6. If the customer has not supplied mapping details, then click the **Generate Tap Position Map** button to create the 'TapPositionCalibration.cfg' file.

   In the dialog box, browse to the folder location for the configuration file and click **OK**.

   A message box confirms with the message 'File creation complete' when the configuration file is successfully created in the specified location. Click **OK**.

   Browse to the folder location of the 'TapPositionCalibration.cfg' file.

   Use a text editor, such as Notepad, to open the 'TapPositionCalibration.cfg' file and verify that the file looks similar to the example shown in Figure 10-14 i.e. that the file is not blank or corrupt.

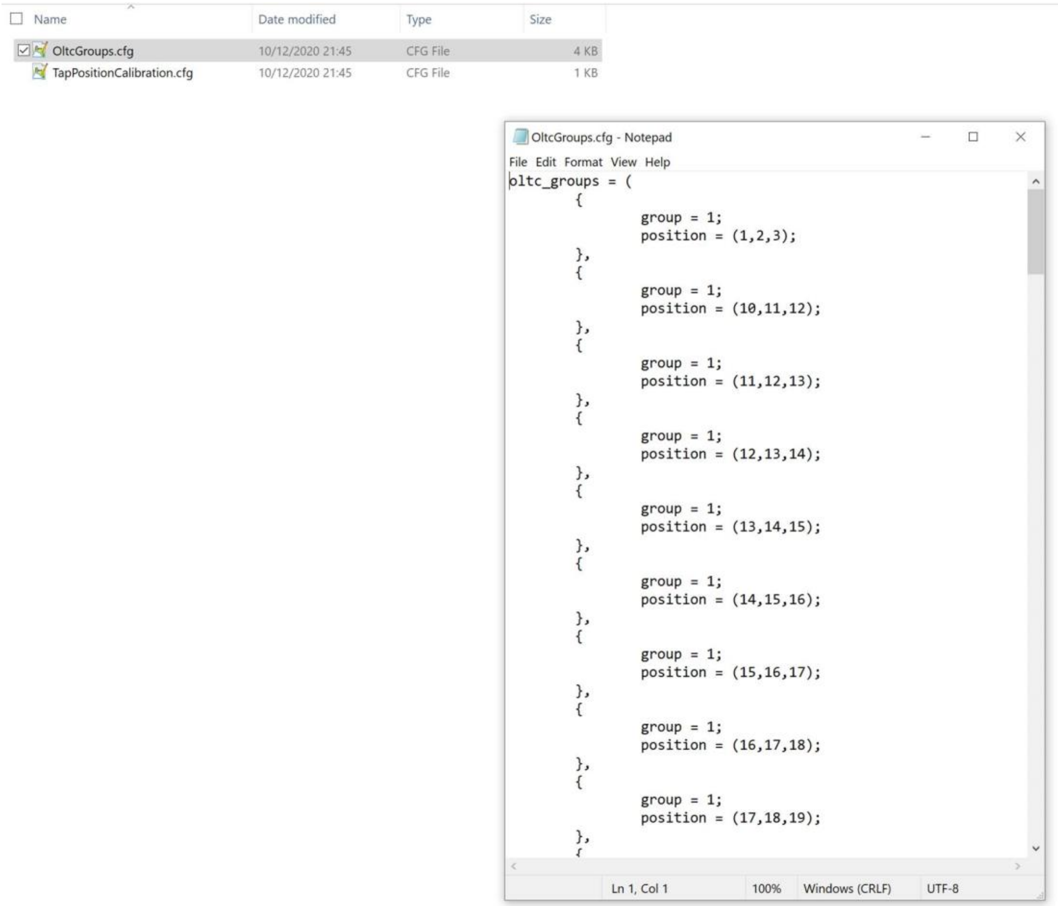


Figure 10-14: TapPositionCalibration.cfg

6. Click the **Generate Group Definition File** button to create the 'OltcGroups.cfg' file.

   In the dialog box, browse to the folder location for the configuration file and click **OK**.

   A message box confirms with the message 'File creation complete' when the configuration file is successfully created in the specified location. Click **OK**.

   Browse to the folder location of the 'OltcGroups.cfg' file.

   Use a text editor, such as Notepad, to open the 'OltcGroups.cfg' file and verify that the file looks similar to the example shown in Figure 10-15 i.e. that the file is not blank or corrupt.

