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Substation Standard

Dynamic Ratings E3 Transformer Manager Application and Settings Guide for Ergon Energy

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Abstract: The aim of this document is to outline the considerations and requirements for the design, construction and setting of the DR-E3 transformer monitor.

Keywords: Transformer, condition monitor, hottest spot, winding temperature, top oil temperature, OLTC, tap position

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DR E3 Transformer Manager Application and Settings Guide for Ergon Energy

1 Overview

1.1 Purpose

The purpose of this document is to outline the hardware, firmware, software, and settings to be employed when using a DR-E3 for power transformers on the Ergon Energy network.

Refer to the DRMCC-E3 PASG for all Energex power transformer applications.

1.2 Scope

This document is the application and settings guide for all Ergon Energy 2-winding and 3-winding power transformers that contain a DR-E3 with the matching part number and firmware versions outlined below. It is recognised that each brownfield transformer application will have various system configurations that require adjustments based on site conditions and designs.

The settings or hardware with a grey background are not to be modified. Any modifications to settings with a grey background shall be to approval of the relevant manager. The settings with a white background are determined on an application basis and will often require plant and site-specific details. All cells with a white background shall be subject to approval prior to installation.

Excluded from this DR-E3 application and setting guide are:

- How to connect and control
- How to download settings
- How to fault find and troubleshoot
- How to manage maintenance plans
- How to respond to operational requirements

This document is not intended to be a user guide.

2 References

2.1 Legislation, regulations, rules, and codes

National Electricity Rules, 2016 (AEMC)

Queensland Electricity Act, 1994 (Queensland Government)

Queensland Electricity Regulation, 2006 (Queensland Government)

Queensland Electrical Safety Act, 2002 (Queensland Government)

Queensland Electrical Safety Regulation, 2013 (Queensland Government)

Queensland Work Health and Safety Act, 2011 (Queensland Government)

Queensland Work Health and Safety Regulation, 2011 (Queensland Government)

2.2 Energy Queensland controlled documents

Plant Rating Manual – 4179110

2.3 Other sources

AS/NZS 60076-1:2014 Power Transformers – General Standards Australia

AS/NZS 60076-2:2013 Power transformers, Part 2: Temperature rise for liquid-immersed transformers Standards Australia

AS 60076-7:2013 Power transformers, Part 7: Loading guide for oil-immersed power transformers Standards Australia

DR-E3-001 Technical Specification Dynamic Ratings

DR-E3-102 Logic Flow diagram Dynamic Ratings

DR-E3-103 Control Unit Manual Dynamic Ratings

DR-E3-105 Commissioning Guide Dynamic Ratings

DR-E3-201 Interface Unit Manual Dynamic Ratings

DR-E3-202 Interface Unit Menu Dynamic Ratings

DR-E3-210 Thermal monitoring and cooling control manualDynamic Ratings

DR-E3-252 Monitoring and control manual Dynamic Ratings

DR-E3-303 DNP User Guide Dynamic Ratings

E3 – Variable Info DR-E3 SCADA Point List (REV 221012) Dynamic Ratings

Guide C Changing the Time and IP Address of the DR-E3 130928 Dynamic Ratings

1080676 (Shts 1-19) 32 MVA application SPEC 2006/0132/T – Item 71 EQL Drawings

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply.

Brownfield application	Installation of a DR-E3 in an existing transformer.
Cooler	Several radiators or heat exchangers providing the applied cooling methods. May include fans and/or pumps.
Download	Transfer files and data from the DR-E3 file system into a PC.
Energy Queensland substation	Refers to bulk supply, zone or C&I substations owned by Ergon Energy or Energex DNSP's. Excludes assets owned by Yurika.
Fan group	A group of fans which are switched on and off together.
Fibre	Multimode glass optical fibre, 50/100 or 62.5/125 micrometres diameter.
Greenfield application	Installation of a DR-E3 into a new transformer.
Heat exchanger	Device for heat transfer from hot fluid (oil, water or air) to cool fluid (water or air).
Menu	Refers to the menu server for the IU in the DR-E3

New Active Alarms	New Active Alarms is a list of all unacknowledged alarms present in the DR-E3.
Rating	Rated power as defined in AS and IEC standards.
RS-232	Serial communication link complying with EIA-232.
RS-485	Serial communication link complying with EIA-485.
Shall	Means mandatory
Should	Means advisory
Smart Auto	A proactive cooling control mode to proactively turn on cooling using calculated ultimate top oil and winding hot spot temperatures. This mode provides the ability to pre-cool the transformer when the monitor identifies a condition that could result in a relatively high transformer temperature. An example of such a condition is a sharp increase in transformer loading.
Spare	Means the feature is not used and is not assigned to any function within the relay (has no purpose in the application)
Unused	Means the feature has a purpose but is not used in this application
Upload	Transfer files and data from a PC into the DR-E3 file system.

3.2 Abbreviations

This list does not include well-known unambiguous abbreviations, or abbreviations defined at their first occurrence within the text.

AC	Alternating current
AVR	Automatic Voltage Regulation
BAU	Busing adapter unit
BHM	Bushing health monitor
CB	Circuit breaker
CF	Compact flash
CPU	Central processor unit
CT	Current transformer
CU	Control Unit
DC	Direct current
DGA	Dissolved gas analysis
DNP	Distributed network protocol
DR	Dynamic ratings.
FISO	Supplier of fibre optic sensors
GIC	Geomagnetically induced currents
HV	The high voltage winding – The winding having the highest rated voltage

IU	Interface Unit. Used to view and edit system parameters
LCD	Liquid crystal display
LED	Light emitting diode
LFT	Load for time. Given an assumed load, how long before the
	Transformer would exceed a specified thermal limit
LTC	Line tap control
LV	Low voltage winding – The winding having the lowest rated voltage
NC	Normally closed, state of contact
NO	Normally open, state of contact
OLTC	On Load Tap Changer, also known as an LTC
OTI	Oil Temperature Indicator – The device for measuring/determining the transformer tank top oil temperature
MV	Medium voltage
PDM	Partial discharge monitor
PELV	Protective extra low voltage
PF	Power factor
p.u.	Per unit A value of current, voltage, power etc divided by the rated value defined as 1.0 pu
RTC	Real Time Clock – The real time clock maintains the time of the DR-E3 while it is powered down. It is the only battery powered component in the system
RTD	Resistance temperature detector
RTU	Remote terminal unit
SBC	Single Board Computer – This is the board where the main CPU is located
SCADA	Supervisory control and data acquisition
SELV	Safety extra low voltage
SFTP	Secure File Transfer Protocol, used to transfer files over a secure connection
SSH	Secure Shell – Secure protocol used to connect to the DR-E3
TCIP	Tap change in progress signal typically derived from a cam switch in the LTC motor drive compartment to provide an indication when the LTC is changing taps
TF	Transformer
TFL	Time for load. Given a specific time duration, what is the maximum
	load the transformer could sustain without exceeding a specific limit
UHS	Ultimate Hot Spot – The calculated transformer winding hottest spot temperature the transformer will reach under the current loading, if all the available cooling is running. This is the value used by 'Smart' cooling
VT	Voltage transformer

WTI	Winding Temperature Indicator – The measured or calculated transformer winding hottest spot temperature
Z pu	Impedance per-unit

Authorities and responsibilities

The responsibility for the management of DR-E3 devices at EQL is as follows:

Table 1: E3 transformer monitor features

Authority	Responsibilities
Substation Standards	Substation Standard for DR-E3
SCADA design	RTU configuration and master station builds
Substation design	Compatibility of DR-E3 and auxiliary components
Wilson Transformers	Interface DR-E3 with transformer protection alarms, analogues and controls
Dynamic Ratings	Build, load and test the E3 settings

4 Hardware

4.1 General

The DR-E3 can be fitted to new transformers in the factory or retrofitted to existing transformers to monitor and control a single transformer. The DR-E3 is capable of interfacing with condition monitors and controlling cooling and tap changing. In Ergon Energy greenfield applications, the DR-E3 shall only be installed on transformers

1. Rated power (max. of all power ratings) 25MVA and larger
2. A voltage rating greater than 100kV
3. In special applications such as embedded generation.

Brownfield applications will depend on Asset Management requirements which will be outlined at the time of the request.

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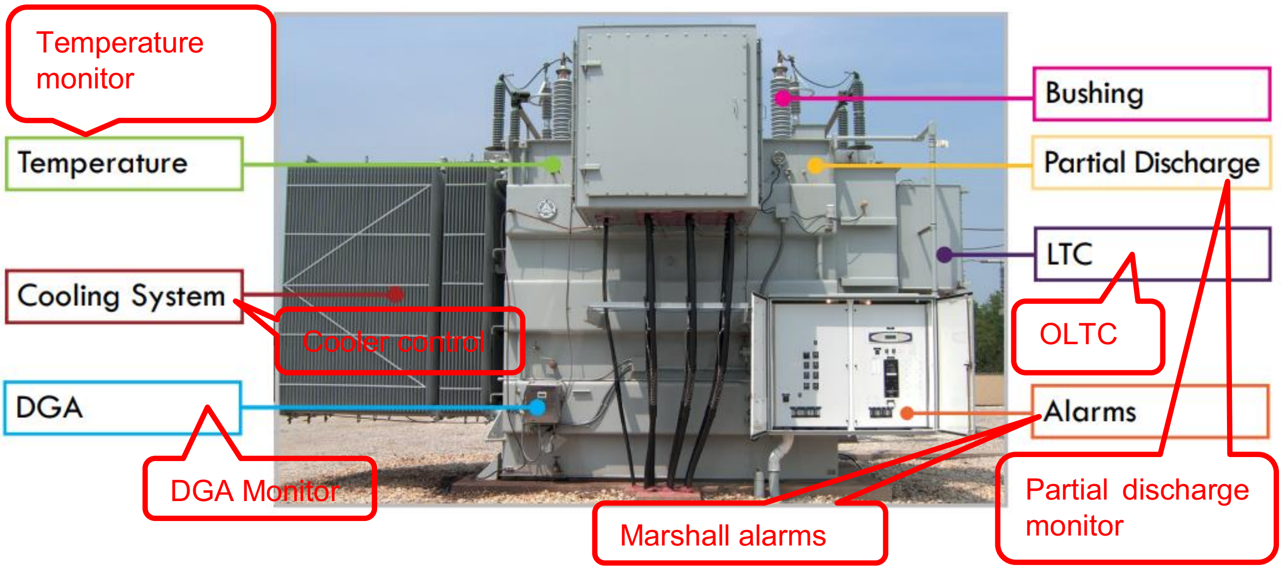


Figure 1: E3 transformer monitor features

The Ergon Energy greenfield application philosophy is to marshal all transformer alarms through the DR-E3 and send indications to SCADA via DNP. Any transformer functions that will trip, generated by devices external to the DR-E3 will be sent to the protection panels via copper wires. The DR-E3 will provide thermal monitoring, cooling control and temperature-based trips via copper wires. Ergon Energy RTU's will provide AVR for the transformer and then send controls to the DR-E3 via DNP which will be used to physically control the OLTC. Current-based harmonic monitoring will be provided in some Ergon Energy DR-E3 applications. The functions provided by the DR-E3 in all Greenfield applications are outlined in the table below.

Table 2: Operating features

Function	Features	Comment
Thermal monitoring of the transformer	Fibre optic input probes at specific locations in the core and coils, top oil temperature input, ambient temperature input, current input and tap position	The DR-E3 will monitor the transformer thermals.
Marshalling of alarms generated within the DR-E3	Winding temperature, oil temperature, harmonics, pump/fan failure	Digital inputs will be sent to SCADA via DNP
Marshalling of alarms generated external to the DR-DR-E3	Buchholz gas,Buchholz low oil, TF low/high oil, OLTC low/high oil, air bag leak, pump/fan/OLTC CB tripped, input voltage supply fail, OLTC upper/lower limits, main supply fail (PF)	Digital inputs will be sent to SCADA via DNP. Some of the digital inputs will be used by the DR-E3 code in calculations and controls
Status of controls and monitoring	Pump/fan run, pump/fan in auto/manual, cooling control inhibit, OLTC control remote, OLTC tap in progress, digital tap position, pump oil flow below threshold	Digital inputs will be used by the DR-E3 code in calculations and controls. Some of these digital inputs will be sent to SCADA via DNP
Control and tripping of certain external features	Pumps/fans on/off, OLTC raise/lower, winding temperature trip send, oil temperature trip send	Thermal monitoring will enable the DR-E3 to control pumps/fan and alarms/trips
External control of internal and external features	Pumps/fan on/off, fan speed, cooling control modes smart/standard, OLTC raise/lower, alarm acknowledgement	SCADA control via DNP
Analogue indications of transformer features	OLTC tap position, thermal status winding/oil/ambient temperatures, predictive thermal status TFL/LFT/ultimate temperature winding/oil	SCADA analogue indication via DNP

Brownfield applications will depend on the controls that are required, and the risks identified for condition monitoring. Consideration will need to be given on the transformer work being performed. An existing transformer that has been re-wound may have fibre probes fitted which will enable the DR-E3 to monitor thermals with the same level of accuracy as greenfield applications.

4.2 Control unit and external modules

The DR-E3 CU (control unit) is made up of individual modules:

1. CPU (central processor unit)
2. Power supply (includes internal 5A slow-blow fuse)
3. Communication module
4. A combination of input/output modules selected by the end user for the application

An IU (interface unit) will be supplied with all Ergon Energy greenfield applications. Brownfield applications will implement an IU on a case-by-case basis. Consideration will need to be given to panel indications if the IU is not supplied based on a communication failure.

Ergon Energy applications will contain the following cards and their locations within the CU for all greenfield applications. Brownfield applications are dependent on the features required.

Table 3: Card and slot allocation

Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7	Slot 8
A1.1	A1.2	A1.3	A1.4	A1.5	A1.6	A1.7	A1.8
Main processor (CPU)	Multi-port communication module	Digital input module	Digital input module	Digital input module	Digital output module	Analogue input/output module	Power supply module

Note: The DR-E3 power supply module has an internal 5A slow-blow fuse.

External modules can be connected to the CU via a communication path to the multi-port.

Table 4: External module allocation

External module	Measurement	Application	Comment
Fibre optic hot spot monitor	Direct winding temperature	Greenfield (and brownfield rewinds)	Fibres located at hottest spot on the winding/s and core.
Bushing health monitor (BMH)	Capacitance and power factor	Brownfield	Current summation method
Partial discharge monitor (PDM)	PD via BAU sensors on all applications and (Rogowski coils at 132kV and above or excessive noisy applications)	Brownfield	Rogowski coils are wrapped around the base of each bushing for noise cancellation
Oil analysis monitor	DGA and moisture	Brownfield	Various vendors can be connected to the DR-E3

Note: There are other external modules which may be applicable for brownfield applications, however these are the most common.

4.3 Voltage specification

Table 5: Rated maximum voltages and relevant measurement categories

Input/Output	Rated Maximum Operating Voltage	IEC 60664 Over-voltage Category
Power Input	275 V DC / 265 VAC 47-63 Hz	Category II
Power Output	24 VDC	Category I
Digital Inputs	125 V DC / 125 VAC 47-63 Hz	Category I
Digital Outputs	125 V DC / 125 VAC 47-63 Hz	Category I
Motor energy input	300VAC 47-63 Hz	Category I
VT Inputs	150 VAC 47-63 Hz	Category I
Analog Inputs (other)	24 VDC	Category I
Analog Outputs	24 VDC	Category I
Communications	24 VDC	Category I

4.4 Communication ports

Table 6: Communication ports

Port	Card/Connection Type	Function	Comment
Slot 1 CPU	Ethernet RJ45	10/100 base T Ethernet port	Engineering access while on site
Slot 1 CPU H1	USB-2 Type A	Peripheral IED's, download data or config. changes	Spare
Slot 1 CPU H2	USB-2 Type A	Peripheral IED's, download data or config. changes	Spare
Slot 1 CPU Client	USB-2 Type B	Peripheral IED's, download data or config. changes	Spare
Slot 1 CPU Console	USB-2 Type B	Peripheral IED's, download data or config. changes	Spare
Slot 1 CPU Fibre	Ethernet FX	Remote engineering access and SCADA	Port is for both SCADA and remote engineering access over ethernet via switch
Slot 1 CPU Local IU	Ethernet RJ45	Local IU	Local IU
Slot 1 CPU Console	RS – 232 DB9		Spare
Slot 1 flash card slot		Firmware	
Slot 2 Comms. Port 0	Fibre optic ST	SCADA	Unused
Slot 2 Comms. Port 1	RS – 232 DB9	Modem	Spare
Slot 2 Comms. Port 2	RS – 485	Hot spot module	Hot Spot Monitor
Slot 2 Comms. Port 3	Refer to analogue input section for voltage and current input cards.		
Slot 2 Comms. Port 4			
Slot 2 Comms. Port 5	Unused		
Slot 2 Comms. Port 6	Unused		
Slot 2 Comms. Port 7	Unused		

Table 7: Communication port on bushing health monitor (brownfield applications)

Port	Card/Connection Type	Function	Comment
RS-485	RS-485	Connection to DR-E3 control unit	
USB	USB-2 Type B	Data download and access	

Table 8: Communication ports on the fibre optic hotspot monitor

Port	Card/Connection Type	Function	Comment
RS – 485 4-wire	RS – 485 4-wire	Connection to DR-E3 control unit	Note: Old applications used RS-232
1	Fibre optic input	Hot spot probe 1	HV/series winding A-ph, unused
2	Fibre optic input	Hot spot probe 2	HV/series winding B-ph, unused
3	Fibre optic input	Hot spot probe 3	HV/series winding C-ph, unused
4	Fibre optic input	Hot spot probe 4	LV winding a-ph, unused
5	Fibre optic input	Hot spot probe 5	LV winding b-ph, Not available on legacy applications
6	Fibre optic input	Hot spot probe 6	LV winding c-ph, Not available on legacy applications

Note: The original DR-E3 applications used a four-fibre input external module (Luxtron). All new applications will use the FISO six-fibre input module.

Table 9: Communication port on the partial discharge monitor (brownfield applications)

Port	Card/Connection Type	Function	Comment
RS-485	RS-485	Connection to DR-E3 control unit	
USB	USB-2 Type B	Data download and access	

4.5 Digital inputs

Table 10: Digital inputs (3 x input modules)

Input	Digital Input	Terminals	Function	Comment
Slot 3	DI 1.0	1,2	Pump 1 control in auto*	Applications where pumps are employed (can be used for fans)
Slot 3	DI 1.1	3,4	Pump 1 on *	
Slot 3	DI 1.2	5,6	Pump 1 motor CB trip alarm *	
Slot 3	DI 1.3	7,8	Pump 2 control in auto*	
Slot 3	DI 1.4	9,10	Pump 2 on*	
Slot 3	DI 1.5	11,12	Pump 2 motor CB trip alarm *	
Slot 3	DI 1.6	13,14	Unused	
Slot 3	DI 1.7	15,16	Unused	
Slot 3	DI 1.8	17,18	Unused	
Slot 3	DI 1.9	19,20	Cooling control inhibit	Protection trip used to block fans and pumps
Slot 3	DI 1.10	21,12	3-Ph Main AC phase failure alarm (PF)	SCADA indication
Slot 3	DI 1.11	23,24	24 VDC supply monitor	inverted bit
Slot 4	DI 2.0	1,2	OLTC control in remote	SCADA indication
Slot 4	DI 2.1	3,4	Unused	
Slot 4	DI 2.2	5,6	OLTC tap-change in progress (TCIP)	Used by AVR code in RTU
Slot 4	DI 2.3	7,8	OLTC motor CB tripped alarm	SCADA indication
Slot 4	DI 2.4	9,10	OLTC tap position lower limit reached	Used by AVR code in RTU
Slot 4	DI 2.5	11,12	OLTC tap position upper limit reached	Used by AVR code in RTU
Slot 4	DI 2.6	13,14	Binary tap position input 1 (1)	
Slot 4	DI 2.7	15,16	Binary tap position input 2 (2)	
Slot 4	DI 2.8	17,18	Binary tap position input 3 (4)	

Input	Digital Input	Terminals	Function	Comment
Slot 4	DI 2.9	19,20	Binary tap position input 4 (8)	Used when digital TPI is available. Used by AVR code in RTU and SCADA indication.
Slot 4	DI 2.10	21,12	Binary tap position input 5 (16)	
Slot 4	DI 2.11	23,24	Unused	
Slot 5	DI 3.0	1,2	Buchholz relay alarm	SCADA indication
Slot 5	DI 3.1	3,4	Main tank low oil alarm	SCADA indication
Slot 5	DI 3.2	5,6	Main tank high oil alarm	SCADA indication
Slot 5	DI 3.3	7,8	OLTC low oil alarm	SCADA indication
Slot 5	DI 3.4	9,10	OLTC high oil alarm	SCADA indication
Slot 5	DI 3.5	11,12	Air bag leak detector alarm	SCADA indication
Slot 5	DI 3.6	13,14	Oil flow below set point alarm	ONLY used in pump applications
Slot 5	DI 3.7	15,16	Metrosil CTPU operation	Available for applications which include metrosils on CT's
Slot 5	DI 3.8	17,18	Unused	
Slot 5	DI 3.9	19,20	Unused	
Slot 5	DI 3.10	21,12	Unused	
Slot 5	DI 3.11	23,24	Unused	

* Digital inputs are shown for pumps only. These inputs can be pump or fan depending on the cooling system.

4.6 Digital outputs

Table 11: Digital outputs (1 x input modules)

Module	Digital Output	Terminals	Function	Comment
Slot 1	System fail	4,5 (NC)	Watchdog alarm	DR-E3 failed alarm
Slot 6	DO 2.0	2,3 (NC)	Pump 1 run *	Used when pump 1 available (Pump 1 runs if DR-E3 fails)
Slot 6	DO 2.1	5,4 (NO)	Pump 2 run *	Used when pump 2 available
Slot 6	DO 2.2	8,7 (NO)	Unused	
Slot 6	DO 2.3	11,10 (NO)	Winding temperature trip	Copper wire to protection panel
Slot 6	DO 2.4	14,13 (NO)	Oil temperature trip	Copper wire to protection panel
Slot 6	DO 2.5	17,16 (NO)	Common Alarm (Transformer voltage alarm, Tap-changer fail alarm, Cooling alarm, Ancillaries alarm)	Single contact used in applications with no communication where an alarm is provided via copper connection to the protection panel.
Slot 6	DO 2.6	20,19 (NO)	OLTC lower tap number (pulse)	Wired to lower contactor
Slot 6	DO 2.7	23,22 (NO)	OLTC raise tap number (pulse)	Wired to raise contactor

* Digital outputs are shown for pumps only. These outputs can be pump or fan depending on the cooling system.

Note: The oil flow contact is wired to the DR-E3. If the DR-E3 fails, there is no oil flow monitor. One oil flow monitor is used for both pump 1 and pump 2, sitting on the output side of piping.

A single output contact is used for all winding temperature trips in 2-winding and 3-winding applications as per design requirements. Ideally 3-winding applications would contain 2 or 3 winding temperature trips to deload via the isolated or weak terminals.

4.7 Analogue outputs

Table 12: Analogue outputs

Module	Analogue Output	Terminals	Function	Comment
Slot 7	AO 1.0	1,2,3,4	Unused	Unused
Slot 7	AO 1.1	5,6,7,8	Unused	Unused
Slot 7	AO 1.2	9,10,11,12	Unused	Unused
Slot 7	AO 1.3	13,14,15,16	Unused	Unused

4.8 Analogue inputs

Table 13: Analogue inputs

Module	Analogue Input	Terminals	Function	Comment
Slot 2	Port 3 (AC input)	1-I,2-C & 3-C,4-V	LV Amps/ LV VT	Voltage inputs are available if DR add voltage harmonic monitoring NOTE: 2-C and 3-C are bridged internally.
Slot 2	Port 4 (2 x CT)	CTa+,CTa- & CTb+,CTb-	HV Amps/(MV Amps or Spare)	Current and current-based harmonic monitoring NOTE: CTa- and CTb- are bridged internally. (2-winding/3-winding)
Slot 7	AI 1.0	1,2	Unused	
Slot 7	AI 1.1	3,4	Unused	
Slot 7	AI 1.2	5,6,7	RTD1 Top Oil	
Slot 7	AI 1.3	8,9,10	RTD2 Ambient. Temp	
Slot 7	AI 1.4	11,12	Tap Position	Used when there is no digital TPI (brownfield ONLY)
Slot 7	AI 1.5	14,15,16	Unused	

Current-based harmonic monitoring is to be implemented in all greenfield applications. Voltage-based harmonic monitoring is currently not available in the DR-E3, however an input card is available for future use if it does become available. Harmonic current-based monitoring is only available on the CT inputs associated with the communication card (slot 2).

5 Firmware

Table 14: Firmware details including the current approved version

Item	Version	Effective
DR-E3 Flash	4.5.0	20/03/2023
DR-E3 Flash	4.4.1	03/02/2023
DR-E3 Flash	3.3.1.4	15/11/2021
Main Module	2.12	15/11/2021
BHM	2.13	15/11/2021
PDM	2.12	15/11/2021
Rows will be added as new versions are approved – retaining the effective date for older approved versions		

The firmware version refers to a complete base CF card image containing the operating system and all required configuration files. There are transformer specific parameters shipped with each device to match the power transformer.

Firmware version 4.5.0 is to be implemented because it provides a fix for harmonic alarming by using the Australian standard periods and thresholds.

6 Passwords

The DR-E3 comes pre-programmed from the factory with default login usernames and passwords. During the installation and commissioning of the DR-E3 change the password to avoid issues with security.

7 I/O settings

7.1 Inputs

Table 15: Input settings (found in file cu_io and show where the inputs are located and their status)

Digital Input (hardware)	Index – module	Reference	Bit – Inverted	Comment
DI 1.0	0 – 0	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.1/Status"	Bit 0 – No	Pump 1 in Control In Auto
DI 1.1	1 – 0		Bit 1 – No	Pump 1 On
DI 1.2	2 – 0		Bit 2 – No	Pump 1 Motor CB Tripped Alarm
DI 1.3	3 – 0		Bit 0 – No	Pump 2 in Control In Auto

Digital Input (hardware)	Index – module	Reference	Bit – Inverted	Comment
DI 1.4	4 – 0	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.2/Status"	Bit 1 – No	Pump 2 On
DI 1.5	5 – 0		Bit 2 – No	Pump 2 Motor CB Tripped Alarm
DI 1.6	6 – 0			Unused
DI 1.7	7 – 0			Unused
DI 1.8	8 – 0			Unused
DI 1.9	9 – 0	"TransformerModelType1.default/CoolingControlSimple.default/DirectInhibit"	Bit 2 – No	Cooling control inhibit
DI 1.10	10 – 0	"TransformerModelType1.default/MiscAlms"	Bit 5 – No	Main Supply Phase Fail Alarm
DI 1.11	11 – 0	"TransformerModelType1.default/MiscAlms"	Bit 6 – Yes	24 VDC Supply Monitoring
DI 2.0	0 – 1	"TransformerModelType1.default/OLTCType1.1/Status"	Bit 0 – No	OLTC Control in Remote
DI 2.1	1 – 1			Unused
DI 2.2	2 – 1	"TransformerModelType1.default/OLTCType1.1/Status"	Bit 1 – No	Tap Changer In Progress
DI 2.3	3 – 1		Bit 2 – No	OLTC Motor CB Tripped Alarm
DI 2.4	4 – 1	"TransformerModelType1.default/OLTCType1.1/OutControl"		OLTC Lower Limit Reached
DI 2.5	5 – 1			OLTC Upper Limit Reached
DI 2.6	6 – 1	"TransformerModelType1.default/OLTCType1.1/TPITypeBinary.default/TapIn"	Bit 0 – No	Binary Tap Position 1 - Input 1
DI 2.7	7 – 1		Bit 1 – No	Binary Tap Position 2 - Input 2
DI 2.8	8 – 1		Bit 2 – No	Binary Tap Position 4 - Input 3
DI 2.9	9 – 1		Bit 3 – No	Binary Tap Position 8 - Input 4
DI 2.10	10 – 1		Bit 4 – No	Binary Tap Position 16 - Input 5
DI 2.11	11 – 1			Unused

Digital Input (hardware)	Index – module	Reference	Bit – Inverted	Comment
DI 3.0	0 – 2	"TransformerModelType1.default/TfBuchholz"	Bit 1 – No	Buchholz Relay Alarm
DI 3.1	1 – 2	"TransformerModelType1.default/TfOilLevelDig"	Bit 0 – No	Transformer Oil Level Low Alarm
DI 3.2	2 – 2		Bit 2 – No	Transformer Oil Level High Alarm
DI 3.3	3 – 2	"TransformerModelType1.default/OLTCType1.1/TCOilLevel"	Bit 0 – No	OLTC Oil Level Low Alarm
DI 3.4	4 – 2		Bit 2 – No	OLTC Oil Level High Alarm
DI 3.5	5 – 2	"TransformerModelType1.default/ConBagLeak"	Bit 0 – No	Air Bag Leak Detector Alarm
DI 3.6	6 – 2	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.1(2)/Status"	Bit 7 – No	Pump 1 Oil Flow Low (Pump 2 Oil Flow Low)
DI 3.7	7 – 2			Metrosil alarm
DI 3.8	8 – 2			Unused
DI 3.9	9 – 2			Unused
DI 3.10	10 – 2			Unused
DI 3.11	11 – 2			Unused

7.2 Outputs

Table 16: Output settings (found in file cu_io and show where the outputs are located and their status)