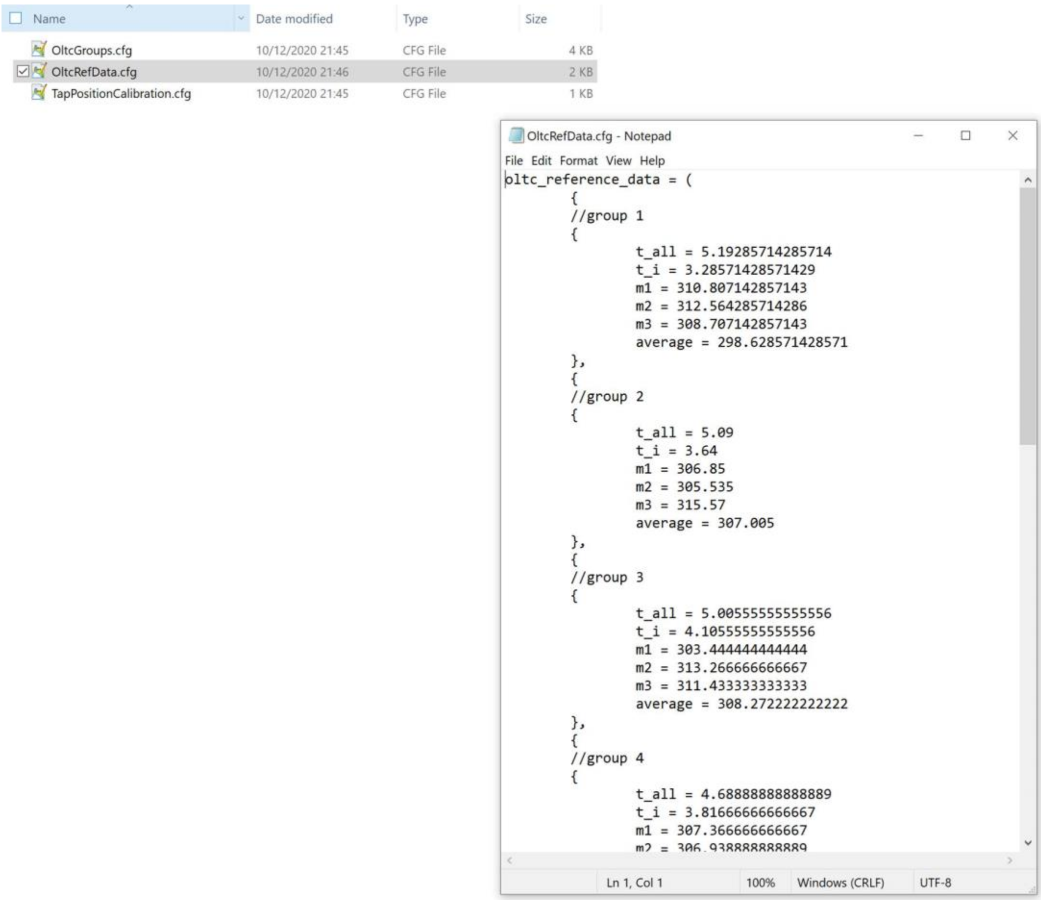


Figure 10-15: OltcGroups.cfg

7. Click the **Generate Group Reference File** button to create the 'OltcRefData.cfg' file.

   In the dialog box, browse to the folder location for the configuration file and click **OK**.

   A message box confirms with the message 'File creation complete' when the configuration file is successfully created in the specified location. Click **OK**.

   Browse to the folder location of the 'OltcRefData.cfg' file.

   Use a text editor, such as Notepad, to open the 'OltcRefData.cfg' file and verify that the file looks similar to the example as shown in Figure 10-16 i.e. that the file is not blank or corrupt.

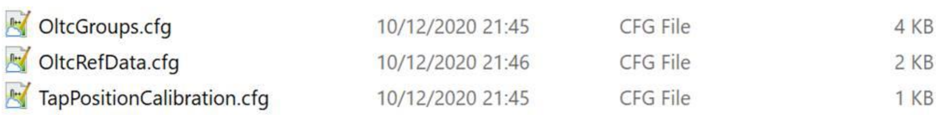


Figure 10-16: OltcRefData.cfg

8. Browse to the folder location for the three valid configuration files as shown in Figure 10-17 to verify that they exist.

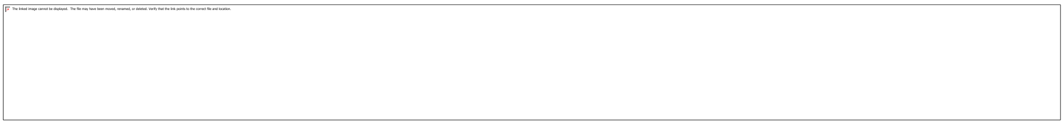


Figure 10-17: Required files for OLTC commissioning

These files should be stored with the Commissioning Report.

10.3.5 Import Configuration Files to DGA 900 Plus

To complete the commissioning process, import the recently generated configuration files into the product. Follow these steps to perform the configuration import:

1. Using the remote HMI from the computer, connect with the DGA 900 Plus and log in as an Administrator.
2. Select **Models > OLTC Tap Position Tracking Configuration**.

   In the Configuration Import section, click into the circle to select the **TapPositionCalibration.cfg** file, or click-and-drag the **TapPositionCalibration.cfg** file directly from File Explorer into the circle as shown in Figure 10-18, and wait for the import to complete.
3. Using the HMI, select **Models > OLTC Motor Torque Configuration**.

   In the Configuration Import section, click into the circle to select the **OltcGroups.cfg** file, or click-and-drag the **OltcGroups.cfg** file directly from File Explorer into the circle as shown in Figure 10-18, and wait for the import to complete.
4. Similar to the previous step, click into the circle to select the **OltcRefData.cfg** file, or click-and-drag the **OltcRefData.cfg** file directly from File Explorer into the circle as shown in Figure 10-18, and wait for the import to complete.

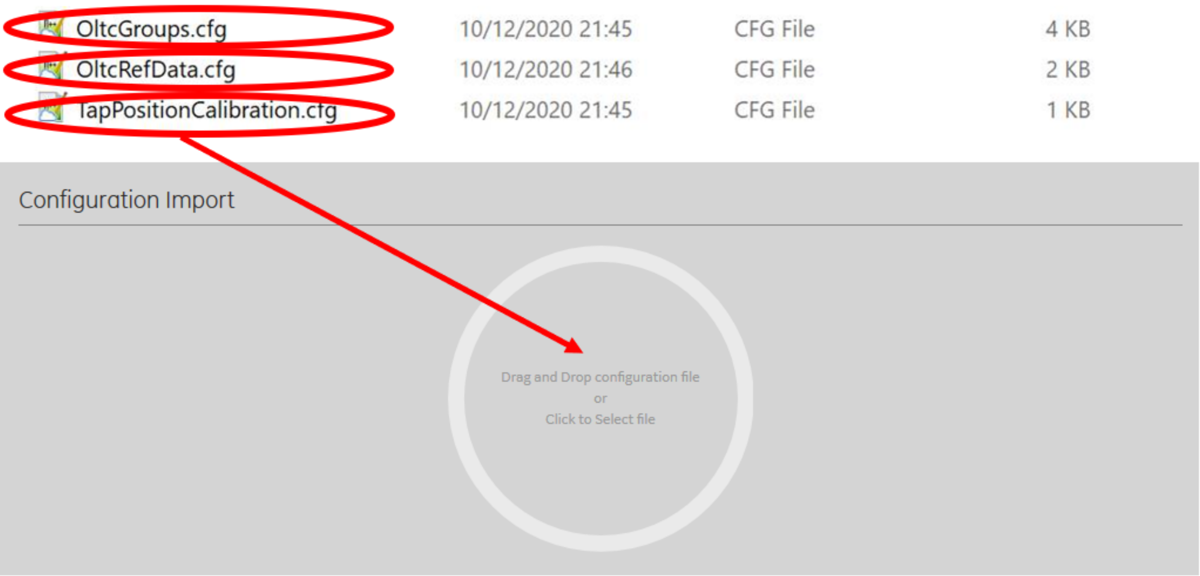


Figure 10-18: Configuration Import – TapPositionCalibration.cfg, OltcGroups.cfg & OltcRefData.cfg

10.3.6 Finalisation

1. Use the product's HMI to perform an OLTC Tap Position reset. On the OLTC Tap Position Tracking Configuration page, click the **Reset to Zero** button as shown in Figure 10-19.