Digital Output (hardware)	Index – module	Reference	Bit – Inverted – pulse time	Comment
DO 2.0	0 – 0	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.1/OutControl"	Bit 1 – Yes – pulse 250	Pump 1 Run
DO 2.1	1 – 0	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.2/OutControl"	Bit 1 – No – pulse 250	Pump 2 Run
DO 2.2	2 – 0			Unused
DO 2.3	3 – 0	"TransformerModelType1.default/TRTeWHS"	Bit 0 – No – pulse 250	Winding Hot Spot Temprature Trip
DO 2.4	4 – 0	"TransformerModelType1.default/ThermalModel.default/TRTeTOTrip"	Bit 0 – No – pulse 250	Top Oil Temperature Trip
DO 2.5	5 – 0	"TransformerModelType1.default/MiscLogic"	Bit 0 – No – pulse 250	Common Alarm
DO 2.6	6 – 0	"TransformerModelType1.default/OLTCType1.1/OutControl"	Bit 0 – No – pulse 1000	OLTC Lower Tap Number
DO 2.7	7 – 0	"TransformerModelType1.default/OLTCType1.1/OutControl"	Bit 0 – No – pulse 1000	OLTC Raise Tap Number

7.3 Analogue Inputs

Table 17: Analogue settings (found in file cu_io and show where the inputs are located and their counts)

Analogue Input (hardware)	Index – module	Reference	max real / min real	Comment
AI 1.0	0 – 0			Unused
AI 1.1	1 – 0			Unused
AI 1.2	2 – 0	"TransformerModelType1.default/TeTankTopOil"	147.7 / -52	Transformer Top Oil Temperature
AI 1.3	3 – 0	"TransformerModelType1.default/TeAmbient"	147.7 / -52	Transformer Ambient Temperature
AI 1.4	4 – 0			Unused
AI 1.5	5 – 0			Unused

8 Configuration

Table 18: Transformer baseline settings (found in file – transformer and some of the settings are shown below using Barcaldine transformer 5 settings as an example)

Setting name	Value	Unit	Comments
SRef	32	MVA	Power rating
Build	Separate		
WindingQty	2		Number of windings
TappedWinding	Primary		Tap changer location
NTapMinTns	23		Min turns tap number
NTapMaxTns	1		Max turns tap number
VPuMinTns	0.825		Min turns voltage p.u.
VpuMaxTns	1.1		Max turns voltage p.u.
hasODCapabilities	Yes		Yes or No
NoLoadLoss	13452	Watts	From test report
numCoolers	1		
V1pu	66000	Volts	Voltage HV
I1pu	279.9	Amps	Amps HV
V1pu	22000	Volts	Voltage LV
I1pu	839.8	Amps	Amps LV
3-winding applications will include extra settings to ouline the tertiary details			

Table 19 below covers the common settings that can be used to confirm the correct site and transformer details.

Table 19: Transformer baseline settings (found in file – transformer and some of the settings are shown below using Barcaldine transformer 5 settings as an example)

Setting name	Value	Unit	Comments
Version number	DR-E3-4.4.1-2021-0719-0842		DR-E3 details
ID	503896_ERGON_P2125-01_TR		Transformer details
Site	BARCALDINE ZSS Tx5		Site details
SRef	32.000	MVA	Rated power fully forced
OilFlow	Directed		
ZpuHLMinTns	0.168900	Z pu	Impedance HV-LV min e.g. 16.89%Z
ZpuHLMaxTns	0.185200	Z pu	Impedance HV-LV max e.g. 18.52%Z
Tml Type (Primary)	HV		Primary terminal
RatedVoltage (Primary)	66000	Volts	Primary nominal Voltage
RatedCurrent (Primary)	279.900	Amps	Primary nominal current
Tml Type (Secondary)	LV		Secondary terminal
BushingCTRatio	175		CT ratio e.g. 600/5
DRCTRatio	333.333		Interposing CT e.g. 5A/5mA
RatedVoltage (Secondary)	22000	Volts	Secondary nominal Voltage
RatedCurrent (Secondary)	839.800	Amps	Secondary nominal current
BushingCTRatio	425		CT ratio e.g. 600/5
DRCTRatio	333.333		Interposing CT e.g. 5A/5mA
3-winding applications will include extra settings to outline the tertiary details			

9 Thermal monitor settings

9.1 General

Thermal monitoring shall be performed by the DR-E3 in all greenfield applications. Thermal monitoring will be available for use in brownfield transformer applications and should be considered during re-winds. Thermal monitoring involves the measurement of:

- Ambient temperature

- Top oil temperature
- Current on at least 1 transformer terminal (all terminals should be current monitored)
- Tap position
- Fibre hot spot temperature sensors where applicable

Thermal monitoring shall:

- Control the cooler
- Provide trips and alarms for oil and winding temperature

Table 20: Heat run and load loss results (found in the file -thermalCfg)

Setting	Value	Unit	Comments
"CoolingMode"	ONAN		Manufacturer heat run test results associated with ONAN parameters • Top oil temperature rise • Average winding temperature gradient
MVAofTest (ONAN)	25	MVA	
TapPositionofTest (ONAN)	23		
TestedTopOilRiseDegrees (ONAN)	45.1	K	
TestedWindingGradientDegrees (HV ONAN)	11.1	K	
TestedWindingGradientDegrees (LV ONAN)	10.8	K	
CoolingMode	ODAN		Manufacturer heat run test results associated with ODAN parameters • Top oil temperature rise • Average winding temperature gradient
MVAofTest (ODAN)	32	MVA	
TapPositionofTest (ODAN)	23		
TestedTopOilRiseDegrees (ODAN)	49.3	K	
TestedWindingGradientDegrees (HV ODAN)	13.0	K	
TestedWindingGradientDegrees (LV ODAN)	8.7	K	
SrefForLossAndImpedance	32	MVA	Power rating
ZMinTns	0.16890	Z pu	Impedance min turns e.g. 16.89%Z
ZMaxTns	0.18520	Z pu	Impedance max turns e.g. 18.52%Z
I2RLossMinTns	172020	W	Min turns I^2R losses
I2RLossMaxTns	149170	W	Max turns I^2R losses
LoadLossMinTns	196063	W	Min turns load losses
LoadLossMaxTns	176414	W	Max turns load losses
I2RLossPrincipleTap	156428	W	Nominal tap I^2R losses
LoadLossPrincipleTap	182991	W	Nominal tap load losses
3-winding applications will include extra settings for the tertiary			

Table 25 is associated with HV-LV Tml1="HV" and Tml2="LV". Extra terminal settings will need to be added for each winding where the settings will be supplied from the manufacturers test results.

9.2 Winding hot spot temperature

Table 21: Winding hotspot alarm and trip settings (found in file – "drConfig" and some of the settings that are available to be set for each transformer application are shown in the table below)

Setting name (hot spot)	Value/Enable	Unit	Comments
ALTeWHS	Yes		WTI alarm enabled or not enabled
ALTeWHSFastTrip	Yes		Fast trip is the alarming function
TeWHSAlarm	105	°C	WTI hot spot alarm level (105°C preferred)
TRTeWHS	Yes		WTI trip enabled or not enabled
TRTeWHSFastTrip	Yes		Fast trip is the tripping function
OnDelayTeWHSTrFast	1	sec	Hot spot fast trip delay
TeWHSFastTrip	125	°C	WTI hot spot alarm level (130°C preferred)

The primary (HV) winding temperature settings below are found in file - drConfig and provide the alarm and tripping enablers. WTI fast trip function is used to the HV and the LV winding. The LV and MV settings are a replica of the HV settings.

```
<WindingSimple Name="Primary">
   <AgingThermalMode Type="IEC" TypeOfGroup="thermal_standard"/>
   <AgeOneDay Value="0"/>
   <Age Value="0"/>
   <AgeYrs Value="0"/>
   <ALTeWHS Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="HV Winding Temperature Alarm"/>
   <ALTeWHSSlowTrip Enable="No" Group="Other" Delay="60" Email="No" Display="Yes" Text="HV slow trip timer"/>
   <TRTeWHSSlowTrip Enable="No" Group="Other" Delay="60" Email="No" Display="Yes" Text="HV slow trip"/>
   <ALTeWHSFastTrip Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="HV Trip Timer Activated"/>
   <TRTeWHSFastTrip Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="HV Winding Fast Trip"/>
   <TRTeWHSInstantTrip Enable="No" Group="Other" Delay="0" Email="No" Display="Yes" Text="HV Winding Instant Trip"/>
   <TRTeWHS Enable="Yes" Group="Other" Delay="0" Email="No" Display="No" Text="HV Winding Temperature Trip"/>
```

9.3 Oil temperature

Table 22: Oil temperature alarm and trip settings (found in file – "drConfig" and some of the settings that are available to be set for each transformer application are shown in the table below)

Setting name (hot spot)	Value/Enable	Unit	Comments
ALTeTO	Yes		OTI alarm enabled
TeTOAlarm	90	°C	OTI top oil alarm level (90°C preferred)
TRTeTOTrip	Yes		OTI trip enabled
TeTOInstantTrip	Yes		Instantaneous is the tripping function
TeTOInstantTrip	110	°C	OTI top oil trip level (115°C preferred)

The top oil temperature settings below are found in file - drConfig and provide tripping enablers. OTI instantaneous trip function is used for tripping where no delay is available.

```
<ALTeTO Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="Oil Temperature Alarm"/>
<ALTeTOSlowTrip Enable="No" Group="Other" Delay="0" Email="No" Display="Yes" Text="OTI slow trip timer"/>
<TRTeTOSlowTrip Enable="No" Group="Other" Delay="0" Email="No" Display="No" Text="OTI slow delay trip"/>
<ALTeTOFastTrip Enable="No" Group="Other" Delay="0" Email="No" Display="Yes" Text="OTI fast trip timer"/>
<TRTeTOFastTrip Enable="No" Group="Other" Delay="0" Email="No" Display="No" Text="OTI Fast delay trip"/>
<TRTeTOInstantTrip Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="Oil Temperature Instant Trip"/>
<TRTeTOTrip Enable="Yes" Group="Other" Delay="0" Email="No" Display="No" Text="Oil Temperature Trip"/>
<ALThermalModel Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="Thermal Model"/>
```

9.4 EQL Trips and alarms

EQL applications shall use the following settings in the table below unless the manufacturer recommends settings lower than these values to maintain transformer warranty. Alarm and trip settings may be increased on a case-by-case basis where operational requirements such as emergency ratings, high loading and nuisance tripping persists. The health and asset condition should be factored into the assessment.

Table 23: EQL trip and alarm levels (EQL Plant Ratings Manual)

Alarm and Trip Settings	**OTI (Top Oil)**	**WTI (Hotspot)**
Alarm	**90°C** (allows a margin between alarm and trip for operator response)	**105°C** (allows a margin between alarm and trip for operator response)
Trip (**without** WTI Indications to SCADA)	**105°C** (based on AS60076.7 normal cyclic loading)	**120°C** (based on AS60076.7 normal cyclic loading limit)
Trip (**with** WTI Indications to SCADA)	**115°C** (based on AS60076.7 emergency loading)	**130**°C (based on AS60076.7 emergency loading limit of 140°C less 10°C safety margin)

9.5 Temperature probes

Temperature fibre probes are fitted directly to the winding and core where the expected maximum temperature will be located. The Luxtron 4-channel hot spot fibre converter is only applicable for Yarranlea substation. The FISO 6-channel hot spot fibre converter is the current Ergon Energy standard and the settings below can be sourced in file – FISO_0. Low and high signal strength settings can also be found in file – FISO_0. All transformers purchased under the new contract (CW43101) and new technical specification will be delivered with 4 hot spot fibres per winding which will require more channels to the converter. The E3 shall be set up accordingly.

Table 24: Temperature fibre probe

Register	Reference	Comment	Comments (Ergon)
12321	"TransformerModelType1.default/DeviceMonitorSimple.default/MiscTypeFiberOptic.default/FiberOpticInputType1.1/TeFO1"	FISO_2 Temperature Channel 1	2-winding HV A-phase 3-winding HV/series A-phase
12323	"TransformerModelType1.default/DeviceMonitorSimple.default/MiscTypeFiberOptic.default/FiberOpticInputType1.1/TeFO2"	FISO_2 Temperature Channel 2	2-winding HV B-phase 3-winding HV/series B-phase
12325	"TransformerModelType1.default/DeviceMonitorSimple.default/MiscTypeFiberOptic.default/FiberOpticInputType1.1/TeFO3"	FISO_2 Temperature Channel 3	2-winding HV C-phase 3-winding HV/series C-phase
12327	"TransformerModelType1.default/DeviceMonitorSimple.default/MiscTypeFiberOptic.default/FiberOpticInputType1.1/TeFO4"	FISO_2 Temperature Channel 4	2-winding LV A-phase 3-winding LV A-phase
12329	"TransformerModelType1.default/DeviceMonitorSimple.default/MiscTypeFiberOptic.default/FiberOpticInputType1.1/TeFO5"	FISO_2 Temperature Channel 5	2-winding LV B-phase 3-winding LV B-phase
12331	"TransformerModelType1.default/DeviceMonitorSimple.default/MiscTypeFiberOptic.default/FiberOpticInputType1.1/TeFO6"	FISO_2 Temperature Channel 6	2-winding LV C-phase 3-winding LV C-phase

9.6 Time for load and load for time

The time for load and load for time settings can be found in file – “drConfig” and are shown below.

```
<CalcTimeForLoad Name="TimeRemaining">
   <UseRealTimeAmb Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeTO Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeWHS Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeTap Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeLoad Type="Yes" TypeOfGroup="yes_no"/>
   <RatingType Type="ShortTimeEm" TypeOfGroup="rating"/>
   <IpuLoadLimit Value="1.300"/>
   <TeTOLimit Value="115.000"/>
   <TeWHSLimit Value="130.000"/>
</CalcTimeForLoad>
<CalcLoadForTime Name="MaxLoad">
   <UseRealTimeAmb Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeTO Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeWHS Type="Yes" TypeOfGroup="yes_no"/>
   <UseRealTimeTap Type="Yes" TypeOfGroup="yes_no"/>
   <RatingType Type="ShortTimeEm" TypeOfGroup="rating"/>
   <TimeEm Value="1440"/>
   <IpuLoadLimit Value="1.300"/>
   <TeTOLimit Value="115.000"/>
   <TeWHSLimit Value="130.000"/>
```

10 Cooling system settings

Cooling control requires the thermal monitor settings to be applied. Cooling control shall be performed by the DR-E3 in all new applications where pumps or fans are implemented. Cooling control will be available for use in brownfield transformer applications. Cooling control requires hard-wired inputs to indicate the status of controls and outputs for fans and/or pumps operation.

The winding hot spot temperatures are calculated for each winding (common and series for auto-transformers). The higher of the calculated hot spot values and measured fibre optic hot spot monitors is then used to control the coolers (pumps and fans).

Table 25: Cooling system settings (found in file – "drConfig" and some of the settings that are available to be set for each transformer application)

Setting name	Value	Unit	Comments
OperateMode	CoSmart		
TeTOPumpOn	50	°C	Top oil pump on (50°C preferred)
TeTOPumpBw	10	°C	Top oil pump hysteresis (10°C preferred)
TeWHSPumpOn	60	°C	Winding hot spot pump on (60°C preferred)
TeWHSPumpBw	10	°C	Winding hot spot hysteresis (10°C preferred)
TeUTOPumpOn	105	°C	Ultimate top oil pump on
TeUTOPumpBw	30	°C	Ultimate top oil pump hysteresis
TeUWHSPumpOn	115	°C	Ultimate winding hot spot pump on
TeUWHSPumpBw	30	°C	Ultimate winding hot spot pump hysteresis

DR provide an option to implement predictive "SMART cooling" to minimise insulation loss of life. There shall be a DNP SCADA control point to enable smart cooling in the DR-E3 for all greenfield applications. Ultimate temperature cooling control is shown in the table above with the "U" designator and is a predictive oil and winding temperature based on thermal and electrical models using transformer losses, nameplate information and raw inputs. The ultimate temperatures are in vogue when "SMART cooling" is enabled. The temperature figures are based on all available cooling running where the steady state load will reach the ultimate temperature settings. Refer to Annex C for more information on "SMART cooling".

Pump alarm settings can be found in file – drConfig and they are shown below. Pump 1 will be the main and pump 2 the standby. The oil flow alarm will trigger after 60 seconds and there are other delays for each alarm. Pump 2 is set the same with standby replacing main.

```
<PumpSimple Name="1">
   <DutyCycleRole Type="Main" TypeOfGroup="main_standby"/>
   <OFLGivenPeriod Value="300"/>
   <OFLMaxOccurrences Value="1"/>
   <PCGivenPeriod Value="300"/>
   <PCMaxOccurrences Value="1"/>
   <StartCounter Value="0"/>
   <RunTimeSec Value="0"/>
   <Status Value="0"/>
   <ALContactorFail Enable="Yes" Group="Other" Delay="6" Email="No" Display="Yes" Text="Pump 1 Contactor"/>
   <ALCBTrip Enable="Yes" Group="Other" Delay="3" Email="No" Display="Yes" Text="Pump 1 CB Trip"/>
   <ALNotInService Enable="Yes" Group="Other" Delay="3" Email="No" Display="Yes" Text="Pump 1 Not in Service"/>
   <ALPumpOilFlowLow Enable="Yes" Group="Other" Delay="60" Email="No" Display="Yes" Text="Pump 1 Oil Flow Low"/>
   <ALCurrentLow Enable="No" Group="Other" Delay="15" Email="No" Display="Yes" Text="C1 Pump1 crnt low"/>
   <ALCurrentHigh Enable="No" Group="Other" Delay="15" Email="No" Display="Yes" Text="C1 Pump1 crnt high"/>
   <ALTrCrnt Enable="No" Group="Other" Delay="6" Email="No" Display="Yes" Text="C1 Pump1 CTI"/>
   <ALPowerFail Enable="Yes" Group="Other" Delay="3" Email="No" Display="Yes" Text="Pump 1 Power Fail"/>
   <ALPumpCtlPwr Enable="Yes" Group="Other" Delay="3" Email="No" Display="Yes" Text="Pump 1 Control Power Fail"/>
   <ALInhibit Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="Cooler 1 Pump 1 Inhibited"/>
   <ALFail Enable="Yes" Group="Other" Delay="0" Email="No" Display="No" Text="Pump 1 Fail"/>
```

EQL applications shall use the following settings in the table 28 below unless the manufacturer recommends settings lower than these values to maintain transformer warranty. The following settings are applicable to non-predictive cooling

Table 26: EQL cooling settings (EQL plant ratings manual)

Cooling Settings	**WTI** (subtract 10 degrees if OTI is used for fans/pumps)	
	ON	**OFF**
Cooling 1 (normally **pumps**)	**60**	**50**
Cooling 2 (normally **fans**)	**65**	**55**
	If fans are the only cooling device, these settings (65/55) still apply.	

Main and standby pumps can be implemented and the duty cycle of each set to alternate their usage. Automatic cooler testing is conducted by the DR-E3 and the table below shows the settings. The pump with the lowest run time by “DutyCyclePumpRunTimeBW” the will be the next to operate.

Table 27: Pump duty cycle settings

Setting name	**Value**	**Unit**	**Comments**
EnablePumpDutyCycle	Yes		Pumps with alternate
DutyCyclePumpScheme	RunTime		Based on run time
DutyCyclePumpRunTimeBW	1	Hour	Time between alternating pumps.

11 Alarms

Table 28: Alarm naming and mapping of alarms (found in file – drAlarm)

Alarm	Map	Comment
Systems alarm	<AlmMap> <AL ID="ALSystem"> <AL ID="ALTrCurrent"/> <AL ID="ALTrVoltage"/> <AL ID="ALThermal"/> <AL ID="ALTrTap"/> <AL ID="ALCUIOProcessFail"/> <AL ID="ALModbusTimeOut"/> <AL ID="ALMBIOProcessFail"/> <AL ID="ALDNPSCADASERProcessFail"/> <AL ID="ALLoggerProcessFail"/> <AL ID="ALTCPServ"/> <AL ID="ALClkBat"/> <AL ID="ALCPUTemp"/> </AL>	Hardware fault with DR-E3 or any other I/O connected. *ALTrCurrent – Any current transducer alarm* *ALTrCurrent – Any voltage transducer alarm* *ALThermal – ALThermalMaodel – problem with WTI or OTI calculations* *ALTrTap – Tap transducer alarm*
Voltage and current transducer alarms	<AL ID="ALTrVoltage"> </AL> <AL ID="ALTrCurrent"> <AL ID="ALTrIctHVb"/> <AL ID="ALTrIctLVb"/>	Out of range *ALTrIctHVb – current tranducer HV* *ALTrIctLVb – current tranducer LV* MV to be added to 3-winding applications
HV and LV WTI alarms and trips	<AL ID="ALTeWHS"> <AL ID="ALTeWHS_HV"/> <AL ID="ALTeWHS_LV"/> </AL> <AL ID="TRTeWHS"> <AL ID="TRTeWHS_HV"/> <AL ID="TRTeWHS_LV"/>	Te – temperature WHS – Winding hot spot MV to be added to 3-winding applications
Oil level alarms	</AL> <AL ID="ALTfOilLow"> <AL ID="ALTfOilDigLow"/> </AL> <AL ID="ALTfOilHigh"> <AL ID="ALTfOilDigHigh"/> </AL> <AL ID="ALTfOilLevel"> <AL ID="ALTfOilLow"/> <AL ID="ALTfOilHigh"/> </AL>	Dig – digital input of oil level status "ALTfOilLevel" – is a combination of high and low from the digital inputs.

Combination of all miscellaneous alarms.	`<AL ID="ALMiscFail">`
	`<AL ID="ALMisc0"/>`
	`<AL ID="ALMisc1"/>`
	`<AL ID="ALMisc2"/>`
	`<AL ID="ALMisc3"/>`
	`<AL ID="ALMisc4"/>`
	`<AL ID="ALMisc5"/>`
	`<AL ID="ALMisc6"/>`
	`<AL ID="ALMisc7"/>`
	`</AL>`
		"ALMisc5" – Main supply phase fail alarm
		"ALMisc" – 24 VDC supply fail alarm

Combination of ancillary alarms	`</AL>`
	`<AL ID="ALAncillary">`
	`<AL ID="ALMiscFail"/>`
	`<AL ID="ALTfOilLevel"/>`
	`<AL ID="ALTfBuchholzGas"/>`
	`<AL ID="ALConBagLeak"/>`
	`<AL ID="ALTCOilLevel"/>`
	`</AL>`
		Main supply phase fail alarm, 24 VDC supply fail alarm, TF main tank low oil, TF main tank high oil, Buccholz alarm, bladder leak alarm, OLTC oil level low, OLTC oil level high

Cooling pump 1 alarms	`</AL>`
	`<AL ID="ALPump11">`
	`<AL ID="ALPump11Pwr"/>`
	`<AL ID="ALPump11Contactor"/>`
	`<AL ID="ALPump11OilFlowLow"/>`
	`<AL ID="ALPump11CBTrip"/>`
	`<AL ID="ALPump11NoService"/>`
	`<AL ID="ALPump11CtlPwr"/>`
	`</AL>`
		All pump 1 checks

Cooling pump 2 alarms	`</AL>`
	`<AL ID="ALPump12">`
	`<AL ID="ALPump12Pwr"/>`
	`<AL ID="ALPump12Contactor"/>`
	`<AL ID="ALPump12OilFlowLow"/>`
	`<AL ID="ALPump12CBTrip"/>`
	`<AL ID="ALPump12NoService"/>`
	`<AL ID="ALPump12CtlPwr"/>`
	`</AL>`
		All pump 2 checks

Cooling control fail and cooler (fans or pumps) fail alarms	`</AL>`
	`<AL ID="ALCCFail">`
	`<AL ID="ALMiscCCFail">`
	`<AL ID="ALMiscCCAlm0"/>`
	`</AL>`
	`<AL ID="ALCoolerFail">`
	`<AL ID="ALPump11"/>`
	`<AL ID="ALPump12"/>`
	`<AL ID="ALMainPumpFail"/>`
	`<AL ID="ALMiscCCAlm0"/>`
		"ALMiscCCAlm0" – "ALMisc0"

All inhibits applied to cooling system	`</AL>`
	`<AL ID="ALAnyCoolingInhibit">`
	`<AL ID="ALAllFansInhibit"/>`
	`<AL ID="ALAllPumpsInhibit"/>`
	`<AL ID="ALAllCoolingInhibit"/>`
	`<AL ID="ALCooler1FansInhibit"/>`
	`<AL ID="ALCooler1PumpsInhibit"/>`
	`<AL ID="ALCooler1AllInhibit"/>`
	`<AL ID="ALPump11Inhibit"/>`
	`<AL ID="ALPump12Inhibit"/>`
	`</AL>`	

OLTC fail	</AL> <AL ID="ALTCFail"> <AL ID="ALTCTooLong"/> <AL ID="ALTCMotTrip"/> <AL ID="ALTCNotRemote"/> <AL ID="ALTCDirError"/> <AL ID="ALTCStepError"/> <AL ID="ALTCPwr"/> <AL ID="ALTCTooManyTaps"/> </AL>	Combination of tap changer alarms
OTI and WTI trip alarms	</AL> <AL ID="TRTeTOTrip"> <AL ID="TRTeTOInstantTrip"/> </AL> <AL ID="TRTeWHS_HV"> <AL ID="TRTeWHSFastTrip_HV"/> </AL> <AL ID="TRTeWHS_LV"> <AL ID="TRTeWHSFastTrip_LV"/> </AL>	

Table 29: Common alarm logic (located in file – calculator and is shown in the table below)

Alarm	Map	Comment
Common	<Operation OpType="OR" Assign="Common Alarm"> <!-- <Input Name="TRFR Voltage"/> --> <Input Name="Tap Changer Fail"/> <Input Name="Cooling"/> <Input Name="Ancillaries-Main Supply Fail"/> <Input Name="24VDC Supply"/> <Input Name="FISO Winding HST Monitor System Alarm"/> </Operation>	Each application has a common alarm contact available to send a hardwired alarm to a panel indication or legacy communication device

12 Harmonic measurement settings

Harmonic measurement will be performed in some Ergon Energy applications. Current-based harmonic measurement can be performed on CT inputs in the communication module (the analogue input card doesn't support harmonic monitoring). Harmonic measurements are performed on the current input on the communication module in slot 2 on port 3 and 4. Previous firmware versions to 4.5.0 alarmed when the even to odd harmonic ratio reached a settable threshold which was designed to monitor GIC events. Firmware version 4.5.0 follows IEEE 519.

Table 30: Harmonic measurement settings (found in file – "drConfig" and some of the settings that are available to be set for each transformer application)

Setting name	Value	Unit	Comments
HarmonicCurrent Name	1		Harmonic monitor number
CardPort Value	4		Port on communication module
CustomizedLabel Text	HV B Phase		TF terminal
BushingCTRatio	175		CT ratio e.g. 600/5
DRCTRatio	333.333		Interposing CT e.g. 5A/5mA
RatedCurrent	279.9	Amps	Nominal current

The following alarm settings are associated with the HV harmonic monitor where both incorporate a delay 5 seconds. The setting the table above and the below are replicated on the MV and LV.

```
<ALFltCrnt Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="CT 1 Fault Count High"/>
<ALTHDRatio Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="CT 1 THD Ratio High "/>
```

13 Tap-changer control settings

On-load tap changer AVR shall be performed by the Foxboro RTU in all Ergon Energy greenfield applications. The DR-E3 shall provide an interface between the RTU and all field controls and indication. The RTU will source the voltage supply from a VT and send raise/lower commands to the OLTC via DR-E3 communication channel. All field indications such as, tap change in progress, lower/upper limit and tap position will also be supplied via communication path between the DR-E3 and RTU. Brownfield applications will depend on site specific requirements.

Table 31: Tap changer settings (found in file – drConfig)

Setting name	Value	Unit	Comments
TapKind Type	DelayedTC		
NTapMaxTns Value	1		Max tap voltage position
NTapMinTns Value	23		Min tap voltage position
VpuMaxTns Value	1.1	p.u.	Voltage range high (72.6/66=1.1)
VpuMinTns Value	0.825	p.u.	Voltage range low (54.45/66=0.825)

Reference – VoltageControlType1/OLTCType1 Name =1

The following settings can be found in file "drConfig" and shall be applied in all greenfield applications.

```
<ALTrTap Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TPI Transducer"/>
<ALPowerFail Enable="No" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC Power Fail"/>
<ALMotorTrip Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC Motor Trip"/>
<ALNotRemote Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC Not in Remote"/>
<ALTCTapPosUpperLimit Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC tap upper limit reached"/>
<ALTCTapPosLowerLimit Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC tap lower limit reached"/>
<ALTCOilLow Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC Oil Level Low"/>
<ALTCOilHigh Enable="Yes" Group="Other" Delay="5" Email="No" Display="Yes" Text="TC oil Level high"/>
<ALTCIPTooLong Enable="Yes" Group="Other" Delay="15" Email="No" Display="Yes" Text="Tap Change Too Long"/>
<ALFail Enable="Yes" Group="Other" Delay="0" Email="No" Display="No" Text="TC Fail"/>
<TPITypeBinary Name="default">
   <TPI_BUF Value="7"/>
   <ALFail Enable="Yes" Group="Other" Delay="0" Email="No" Display="Yes" Text="TPI Fail"/>
```

14 Email Settings

The DR-E3 has the ability to send an email to a certain address with fault details. This function is not used in Ergon Energy greenfield applications, it may be used in brownfield applications at the discretion of asset maintenance. The email enablers can be found in file – drConfig for all alarm types. The email addresses and other settings can be found in file – email.

15 Bushing monitor settings

Bushing monitoring will only be available in brownfield transformer applications at the discretion of asset maintenance. The DR-E3 bushing monitor involves connecting the CU via communication channel to an external module. The external monitor implements BAU sensors on the bushing test/voltage tap. The BAU sensors provide current from each bushing to a summation unit which is fed into the DR-E3. The hardware and settings will be decided by asset maintenance.