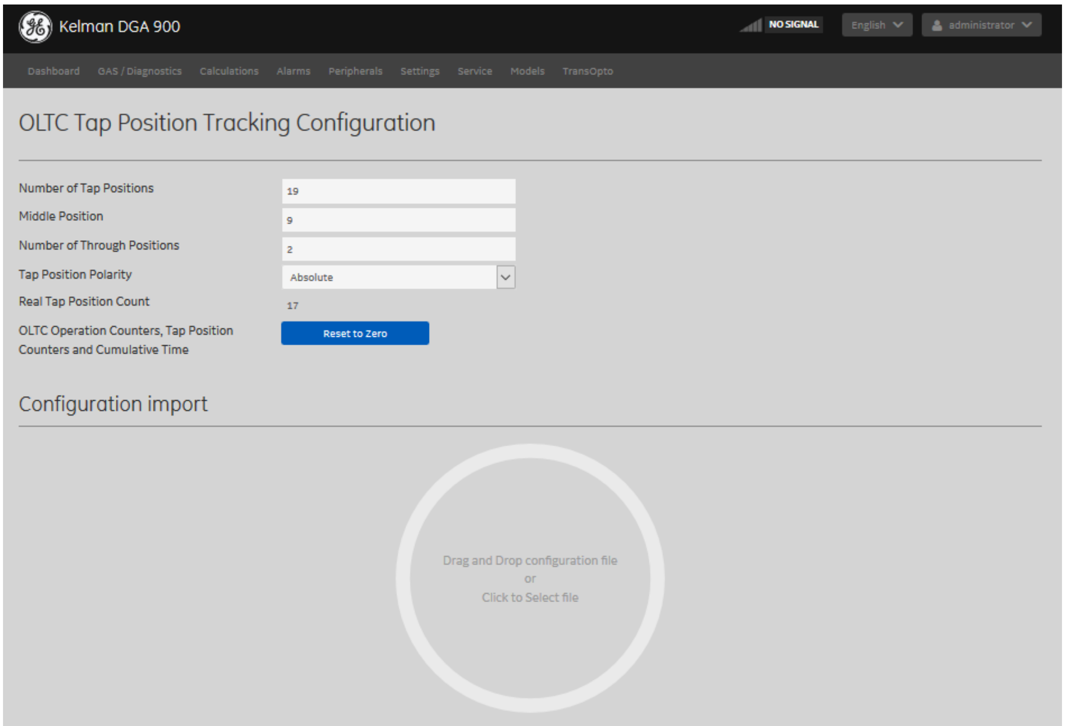


Figure 10-19: OLTC Tap Position Tracking Configuration

2. If the OLTC Motor Torque Alarms were disabled, they should be re-enabled at this point.

This completes the commissioning process. Service personnel must fully complete the hardcopy Commissioning Report onsite to sign off the commissioning (a triplicate booklet from the GE Service Team).

10.4 Bushing & PD Monitor Commissioning

DGA 900 Plus products with a bushing card enabled must undergo BMT commissioning. This section outlines parameters to be verified while the transformer is energised and running at operational conditions regarding the grid voltage (phase and amplitude).

Note: Transformer load is irrelevant for commissioning.

Note: Administrator level access is required to view settings, but to make changes a factory POTM is required to enable service mode.

Note: While the transformer is offline, enable Service mode to switch Alarms off to prevent nuisance alarms occurring until the transformer is re-energised.

WARNING: The transformer is live during this process. Ensure that the Bushing Adaptor cables are undamaged as far as can be observed before approaching the Hub enclosure and always maintain a safe working area.

All settings should be checked against the customer specific workflow created for each individual bushing system and recorded in the Commissioning Report (and to be stored with the Installation Report).

10.4.1 General Settings

Select **BMT > General Settings** as shown in Figure 10-20 and ensure that the following parameters are correct:

- Operational Voltage Format – **Peak to Ground** or **RMS**
- Primary Operational Voltage and Secondary Operation Voltage (If applicable)

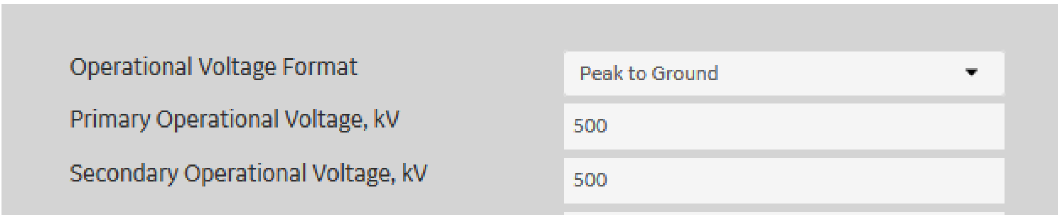


Figure 10-20: BMT > General Settings

Select **BMT > Configuration** as shown in Figure 10-21 and ensure that the following parameters are correct:

- Operating Frequency
- Monitoring mode – **Single transformer** or **Multiple Transformer**

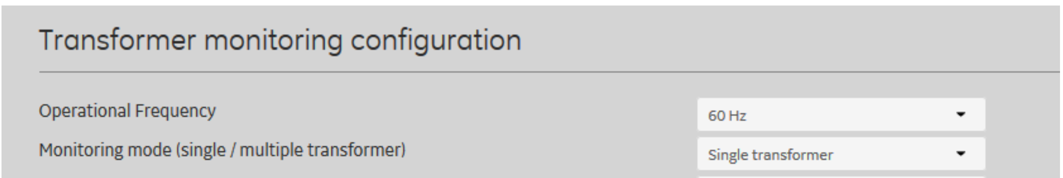


Figure 10-21: BMT > Configuration

10.4.2 Voltage Measurement

Measure the voltage across each bushing adaptor input on the terminal rail as shown in Figure 10-22. Each input should measure between 0.9 V rms to 1.4 V rms.

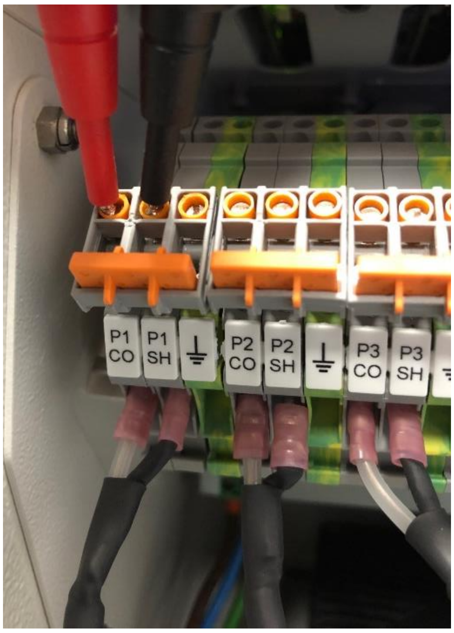


Figure 10-22: Voltage Measurement

10.4.3 C1% Measurement

To ensure that the configuration is correct for this system:

- Select **BMT > Live Measurement** as shown in Figure 10-23 and ensure that the ‘Expected Current mA’ for each phase is within 10% of the measured current mA reading.

  Troubleshooting Tip: If there is a ±40% difference between the expected and measured C1 values, the likely reason for this is an incorrect ‘Operational Voltage Format’ (see Section 10.4.1 and check with the customer to confirm Peak to ground or RMS).

Bushing

Primary | Secondary

Phase	A	B	C	
	Capacitance			Imbalance
NamePlate C1, pF	197.8	197.4	198.4	
Expected Current, mA	21.53	21.48	21.59	
Measured Current, mA	26.74	30.74	37	
Estimated C1, pF	245.75	282.48	339.98	41.11

Figure 10-23: Bushing

Note: Refer to ‘Section 10: Bushing & PD Monitor’ in the ‘MA-040 – DGA 900 Plus – Operator Guide’ for operational guidance on the settings below.

- Select **BMT > Configuration** and ensure that the Bushing Profiles Nameplate nominal values are correct and assigned to the correct bushing.
- Select **BMT > General Settings** and ensure that the Primary Operational voltage is correct.
- Select **BMT > Calibration** and ensure that the Bushing Adaptor Calibration Data load impedance is set correctly for each bushing profile.

If the C1% measurement is above 5% after these checks, please contact GE customer support team.

10.4.4 C.4 Tan δ (Power Factor) Measurement

To verify that the wiring is correct and that initial alarms levels are appropriate for the system with instantaneous Tan δ measurements:

- Select **BMT > Configuration** as shown in Figure 10-24 to verify the 'Exponential Moving Average Configuration'. Ensure that:
  - 'Daily Moving Average Enable' is **Off**
  - 'Moving Average Factor Phase Angle' is **100** (factory default is 10000)

Exponential Moving Average Configuration	
Moving Average Factor Phase Current	1000
Moving Average Factor Phase Angle	100
Moving Average Factor Environment	100
Moving Average Factor PDI	1000
Moving Average Factor PD Value	1000
Moving Average Factor PD Count	1000
Daily Moving Average Enable	Off

Figure 10-24: Exponential Moving Average Configuration

- Select **BMT > Live Measurement** as shown in Figure 10-25 to verify the 'Measured Phase Angle'. Ensure that:
  - the measured angles are within 2 degrees of the expected angles. If the phase angles are measuring more than 2 degrees, contact GE Technical Support for further guidance. If applicable, check the same on secondary bushings.
  - the imbalance (polar plot amplitude) for tan δ is less than 120%. If the tan δ is more than 120%, the alarm limit should be adjusted. The alarm is recommended to be set at 50% above the highest measurement. If applicable, check the same on secondary bushings.

	Insulation			Imbalance
NamePlate tanδ, %	0.01	0.01	0.01	
Expected Angle, °	0	120	-120	
Measured Angle, °	0	120.01	-119.94	
Estimated tanδ, %	0.01	0.03	0.11	926.51

Figure 10-25: Measured Phase Angle

To change the **Polar Plot PF** % alarms:

- Select **Alarm > Bushing Alarm Configuration > Primary Polar Plot PF%** as shown in Figure 10-26 to adjust the alarm as required for both Primary and Secondary sources, High-High and High limits.