16 Dissolved gas analyser settings

Dissolved gas analysis will only be available in brownfield transformer applications at the discretion of asset maintenance. An external monitor that may be capable of measuring dissolved gases and/or moisture is connected to the DR-E3 via a communication link. The hardware and settings will be decided by asset maintenance.

17 Partial discharge settings

Partial discharge analysis will only be available in brownfield transformer applications at the discretion of asset maintenance. Partial discharge can be measured electrically by connecting a PD sensor to the bushing test/voltage tap. An acoustic method can also be employed which adds an extra module. The acoustic method requires a Rogowski coil wrapped around the base of the bushing. The hardware and settings will be decided by asset maintenance

18 DNP Communications (SCADA)

18.1 Port settings

Ethernet communication shall be implemented in all Ergon Energy DNP applications. The CPU fibre “COMM PORT 100 Base FX” shall be connected to an ethernet switch. The CPU fibre port will be used for DNP and remote engineering access. The IP address of the E3 is not entered in settings file, it is entered directly into the E3.

Table 32: DNP communication port settings(found in file "file - dnp_scada_net")

Keyword	Value	Comment
ROLE_SLAVE Address	42	Port address (often last octet of the IP address)
Net Host	0.0.0.0	DR-E3 IP address (leave as all zeros when engineering access and DNP over single LAN connection)
Port	20000	IP port number preferred 20000
Protocol	TCP	

A DNP port communication failure alarm will appear at the IU and the settings can be found in file – drConfig.

DNP settings (Option):

var_AnalogIn="1" var_AnalogOut="1" var_BinaryIn="2" var_BinaryOut="1" var_AnalogChange="2" var_BinaryChange="2" master_timeout="10" integrity_interval="60" max_timeouts="3" link_timeout="3000" confirm_timeout="5000" response_timeout="2500" local_timezone="yes" allow_timesync="yes" request_mode="static" multi_sync="no"

18.2 RTU digit inputs

The following table outlines the SCADA digital input points which are provided to an RTU via DNP communications in Ergon Energy applications.

- All digital input points shall be class 1
- All digital input points shall be read only

Table 33: DNP SCADA digital inputs (found in file - dnp_scada_net)

Index	Reference	Bit – Inverted	Comment (Within E3 code)	Comment (Ergon)
0	"TransformerModelType1.default/OLTCType1.1/TPITypeBinary.default/TapIn"	Bit 0 - No	Binary Tap Position 1	Tap position bit 1
1		Bit 1 - No	Binary Tap Position 2	Tap position bit 2
2		Bit 2 - No	Binary Tap Position 3	Tap position bit 4
3		Bit 3 - No	Binary Tap Position 4	Tap position bit 8
4		Bit 4 - No	Binary Tap Position 5	Tap position bit 16

Index	Reference	Bit – Inverted	Comment (Within E3 code)	Comment (Ergon)
5	"TransformerModelType1.default/OLTCType1.1/Status"	Bit 1 - No	Tap Change in Progress	TCIP
6	"TransformerModelType1.default/OLTCType1.1/ALFail"	Bit 0 - No	Any TC Alarm	OLTC general alarm
7	"TransformerModelType1.default/OLTCType1.1/Status"	Bit 0 - Yes	OLTC Control in "Remote"	OLTC control in remote/local at TC mashalling box
8	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.1/State"	Bit 1 - No	Pump 1 started	Pump 1 is running
9	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.2/State"	Bit 1 - No	Pump 2 started	Pump 2 is running
10	"TransformerModelType1.default/ALTfBuchholzGas"	Bit 0 - No	Buchholz Gas Alarm	Buchholz relay gas alarm
11	"TransformerModelType1.default/WindingSimple.Primary/ALTeWHS"	Bit 0 - No	HV Hot Spot Temperature Alarm	HV WTI Alarm
12	"TransformerModelType1.default/WindingSimple.Secondary/ALTeWHS"	Bit 0 - No	L/MV Hot Spot Temperature Alarm	2-winding LV WTI Alarm 3-winding MV WTI Alarm
13	"TransformerModelType1.default/ThermalModel.default/ALTeTO"	Bit 0 - No	Oil Temperature Alarm	Top oil temperature alarm
14	"TransformerModelType1.default/ALTfOilLow"	Bit 0 - No	Transformer Oil Level Low	Main transformer tank oil level low
15	"TransformerModelType1.default/ALTfOilHigh"	Bit 0 - No	Transformer Oil Level High	Main transformer tank oil level high
16	"TransformerModelType1.default/OLTCType1.1/ALTCoilLow"	Bit 0 - No	OLTC Oil Low Alarm	OLTC oil level low
17	"TransformerModelType1.default/OLTCType1.1/ALTCoilHigh"	Bit 0 - No	OLTC Oil High Alarm	OLTC oil level high
18	"TransformerModelType1.default/OLTCType1.1/ALMotorTrip"	Bit 0 - No	OLTC Motor Trip Alarm	OLTC motor supply CB tripped
19	"TransformerModelType1.default/CoolingControlSimple.default/ALFail"	Bit 0 - No	Cooler Fail Alarm	General pump alarm
20	"TransformerModelType1.default/ALConBagLeak"	Bit 0 - No	Air Bag Leak Detector Alarm	Bladder alarm

Index	Reference	Bit – Inverted	Comment (Within E3 code)	Comment (Ergon)
21	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/OperateMode"	Bit 2 - No	Cooler in manual Control Mode	Indication that the pumps are in manual control mode within E3. Not auto or smart mode.
22	"ALSystem"	Bit 0 - No	DRMCC System Alarm	DR-E3 general alarm
23	"TransformerModelType1.default/ALMisc5"	Bit 0 - No	Earthing Transformer 1 Buchholz Gas Alarm	Unused
24	"TransformerModelType1.default/ALMisc6"	Bit 0 - No	Earthing Transformer 1 Oil Temperature Alarm	Unused
25	"TransformerModelType1.default/ALMisc2"	Bit 0 - No	Earthing Transformer 2 Buchholz Gas Alarm	Unused
26	"TransformerModelType1.default/ALMisc3"	Bit 0 - No	Earthing Transformer 2 Oil Temperature Alarm	Unused
27	"DummyHold"	Bit 0 - No	Spare - LV2 WHS Alarm	Unused
28	"TransformerModelType1.default/ALMisc4"	Bit 0 - No	Regen Breather Alarm	Unused
29	"TransformerModelType1.default/ALMisc0"	Bit 0 - No	Three-phase supply/phase phase fail	Main incoming 415VAC supply fail or rotation alarm.
30	"TransformerModelType1.default/ALMisc1"	Bit 0 - No	24 VDC supply monitoring	24 VDC supply for digital inputs alarm
31	"TransformerModelType1.default/ALMisc7"	Bit 0 - No	FISO System Alarm	Hot spot fibre monitor alarm (FISO to E3 comms failure or FISO hardware fail)
32	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.1/ALCBTrip"	Bit 0 - No	Cooler 1 Pump 1 CB Trip	Pump 1 supply CB tripped

Index	Reference	Bit – Inverted	Comment (Within E3 code)	Comment (Ergon)
33	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.2/ALCBTrip"	Bit 0 - No	Cooler 1 Pump 2 CB Trip	Pump 2 supply CB tripped
34	"TransformerModelType1.default/OLTCType1.1/ALMisc0"	Bit 0 - No	OLTC lower Limit Reached	Tap position minimum reached
35	"TransformerModelType1.default/OLTCType1.1/ALMisc1"	Bit 0 - No	OLTC Upper Limit Reached	Tap position maximum reached
36	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.1/Status"	Bit 0 -Yes	Cooler 1 Pump 1 not in auto	Pump 1 in manual control
37	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/PumpSimple.2/Status"	Bit 0 -Yes	Cooler 1 Pump 2 not in auto	Pump 2 in manual control
38a	"DummyHold"	Bit 0 - No	Unused	2-winding unused
38b	"TransformerModelType1.default/WindingSimple.Tertiary/ALTeWHS"	Bit 0 - No	LV Hot Spot Temperature Alarm	3-winding LV WTI Alarm

18.3 RTU digital outputs (control points)

The following table outlines the SCADA digital points which are provided as controls by the RTU via DNP communications in Ergon Energy applications.

- All digital outputs shall be class 0
- All digital outputs shall be read/write

Table 34: DNP SCADA digital outputs (found in file - dnp_scada_net)

Index	Reference	Bit - Invert	Op	Comment (Within E3 code)	Comment (Ergon)
0	"TransformerModelType1.default/VoltageControlType1.default/RemoteManualTapCtrl"	Bit 0 - No	T0	Scada OLTC Control - Lower	Lower tap number
0		Bit 2 - No	C0	Scada OLTC Control - Raise	Raise tap number
1	TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/OperateMode	Bit 2 - No	T0	Cooler 1 Mode Control - Manual	E3 cooling in manual
1		Bit 4 - No	C0	Cooler 1 Mode Control - Smart	E3 cooling in smart (type of auto)
3	"TransformerModelType1.default/CoolingControlSimple.default/CoolerTypeRads.1/ManMainPumpCtl"	Bit 0 - No	T0	Manual Cooler 1 Pump Control – Stop	Turn off the pump that is running
3		Bit 2 - No	C0	Manual Cooler 1 Pump Control – Start	Turn on a pump. The E3 decides which pump will be started
5	"DummyHold"	Bit 0 - No	T0		Spare for fans
5		Bit 2 - No	C0		Spare for fans
7	"AckAlms"	Bit 2 - No	T0	Acknowledge Alarms	Acknowledge alarms

18.4 RTU analogue inputs

The following table outlines the SCADA analogue read only points which are provided to an RTU via DNP communications in Ergon Energy applications.

- All analogue input points shall be class 2
- All analogue input points shall be read only

Table 35: DNP SCADA analogue inputs (found in file - dnp_scada_net)

Index	Reference	Gradient – Offset	Comment (Within E3 code)	Comment (Ergon)
0	"TransformerModelType1.default/TeAmbient"	40.96 – 0 (short)	Ambient Temperature	Ambient temperature 1°C = 40.96 count
1	"TransformerModelType1.default/TeTankTopOil"	27.30 – 0 (short)	Top Oil Temperature	Top oil temperature 1°C = 27.30 count

Index	Reference	Gradient – Offset	Comment (Within E3 code)	Comment (Ergon)
2	"TransformerModelType1.default/WindingSimple.Secondary/TeWHS"	27.30 – 0 (short)	L/MV Windings Hot Spot Temperature	Maximum of measured or calculated hot spot temperature 2-winding LV 3-winding MV 1°C = 27.30 count
3	"TransformerModelType1.default/WindingSimple.Primary/TeWHS"	27.30 – 0 (short)	HV Windings Hot Spot Temperature	Maximum of measured or calculated hot spot temperature on HV 1°C = 27.30 count
4	"TransformerModelType1.default/CoolingControlSimple.default/TeUWHS"	27.30 – 0 (short)	Ultimate Hot Spot Temperature	Expected ultimate hot spot is calculated based on heat run results using ambient temperature if all cooling is running 1°C = 27.30 count
5a	"DummyHold"	27.30 – 0 (short)	Unused	2-winding Unused
5b	"TransformerModelType1.default/WindingSimple.Tertiary/TeWHS"	27.30 – 0 (short)	LV Winding Hot Spot Temperature	3-winding LV or Dual-winding LV2 Maximum of measured or calculated hot spot temperature 1°C = 27.30 count
6	"TransformerModelType1.default/ThermalModel.default/CalcTimeForLoad.TimeRemaining/TimeToReachAnyLimit"	1 – 0 (short)	Time for Load	Time remaining before any thermal limit is reached, based on current load and all cooling working
7	"TransformerModelType1.default/ThermalModel.default/CalcLoadForTime.MaxLoad/LoadMVAToReachAnyLimit"	0.0001 – 0 (short)	Load for Time	Load allowable before reaching any thermal limit 100kVA = 1 count

“Short” is 2 bytes, Count is the Gradient x temperature (e.g. 27.3 counts/ x 150°C = 4095 count), Offset is shift in count.

Annex A

Informative

Ergon Energy application rational

1. The hot spot and oil temperature tripping relays -K31 and -K32 are to be supplied from the 110VDC input.
   - More reliable source compared to being supplied by the 24 VDC.
   - A loss of 24 VDC will cause the FISO to fail however the oil temperature trips will not be affected and the winding temperature trips based on current and oil temp will not be affected.
   - Although the 110VDC supply implies more voltages to work within the panel and non-SELV/PELV the benefits are greater having a more reliable supply to maintain tripping.
   - High speed operation is not required for temperature trips and the preference is to not provide a clean contact from the DR-E3 to the protection panel.

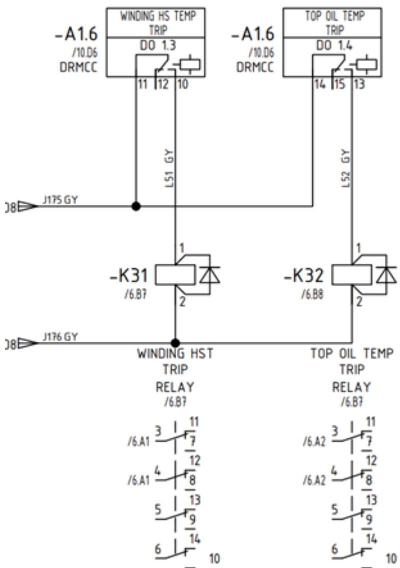


Figure 2: Winding and oil temperature trips

2. The FISO power supply can only be 24 VDC (wide-range power supply not available), there is no allowance for 110VDC power supply. Ideally the FISO would be supplied directly from the 110VDC supply removing any possible 24 VDC failures. The FISO watchdog is not required, any hardware faults are sent as a system alarm to the DR-E3. A complete failure of the FISO will cause a communication failure to the DR-E3 which will generate a system alarm in the DR-E3.

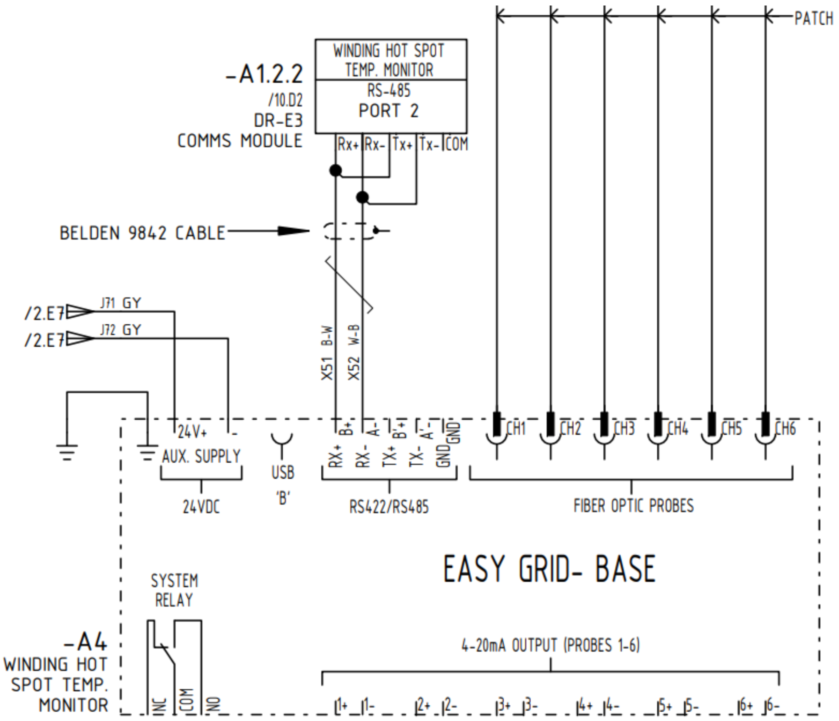


Figure 3: FISO converter

3. The TPI encoder is a single output type which doesn't require a power supply (i.e. no internal relays). The single output supplies the DR-E3 digital inputs. Single output encoders are more reliable and there is no demand for a second output.