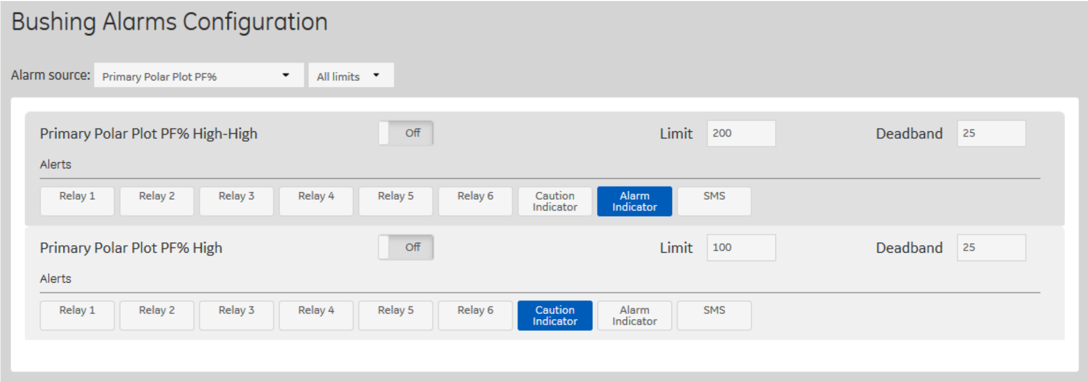


Figure 10-26: Bushing Alarms Configuration

To disable instantaneous Tan δ measurements:

- Select **BMT > Configuration** as shown in Figure 10-27 to verify the 'Exponential Moving Average Configuration'. Ensure that:
  - 'Daily Moving Average Enable' is **On**
  - 'Moving Average Factor Phase Angle' is **10000**

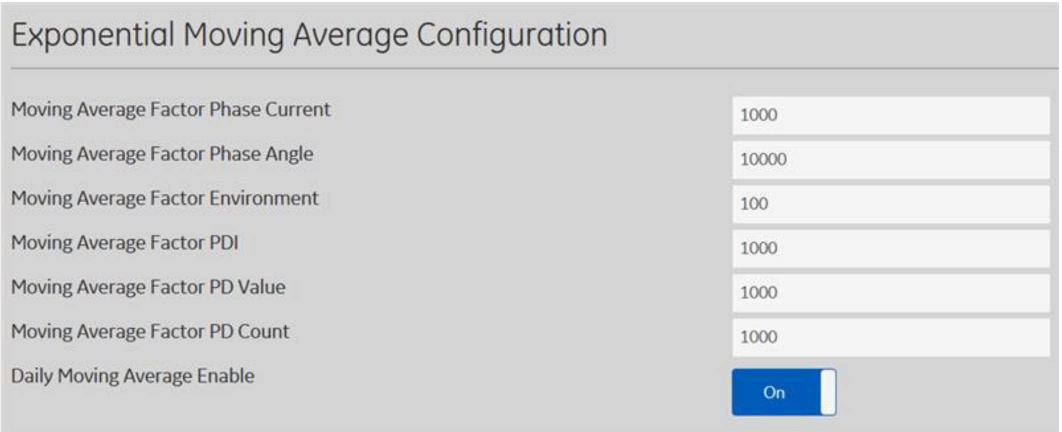


Figure 10-27: Exponential Moving Average Configuration

10.4.5 PD Live HF Noise Threshold Measurement

The HF input noise can range over many orders of magnitude depending on the transformer, so the 'Live HF Noise' is used to estimate the input noise levels and consequently adjust the input gains.

- Select **BMT > Configuration** and scroll down to the 'Live HF Noise' section as shown in Figure 10-28.

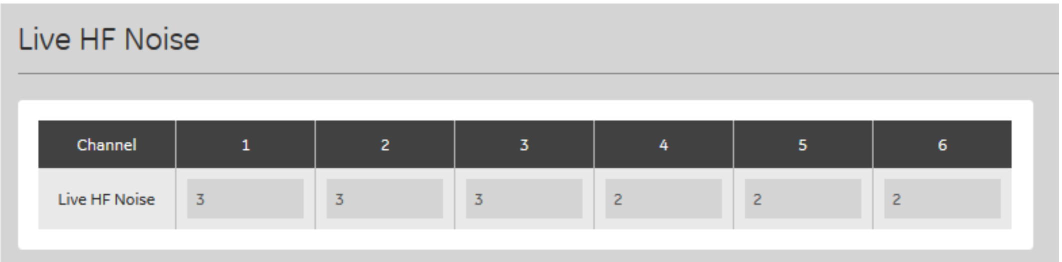


Figure 10-28: Live HF Noise

If the 'Live HF Noise' value for any channel exceeds 180, scroll further down to the 'HF Gain Control' section and select **High gain** for each affected channel as shown in Figure 10-29.

HF Gain Control

Gain position, Primary A	High gain
Gain position, Primary B	High gain
Gain position, Primary C	High gain
Gain position, Secondary A	High gain
Gain position, Secondary B	High gain
Gain position, Secondary C	High gain

Figure 10-29: HF Gain Control

10.4.6 PDI Associated Power Measurement

- Select **BMT > Live Measurement** and scroll down to the 'PD' section with the Primary tab active as shown in Figure 10-30. Ensure that:
  - Associated Power (PDI) measurement is less than 800 mW for each phase. If above 800 mW, the PDI Polar Plot alarm levels must be adjusted.

PD

Primary | Neutral PD | PD N-Less

Primary				
Phase	A	B	C	
				Imbalance
Events/cycle	0	0	0	0
Avg. Apparent Charge, pC	0	0	0	0
Max. Apparent Charge, pC	0	0	0	
Associated Power, mW	0	0	0	0

Figure 10-30: PD > Primary > Associated

To adjust the Associated Power Measurement alarm:

- Select **Alarms > PD Alarms Configuration** and expand the **Primary PDI** alarms as shown in Figure 10-31.
  - Adjust the **High** & **High-High** limits as required.

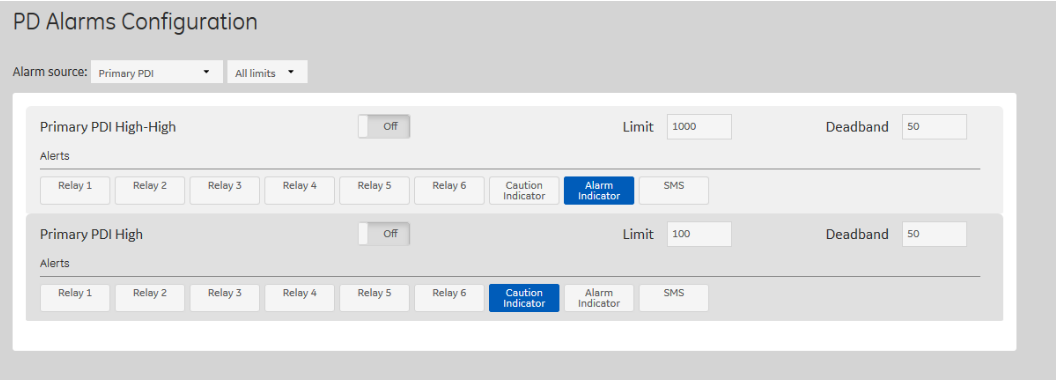
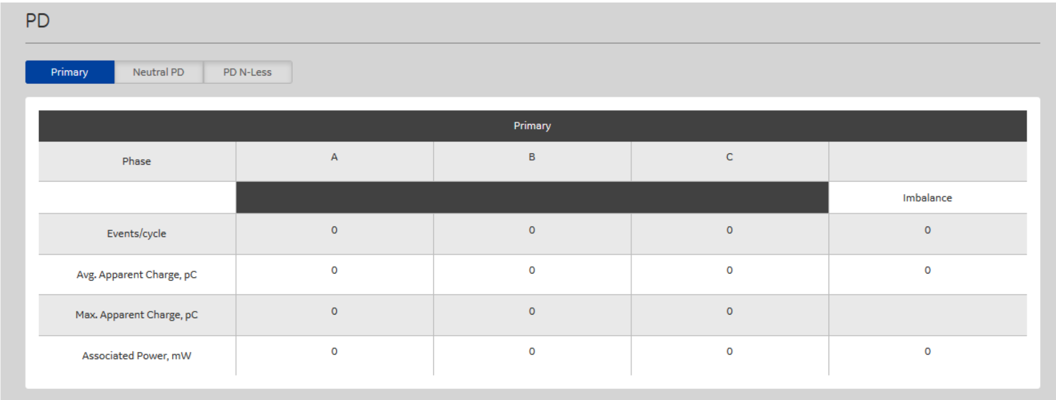


Figure 10-31: PD Alarms Configuration > Primary PDI

10.4.7 PD Average Apparent Charge Measurement

- Select **BMT > Live Measurement** and scroll down to the ‘PD’ section with the **Primary** tab active as shown in Figure 10-32. Ensure that:
  - Avg Apparent Charge measurement is below 800 pC for each phase. If above 800 pC, the PD Polar Plot Level Alarm must be adjusted.



PD

Primary | Neutral PD | PD N-Less

Primary				
Phase	A	B	C	
				Imbalance
Events/cycle	0	0	0	0
Avg. Apparent Charge, pC	0	0	0	0
Max. Apparent Charge, pC	0	0	0	
Associated Power, mW	0	0	0	0

Figure 10-32: PD > Primary > Avg Apparent Charge

To adjust the Associated Power Measurement alarm:

- Select **Alarms > PD Alarms Configuration** and expand the **Primary PD value** alarms as shown in Figure 10-33.
  - Adjust the **High** & **High-High** limits as required.

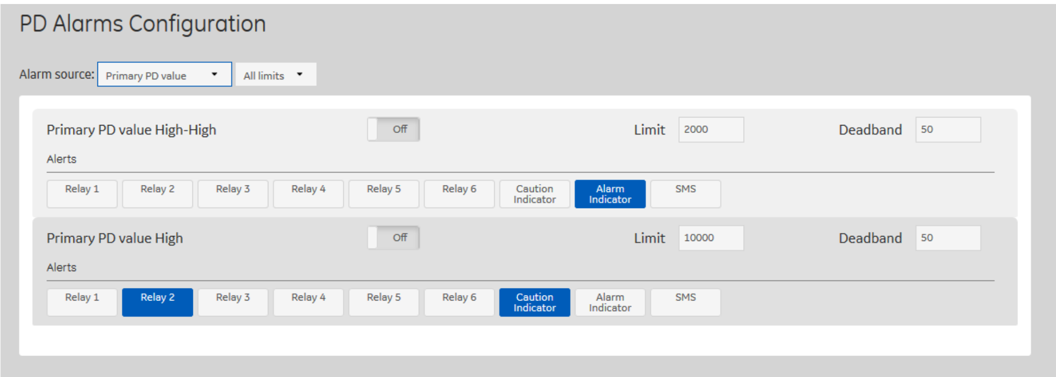
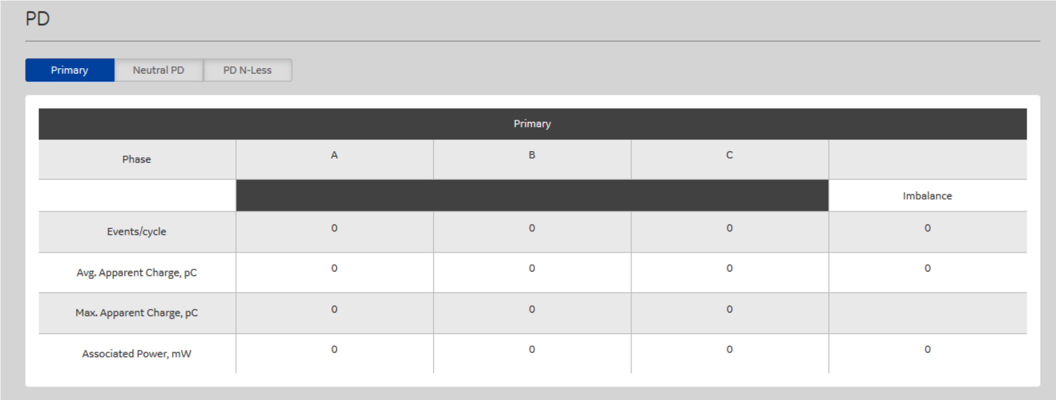


Figure 10-33: PD Alarms Configuration > Primary PD value

10.4.8 PD Max Apparent Charge Measurement

- Select **BMT > Live Measurement** and scroll down to the 'PD' section with the **Primary** tab active as shown in Figure 10-34. Ensure that:
  - PD Max Apparent Charge measurement is below 600 pC for each phase. If above 600 pC, the PD Max Level Alarm must be adjusted.