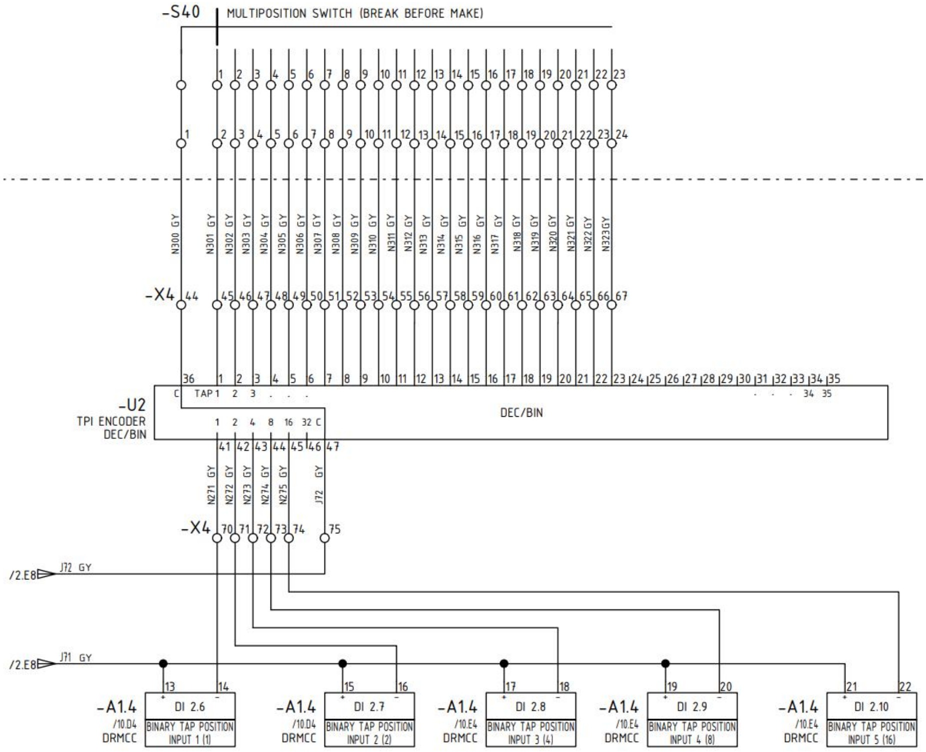


Figure 4: TPI encoder

4. There will be no tap position transducer connected to the tap changer, the encoder is all that's required. Field crews won't need to manage something that is not used in Ergon Energy applications.

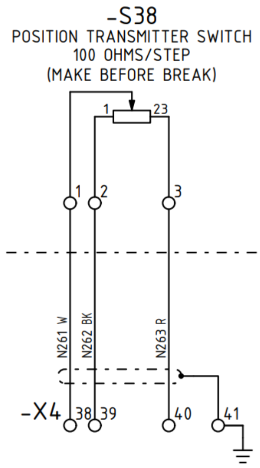


Figure 5: Analogue tap position transducer connection

5. -K1 phase failure (rotation) relay is located on the main 3-phase supply. If the -Q1 is isolated for work, the DR-E3 will alarm to indicate the supply has been removed. If a fuse on the main supply operates the -K1 will operate.

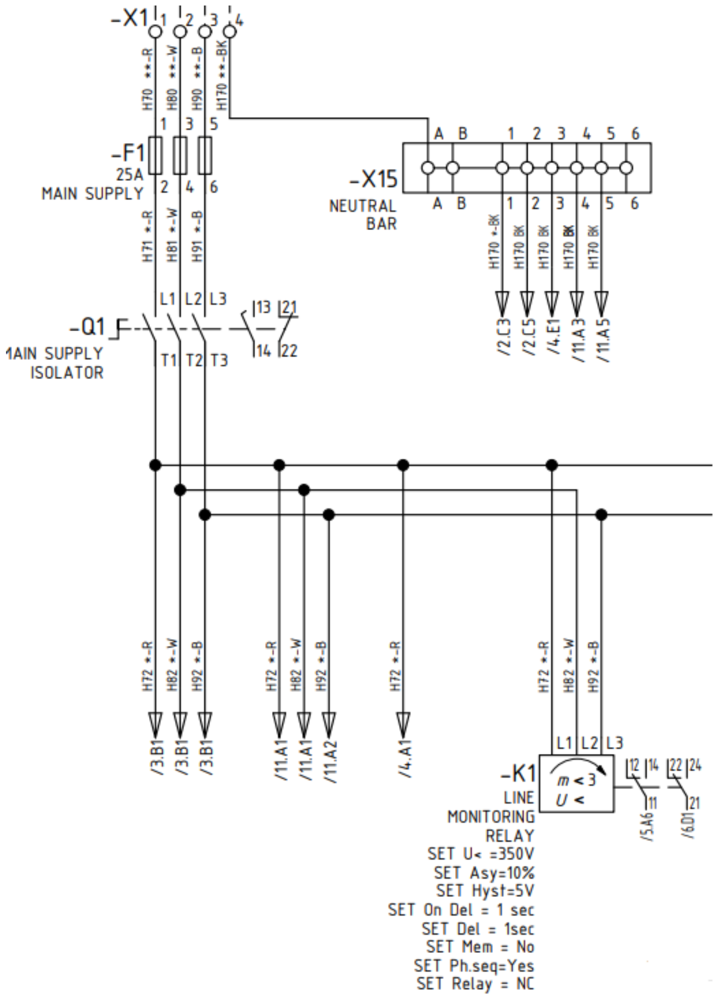


Figure 6: K1 phase failure relay and 415VAC supply

6. The DR-E3 layout is shown below.

- Current harmonic monitoring is only available in the CT input modules in the communication module. The CT inputs on the “analogue input/output” card don’t support harmonic measurement and Ergon Energy applications may require harmonic monitoring.
- A voltage input module has been supplied for voltage harmonic monitoring if DR make it available in the future. If Watts, Vars and voltage is required, supply the DR-E3 with the correct voltage.

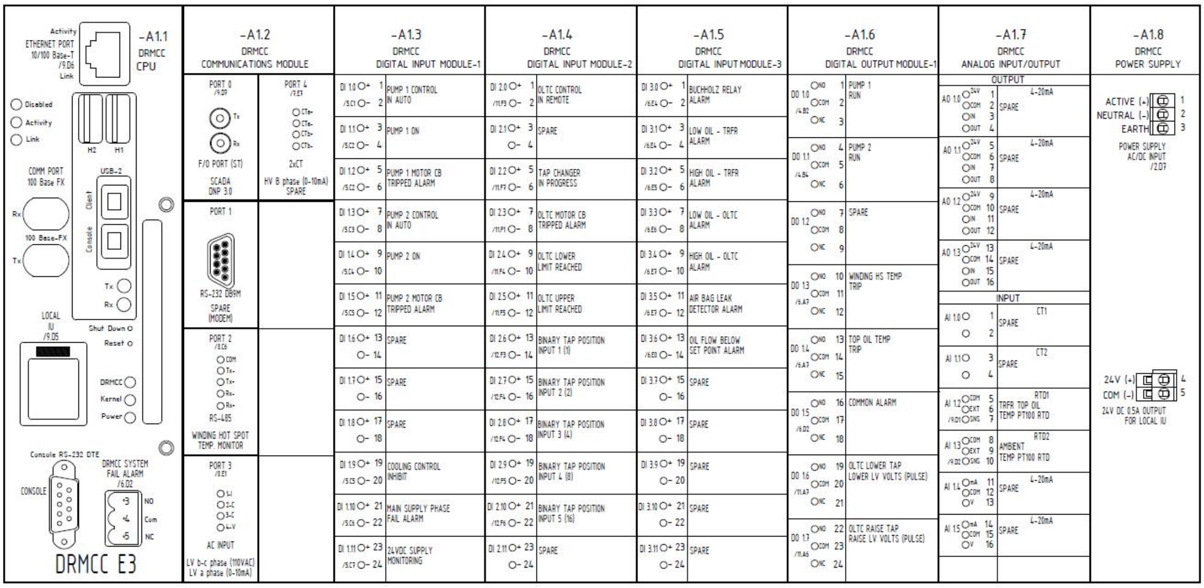


Figure 7: E3 layout

7. The IU is powered through the ethernet connection, so doesn't require an external power supply.

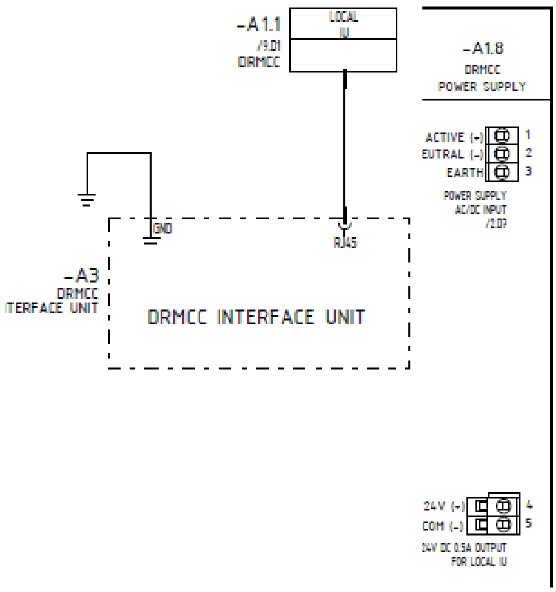


Figure 8: Interface unit and power supply

8. The 110VDC to 24 VDC converter (assuming Omron S8VK-G or equivalent) is self-protecting for overload conditions. The output voltage will collapse at 121% of rated output current and cycle the process until the fault is repaired.

- No fuses are required on the 24 VDC side of the converter (a fuse would need to be well below 121% of the rated current for it to operate correctly)

- -X1 terminal positives 19, 20, 21, 22 and negatives 23, 24, 25, 26 are all knife blades to allow isolation and sectionalising each circuit from the source for fault finding.
- -X1 terminals 22 and 26 are the supervisory supply monitor into the DR-E3 digital input. It is located at the end of the looping to ensure connection to each circuit.

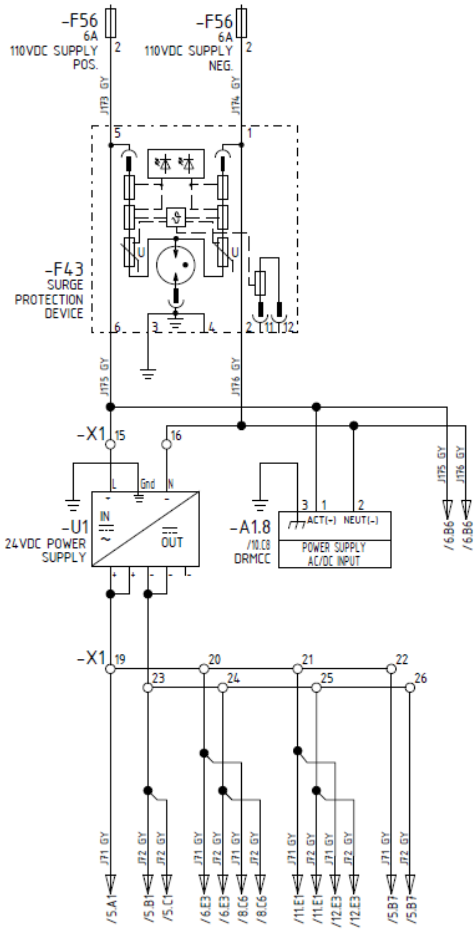


Figure 9: 110 VDC and 24 VDC supply

9. In transformer applications with oil pumps soft starters are implemented to control the inrush and minimise the oil disturbance, reducing the risk of tripping an oil surge relay.

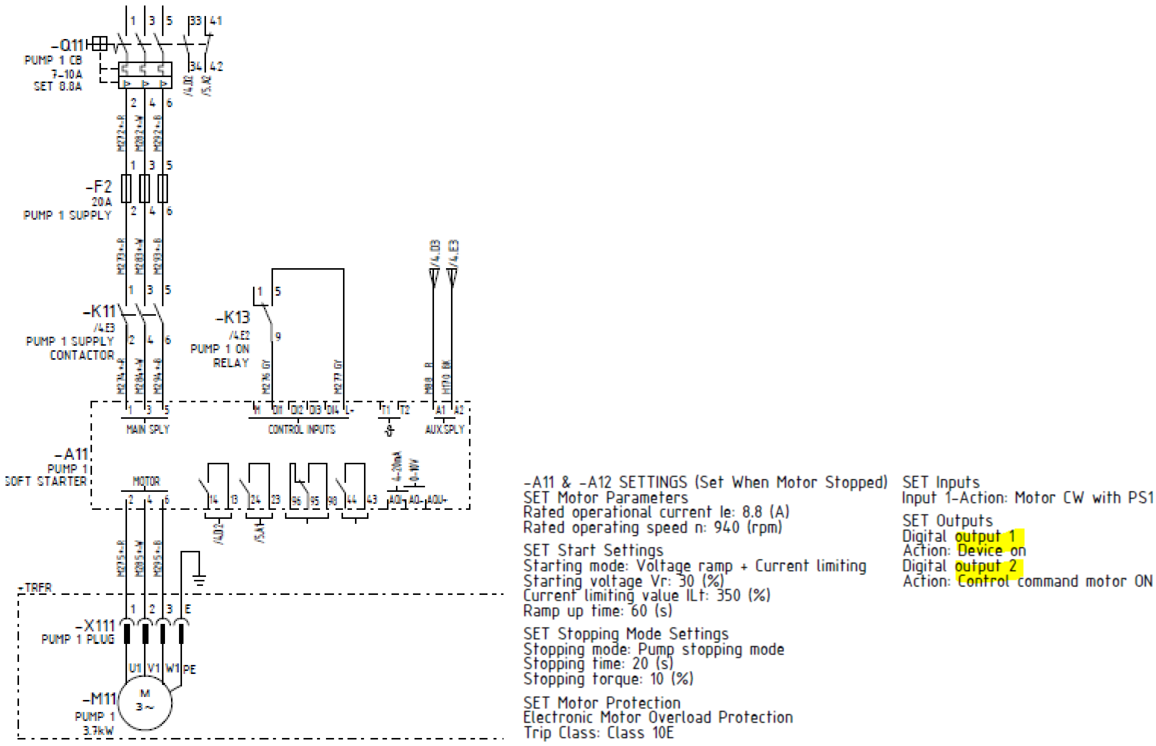


Figure 10: Pump starter and pump starter settings

Assuming the Siemens 3RW5513-1HA14 or equivalent, the following outputs can be configured.