Primary				
Phase	A	B	C	
				Imbalance
Events/cycle	0	0	0	0
Avg. Apparent Charge, pC	0	0	0	0
Max. Apparent Charge, pC	0	0	0	
Associated Power, mW	0	0	0	0

Figure 10-34: PD > Primary > Max Apparent Charge

To adjust the PD Max Apparent Power Measurement alarms:

- Select **Alarms > PD Alarms Configuration** and expand the **Primary PD value**, **Primary B PD Max** and **Primary C PD Max** alarms as shown in Figure 10-35 to Figure 10-37.
  - Adjust the **High** & **High-High** limits as required for each phase.

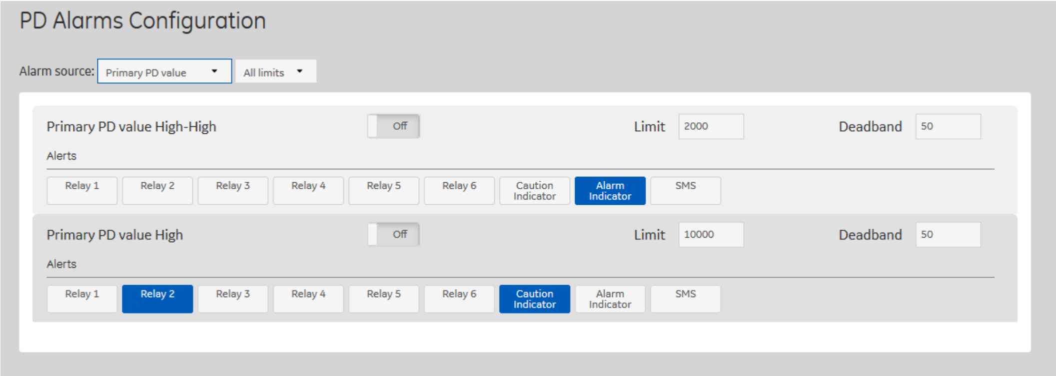


Figure 10-35: PD Alarms Configuration > Primary PD value

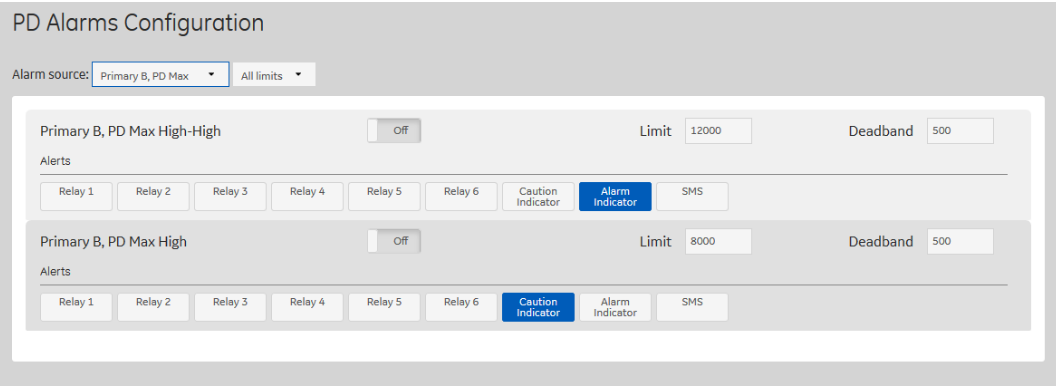


Figure 10-36: PD Alarms Configuration > Primary B PD Max

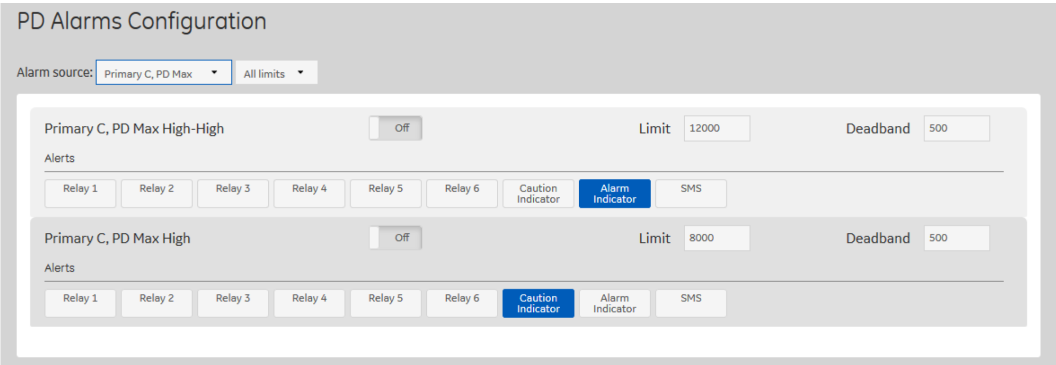


Figure 10-37: PD Alarms Configuration > Primary C PD Max

10.4.9 Export Setting

After the alarms are configured on the energised transformer, select **BMT > General Settings** and click **Export to PC** to retain a record of the configuration as shown in Figure 10-38.

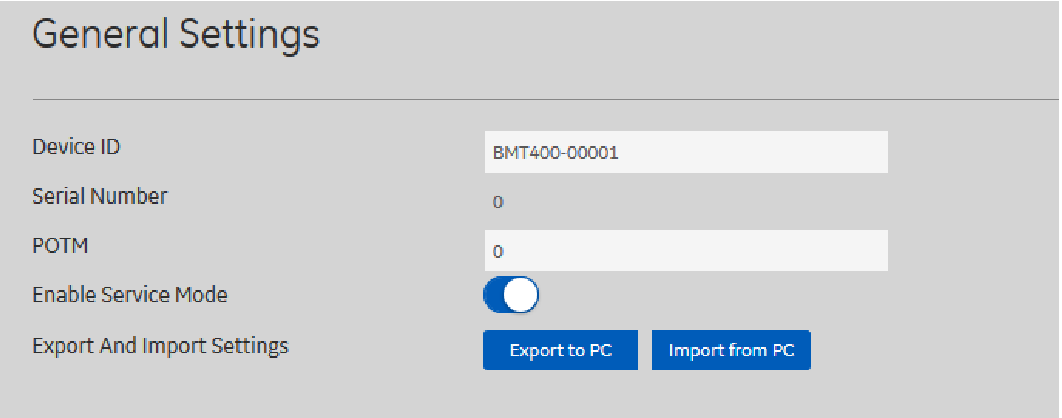


Figure 10-38: BMT > General Settings

10.4.10 Finalisation

After installation, ensure that the Bushing Adaptor failure alarms are all cleared as shown in Figure 10-39.

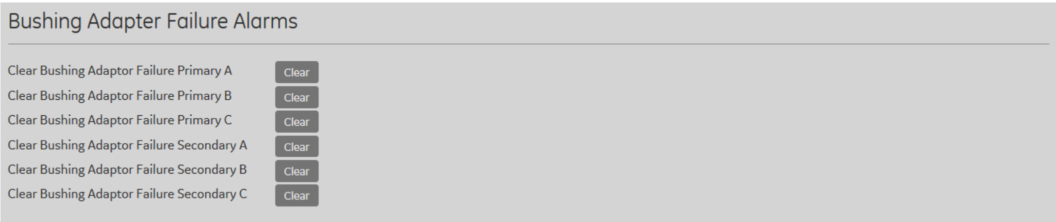


Figure 10-39: Bushing Adaptor Failure Alarms

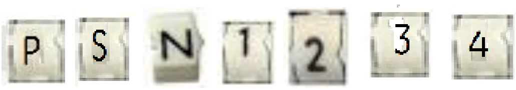
The parts, supplies and tools for the bushing and PD monitor installation are listed in Table A-1 to Table A-3 and are needed on site at the time of the installation.

Note: Confirm with GE Technical Support as lubricants and quantities are subject to change without prior notice.

A.1 GE-supplied items (shipped with the product)

Table A-1: GE-supplied items

Qty	Description
Standard Items	
1	DGA 900 Plus with Bushing and PD monitoring card
3	Primary Bushing Adaptors (primary installation)
3	Secondary Bushing Adaptors (secondary installation) Note: Each Bushing Adaptor is supplied with a full set of O-rings (and one spare set)
Up to 3	High Frequency CT (1 if a primary installation only)
Up to 3	Magnetically-Mounted Temperature Sensors (1 if a primary installation only)
1	Base stand (optional)
1	GPS antenna (supplied with 5 m cable)
Installation Kit	
1	Standard: RG58C/U 50 Ω coaxial cable (Belden P/N: 8262) to connect the Bushing Adaptor and Neutral CT to the product. Length to be determined from the pre-installation information (GE P/N = CABL02048). 500 ft reel. 
1	Standard three-phase transformer: 4-wire CANbus cable (Belden 8729) (20 m long) to connect the MMTS to the product. Three single phase transformer: 4-wire CANbus cable (Belden 8729) (152 m long) to connect the MMTS to the product (GE P/N is CABL02053).
	Hardware for coaxial cables connection:
15	Red pin terminals 18-22 AWG (Molex 19213-0009) 
1	Heat shrink 3/16 in. tubing 60 mm (2.4 in) 
1	Heat shrink ¼ in. tubing 60 mm (2.4 in) 

Qty	Description
6 of each (N x8)	Cable markers P, S, N, 1, 2, 3 and 4 
1	NYOGEL 753G (electrically conductive grease)
1	Thermal jointing compound (Wakefield Engineering, 120 series) (GE P/N: CONS01026)
1	Ethernet cable Ferrite (Würth 7427 154) when optional copper Ethernet module is ordered (GE P/N: ELEC04004)

A.2 GE Field Service Engineer (FSE)-supplied items

If GE performs the installation, the GE FSE will bring the following items:

Table A-2: GE FSE-supplied items

Qty	Description
1	Handheld multimeter 4½ digit with: ▪ Testing continuity capability ▪ AC voltage measurement (0.5%) ▪ Resistance measurement (0.5%) (Suggested model: Fluke 87 or 287 or equivalent).
>	Required material as described in 'Section 9.8 - Bushing Adaptor Circuit Integrity Test Record'.
1	27 mm socket to fit ½ in. square drive torque wrench
1	½ in. square drive torque wrench with a range of 10 - 100 Nm (7 – 73 lb ft)
1	1.25 N m torque screwdriver
1	3 mm ball hex blade for torque screwdriver
1	Ratchet crimp tool.

A.3 Customer-supplied Items

The following items are procured by the customer:

Table A-3: Customer-supplied items

Qty	Description
1	Armoured mains cable to power the product.
1	Grounding cable to connect primary protective earth terminal lug of the product cabinet to the ground.
>	Liquid-tight flexible metal conduit (½ in. and/or ¾ in.) to provide protection for the Bushing Adaptors' cables and Neutral CT cable (working temperature range: −55 °C to 105 °C recommended). Recommended models from Thomas & Betts: ▪ Metal conduit ½ in. liquid-tight, Model ATLA050 (length as required) ▪ Metal conduit ¾ in. liquid-tight, Model ATLA075 (length as required)
>	Liquid-tight metal fittings and gaskets for the Bushing Adaptor. Recommended model from Thomas & Betts: ▪ Liquid-tight fittings, ½ in. NPT, Model 5332-HT. ¾ in. NPT, Model 5333-HT ▪ Sealing gasket ½ in., Model 5262. ¾ in., Model 5263
>	Plastic conduit with enough length to provide protection for the temperature sensor cables (optional).
>	Cable trays and cable ties to run the cables.
1	RTV (Room Temperature Vulcanization: silicon-based mastic), 3M Super Silicone Sealant No. 8663 or equivalent for the MMTS.
1	Heat gun (for heat shrink)
>	General tools (drill, drill bits, screwdrivers, cutter and spanners)

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GA.support@ge.com

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