Operating principle

The 3RW55 and 3RW55 Failsafe soft starters have 4 digital outputs (DQ1 = output 13, 14; DQ2 = output 23, 24; DQ3 = output 95, 96, 98; DQ4 = output 43, 44 or output 41, 42 (F-RQ)) with which external actuators such as a brake contactor or indicator lamp can be activated.

Using the output actions, you can assign an output action to the digital outputs. Digital output 3 is permanently assigned to the output action "Group error". The 3RW55 Failsafe soft starter has a safety signaling output (output 4, F-RQ). This output cannot be parameterized. The remaining outputs of the 3RW55 and 3RW55 Failsafe soft starters can be assigned an output action independently of one another.

Ergon Energy applications provide two contacts from the soft starter. One contact is in the pump run control circuit when the soft starter 240VAC electronic supply is healthy. The second contact is used by the DR-E3 to indicate the pump is running.

Output action	Description	Factory setting			
		DQ1	DQ2	DQ3[1]	DQ4[2]
No action	-	-	x	-	x
Activation by external control sources					
Control source PIQ-DQ-1.0 output 1	The control command "Output 1" is assigned to the corresponding digital output. Refer to chapter Control via 3RW5 HMI High Feature.	-	-	-	-
Control source PIQ-DQ-1.1 output 2	The control command "Output 2" is assigned to the corresponding digital output. Refer to chapter Control via 3RW5 HMI High Feature.	-	-	-	-
Control source PIQ-DQ-2.0 output 3[3]	The control command "Output 3" is assigned to the corresponding digital output. Refer to chapter Control via 3RW5 HMI High Feature.	-	-	-	-
Control source input 1	Digital output is activated by "Digital input 1".	-	-	-	-
Control source input 2	Digital output is activated by "Digital input 2".	-	-	-	-
Control source input 3	Digital output is activated by "Digital input 3".	-	-	-	-
Control source input 4	Digital output is activated by "Digital input 4".	-	-	-	-
Activation by means of soft starter					
Start-up	For further information, refer to the diagram in chapter Operating principle.	-	-	-	-
Operation / bypass		-	-	-	-
Stopping		-	-	-	-
On time motor (RUN)		x	-	-	-
Operation / Run-down		-	-	-	-
Control command MOTOR ON (ON)	The output is activated for as long as the control command "Motor CW" or "Motor CCW" is present.	-	-	-	-
DC brake contactor[3]	The output action controls a DC braking contactor via this output. You will find more information in chapter DC braking with external braking contactors.	-	-	-	-
Device ON	The output is active for as long as the electronic supply is present at the 3RW55 or 3RW55 Failsafe soft starter.	-	-	-	-
Activation by signals from the soft starter					
Group warning	Group signals	-	-	-	-
Group error		-	-	x	-
Bus error		-	-	-	-
Device error		-	-	-	-
Reversing switching element - right	The internal control signal for the reversing function is assigned to the corresponding digital output of the soft starter.	-	-	-	-
Reversing switching element - left		-	-	-	-
Generator operation	Status messages	-	-	-	-
Ready to start for motor ON		-	-	-	-
Pump cleaning active		-	-	-	-
Alternative stopping mode active		-	-	-	-
External bypass[3], [4]		-	-	-	-
CM - maintenance demanded		-	-	-	-
CM - error		-	-	-	-

[1] Permanently set to the output action "Group error".
[2] For 3RW55 Failsafe soft starters, this is the safety signaling output (output 4, F-RQ). This output cannot be parameterized.
[3] Output action is not available for the 3RW55 Failsafe soft starter.
[4] 3RW55 soft starter from firmware version V2.0

Figure 11: Siemens 3RW5513-1HA14 available settings

- There is currently no indication to the DR-E3 on the health of the soft starter 3-phase supply. In the future Ergon Energy will seek to provide a contact from the soft starter to indicate that there is an error with the device. This will be used by the DR-E3 to know if there is a soft starter hardware problem or 3-phase supply and bus problem. This would effectively be an extended watchdog.

10. The control circuit for pump starters and fans is designed to ensure normal operation from the DR-E3 or upon failure of the DR-E3 is supported.
    - -K5 should block the pump run from a protection operation
    - -K14 is an interlock from a second pump (if applicable) to ensure single pump operation
    - -Q11 is the pump 3-phase supply isolator to ensure the pump will only try to run with a supply
    - -A11 is the soft starter 240VAC electronic supply is healthy
    - The pumps can be operated manually upon a failure of the DR-E3

- A failure or power cycle of the DR-E3 will see pump 1 run automatically
- -K13 relay will call for the pumps to run by applying a 240VAC input to the soft starter.

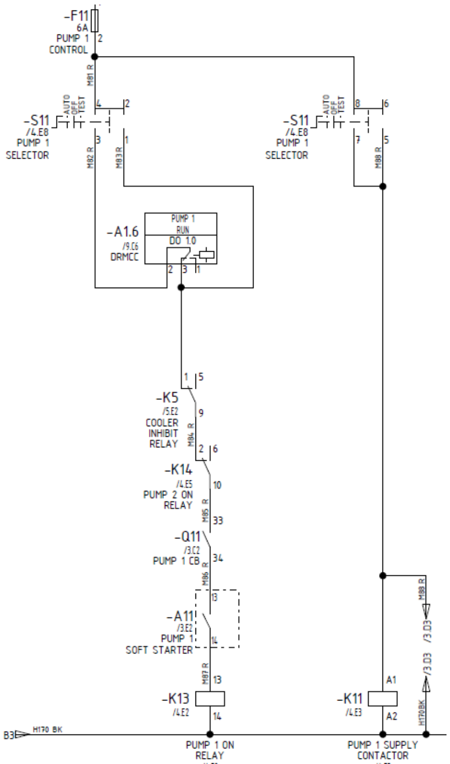


Figure 12: Pump control circuit

11. The cooler inhibit relay will be available for future designs to block the fans and/or pumps upon a transformer trip. A transformer trip may cause an oil leak and is undesirable to have a pump expediting the oil leaving the vessel. A transformer trip may cause a fire and is undesirable to have the fans fan the flames. The -K5 cooler inhibit relay provides the DR-E3 with a digital input indicating it has operated and block manual or automatic operation of the pumps.

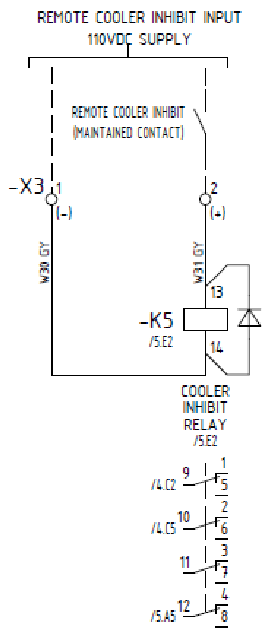


Figure 13: Cooler control inhibit circuit

12. The -F3 Buchholz relay shall be a 3-contact type which allows the designers to choose how the trips and alarms will be wired. In most instances the low oil and surge vane will be trips and the gas accumulation will be an alarm.

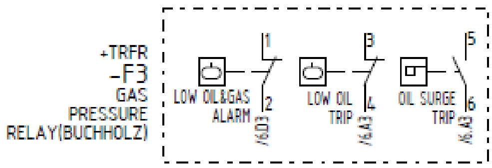


Figure 14: Buchholz relay contacts

13. All transformer trips are clean contacts to be used in the protection panels. The non-temperature-based trips are without follower relays to ensure high speed unimpeded operation. No follower relays assume the trips will operate a tripping relay or protection relay opto-isolated input to ensure positive indication of the device sending the trip command.

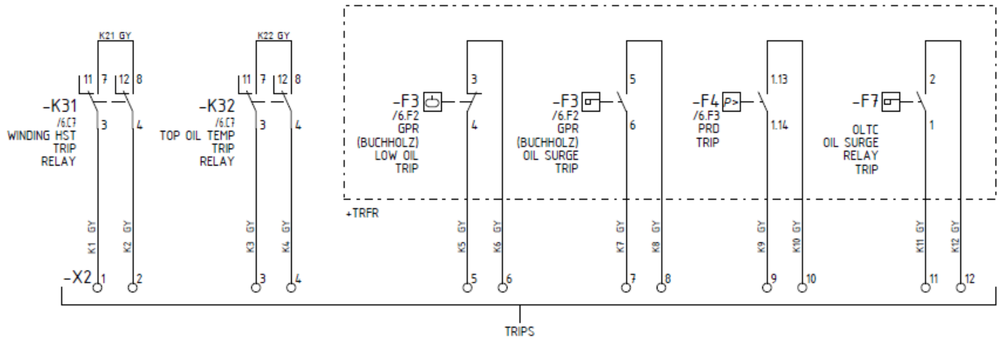


Figure 15: Trips

14. The transformer alarms will be marshalled by the DR-E3 and sent to SCADA and the digit output “common alarm”.

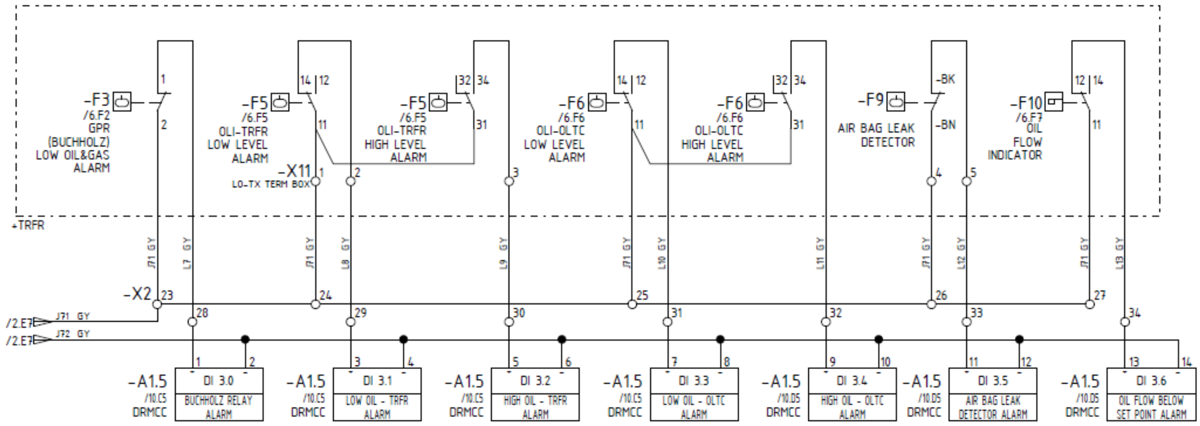


Figure 16: Alarms

15. Hard wired alarms are available for direct connection to an RTU or some other device. Cases where there may be limited (or no) communication between the site and SCADA hard wired contacts are available as indication in panels.

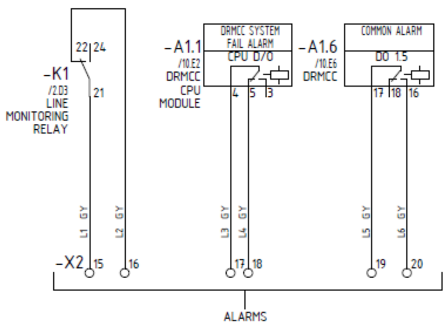


Figure 17: Hard wired alarms

16. The AC input card (energy card) has a CT and VT input which is used by Ergon to monitor voltage, current and harmonics.

NOTE: Terminals 2-C and 3-C are bridged internally which is a hazard that must be understood.

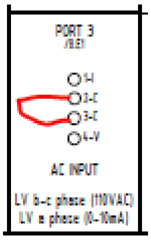


Figure 18: AC card showing the internal bridge

Hazards:

- Phase to phase VT with an earthed neutral MUST NOT be used because one of the phases must be connected to 3-C and hence 2-C (diagram below should not be used). 1-I and 2-C are rated for greater than 110VAC but the CT wiring must also be rated. If C1, C2 and C3 are not identical current will circulate in the measurement circuit and hence the CT input will be affected by the VT input.
- Phase to ground VT with the phase (unearthed at the phase) MUST NOT be connected to 3-C
- Consideration should be given to how the auxiliary CT input to the AC card is earthed.
- If a VT phase is connected to 4-V and the earthed VT neutral is connected 3-C this will effectively earth the CT via 2-C.

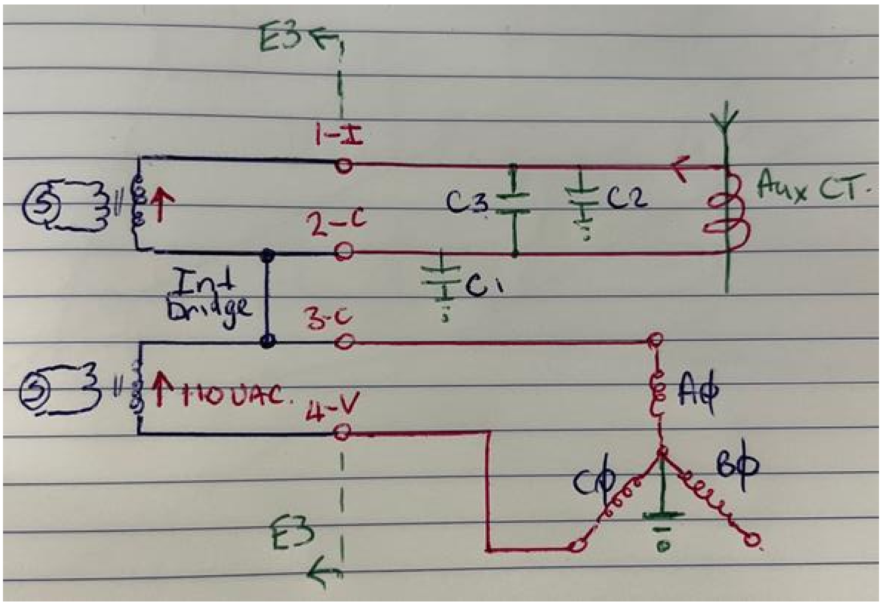


Figure 19: CT and VT connection considerations

Annex B

Informative

Hardware

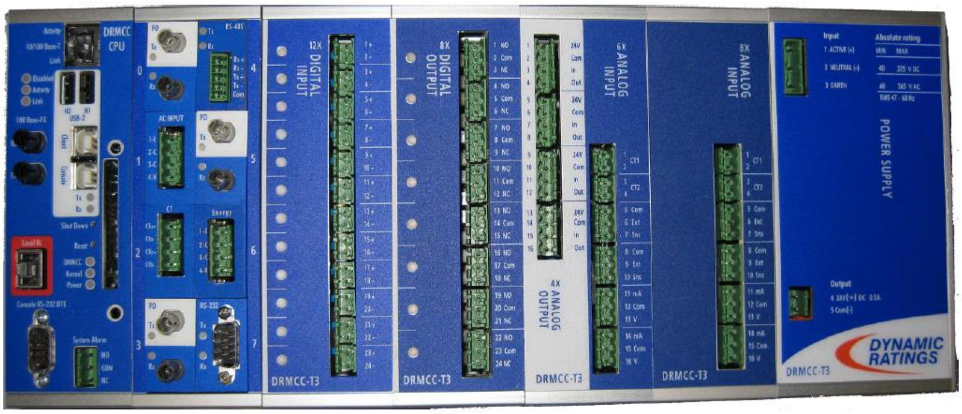


Figure 20: E3 physical example

Note: Picture doesn't represent Ergon Energy application

Fibre optic hotspot monitor - 4 channels available for connecting fibre sensors on the winding/s (old hot spot monitor shown below)

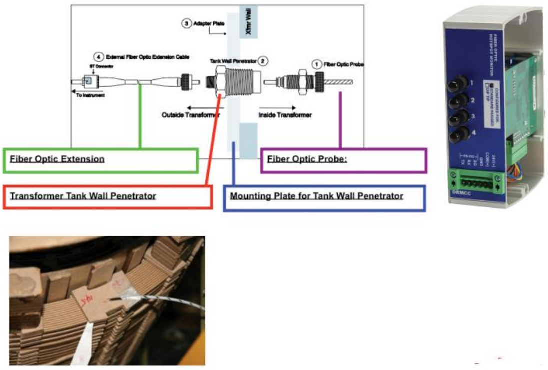


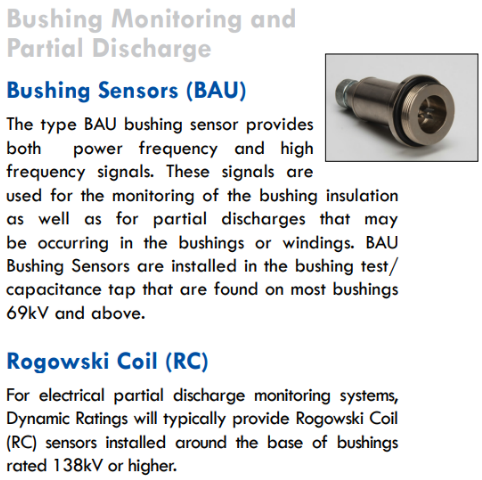
Figure 21: Fibre optic hot spot monitor

Bushing health monitor – Connect to BAU sensors to measure current on each bushing tap.

Figure 22: Bushing monitor

Partial discharge monitor – BAU sensors connect to the bushing test/voltage tap and measure partial discharge. Rogowski coils can be connected at the base of the bushing to negate noise (recommended on 132kV and above applications).

Figure 23: Partial discharge monitor



Bushing Monitoring and Partial Discharge

Bushing Sensors (BAU)

The type BAU bushing sensor provides both power frequency and high frequency signals. These signals are used for the monitoring of the bushing insulation as well as for partial discharges that may be occurring in the bushings or windings. BAU Bushing Sensors are installed in the bushing test/capacitance tap that are found on most bushings 69kV and above.

Rogowski Coil (RC)

For electrical partial discharge monitoring systems, Dynamic Ratings will typically provide Rogowski Coil (RC) sensors installed around the base of bushings rated 138kV or higher.

Figure 24: Bushing sensor

Interface unit (IU). Typically, the IU will be supplied to access settings, alarms and measurements within the DR-E3 via push buttons and an LCD display. The IU is normally mounted at the transformer marshalling box in an accessible location. If the IU is not supplied considerations will need to be given into LED indications at the transformer marshalling box.

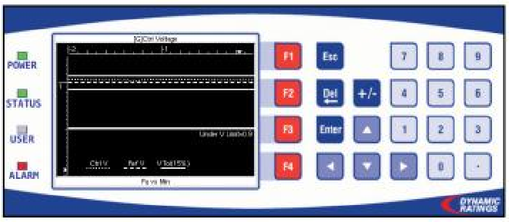


Figure 25: Interfact unit

CPU card

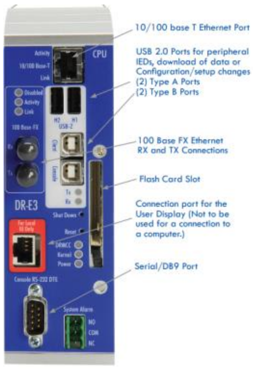


Figure 26: CPU card

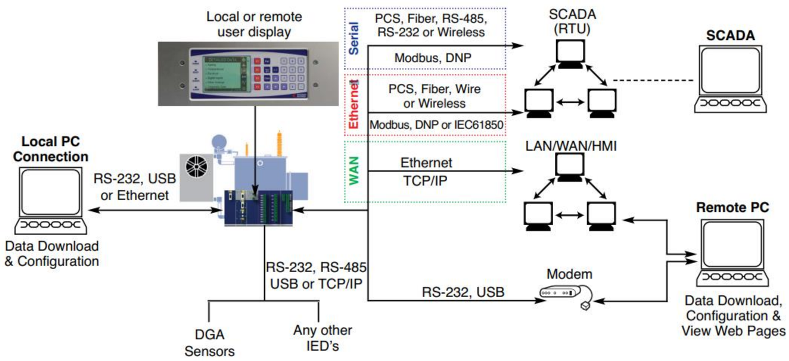


Figure 27: Communication single line diagram

Figure 28: Example of brownfield DR-E3 at Barcaldine substation on transformer 2

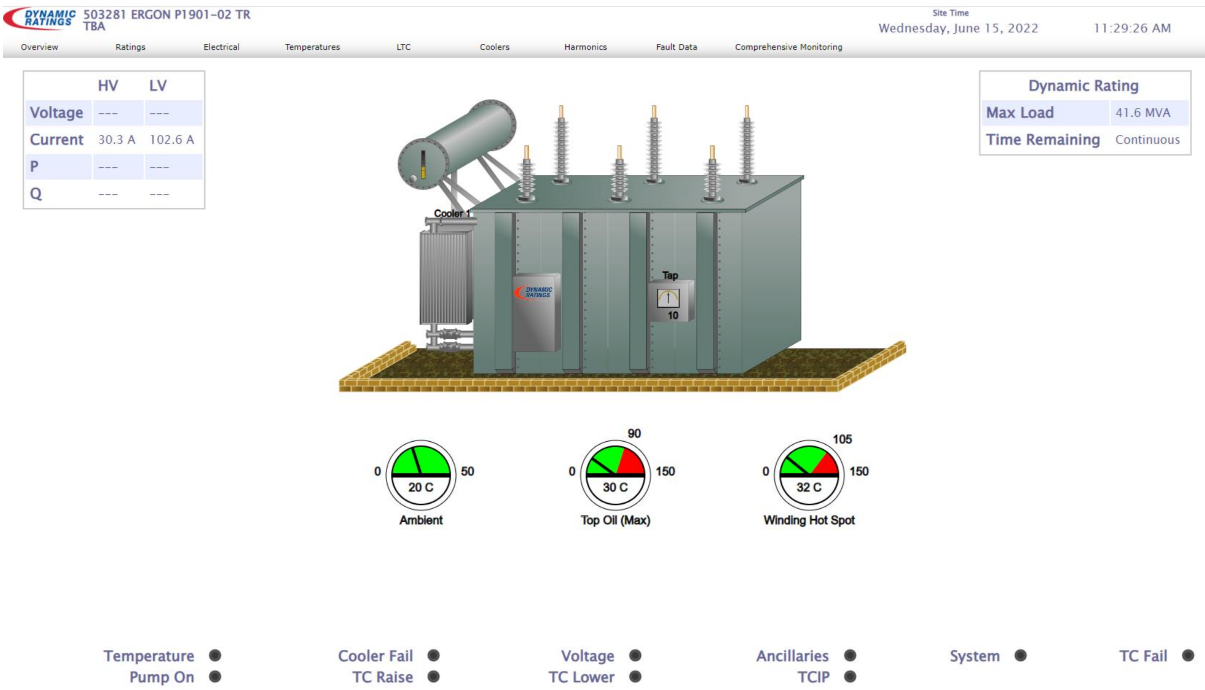


Figure 29: Example of the main dashboard (overview) for a DR-E3 on transformer 4 at Yarranea substation. (Note: no voltage is provided and hence no Voltage, P or Q)

The DR-E3 settings and log files can be extracted using web-base access or WinSCP and viewed in notepad or excel. The DR-E3 configuration (setting) files can be uploaded by DR tool kit. Any changes to the configuration can also be performed using PuTTY. BHM and PDM alarms and logs can be downloaded via Athena software.

Main folder	“etc” folder	“log” folder
etc log xeditor.xed	drConfig.d menupages webpages calculator cu_io custom_labels dnp_scada_net drAlarm drConfig drMenu email localization logdata logdata_master luxtron mb_dualct_plus mb_io menu_favourites motd passthrough thermalCfg	drmcc log

Figure 30: E3 setting file example from Yarranlea transformers

Annex C

Informative

Predictive cooling

All of the information below has been copied from DR-E3-210 Thermal Monitoring and Cooling Control Manual Rev-141124.

Smart Auto Cooling Control

Smart Auto or SMARTCOOL™ is available if the required parameters have been configured in the thermal model before commissioning. It uses the Auto mode inputs as well as the ultimate top oil and winding hot spot temperatures predicted on the basis of all the cooling running. This approach anticipates temperature increases before they occur, such as when there is a sharp increase in transformer loading. ***SMARTCOOL™*** runs the transformer at a cooler temperature, thus reducing the aging of the transformer, as well as giving more capacity to overload the transformer.

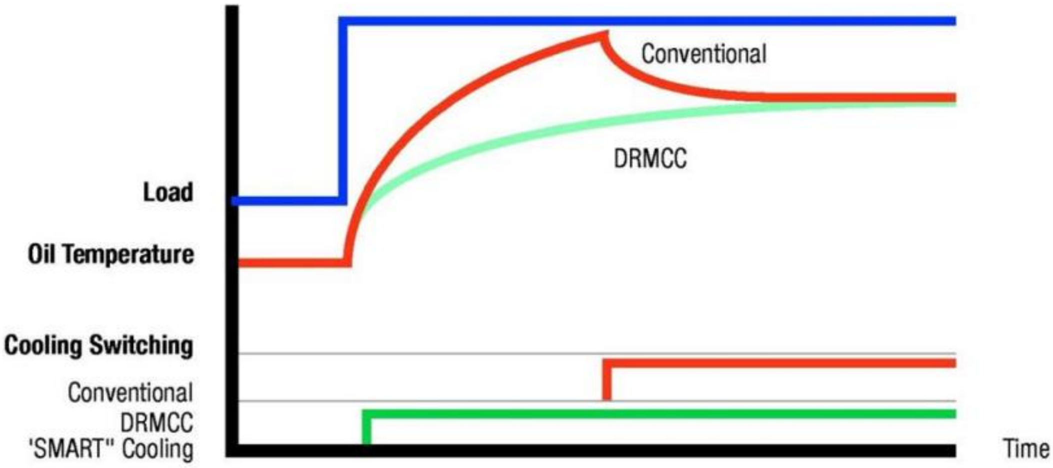


Figure 8: DMRCC Smart Cooling

In addition to the temperature set points used in the automatic mode, Smart Auto also uses the predicted ultimate top oil and ultimate winding hot spot temperature(s) (which are calculated assuming all the cooling is running), to proactively switch the cooling on when the transformer is going to reach a relatively high temperature (generally the temperature alarm and trip settings). This approach can compensate for an increase in temperature before it is detected by the conventional approach, such as when there is a sharp increase in transformer loading. Smart cooling pre-cools the transformer during high load conditions, thus reducing the aging of the transformer, as well as giving more capacity to overload the transformer. However, since the calculated ultimate top oil and winding hot spot temperatures take into account ambient as well as other factors that the affect transformer temperatures, the smart automatic mode will only proactively turn on the cooling when system conditions warrant it.

When in smart cooling mode, if a failure is detected in the first group of cooling, the failure will be reflected in the ultimate temperatures causing the second group of cooling to turn on sooner than if all cooling were available.

Figure 31: Smart cooling information from E3 manual

Transformer Ageing

The thermal model in the DR-E3 can be selected to run as IEC or IEEE. If you require more information, please consult the appropriate standard. For example purposes, we have chosen to illustrate the IEC thermal model. The IEC loading guide states that for every 6°C / (42.8 °F) winding hot spot temperature rise over 98°C / (208.4 °F), the ageing rate doubles. If the transformer was running at a steady state temperature of 98°C / (208.4 °F), it would age 1 year, every year. Running at 110°C / (230 °F), the transformer would age at 4pu, for a 2-hour emergency this would equate to 8 hours of transformer ageing. At 128°C / (262.4 °F), the transformer is ageing at 32pu. For a 2-hour emergency this is an accumulated age of 64 hours, or 2.66 days.

The DR-E3 also has a minimum age rate of 0.00256pu for temperatures below 80°C / (176 °F). Thus a transformer running at low temperature will still experience some ageing (1 day per year).

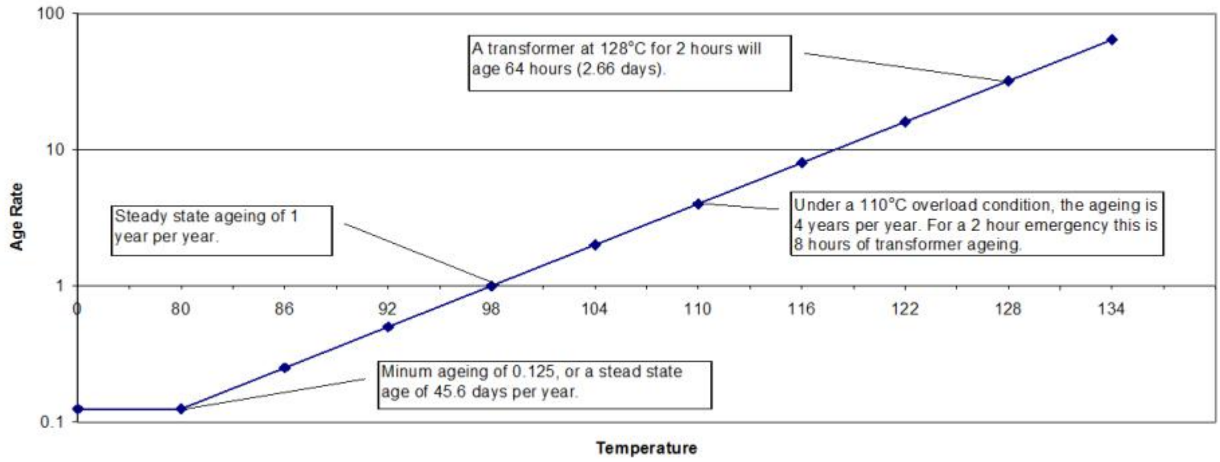


Figure 9: IEC Age Rate

Figure 32: Ageing rate information from E3 manual

Appendix A

Revision history

Revision date	Version number	Author	Description of change/revision
June 2023	1.0	Substation Design Standards	Initial issue