



Eskom

Standard

Technology

Title: **STANDARD FOR DIGITAL
TRANSDUCER-BASED
MEASUREMENT SYSTEM FOR
ELECTRICAL QUANTITIES**

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1. Introduction

This document provides for a standard on digital transducers to be used in substation control equipment.

The functional measurements requirements for each electrical substation bay are specified in [10] 240-75651280

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

This standard describes Eskom's requirements in respect of a measurement transducer system for the following electrical quantities:

Instantaneous values:

- a) True root-mean-square (rms) voltage
- b) True rms current
- c) Active power (P)
- d) Reactive power (Q)
- e) Frequency (Hz)
- f) Power factor (pf)
- g) Phase angle (φ)

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions with the exception of Power Stations where transducers are utilised for turbine control systems.

2.2 Normative/informative references

2.2.1 Normative

- [1] ISO 9001, Quality Management Systems.
- [2] IEC 60688, Electrical measuring transducers for converting AC electrical quantities to analogue or digital signals
- [3] IEC 61557-12, Electrical Safety in low voltage distribution systems up to a 1000V a.c. and 1500V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices
- [4] IEC 60297-3-100, Mechanical structure for electronic equipment – Dimensions of mechanical structures for 482,6 mm (19 in) series - Part 3-100: Basic dimensions of front panels, sub racks, chassis, racks and cabinets
- [5] IEC 60870-5-1, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 1: Transmission frame formats
- [6] SANS/IEC 61010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use Part 1: General requirements
- [7] SANS/IEC 60529, Degrees of protection provided by enclosures (IP-Code)
- [8] SANS/IEC 60947-7-1, Low voltage switchgear and control gear – Part 7: Ancillary equipment – Section 1: Terminal blocks for copper conductors

- [9] DIN 43807, Measuring and control; electrical measuring instruments; terminal markings for switchboard meters, panel meters and measuring transducers for the measurement of power and power factor
- [10] 240-75651280, Functional measurement requirements for network management
- [11] 240-76624509, The control of new products and version changes in the technical software, firmware and hardware in the measurement field
- [12] IEC 62053, Electricity metering equipment (a.c.) – Particular requirements

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
19"	Unit used to describe the width of panel equipment. 19" = 482,6 mm,
Accredited test facility	A test facility accredited by a full member facility which is listed at the International Laboratory Accreditation Cooperation (ILAC).
Fiducial value	A value to which reference is made in order to specify the accuracy of a transducer. The fiducial value is the span, except for transducers having a reversible and symmetrical output signal when the fiducial value may be half the span if specified by the manufacturer.
Measurand	The parameter to be measured.
Rack	The 19" three-unit (3U) rack.
Response time	The time from the instant of application of a specified change of the measurand until the output signal reaches and remains at its final steady value or within a specified band centred on this value.
Ripple content	With steady-state input conditions, the ratio of the peak-to-peak value of the fluctuating component of an analogue output signal, expressed in percentage, to the fiducial value.
Transducer	A device intended to transform, with a specified accuracy and based on some measurement theory that predicts how a value will behave when a certain measurement procedure is applied.
True Vrms	$V_{RMS} = \sqrt{\frac{1}{T} \int_0^T v^2(t) dt}$ For a pure sinusoidal wave, $V_{RMS} = 0.707 V_{peak}$
U	Unit used to describe the height of panel equipment. One unit (1U) = 44,45 mm.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
ϕ	Phase angle between voltage and current
AC	Alternating current
CT	Current Instrument Transformer
DC	Direct Current
DNP 3.0	Distributed Network Protocol
DSP	Digital Signal Processor
E	Phase-to-phase voltage
FSD	Full-scale Deflection
GM	General Manager
I	Effective current, line current
ILAC	International Laboratory Accreditation Cooperation
IP	Ingress Protection
LSD	Least Significant Digit
n/a	not applicable
NRCS	National Regulator for Compulsory Specifications
P	Active power
pf	Power factor
PTM&C	Protection, Telecoms, Metering and Control
Q	Reactive power
RCC	Regulatory Compliance Certificate
rms	root mean square
RTU	Remote Terminal Unit
S	Apparent power
SC	Steering Committee
SCADA	Supervisory Control and Data Acquisition
USB	Universal Serial Bus
VA	Volt–Amp rating
VT	Voltage Instrument Transformer

2.5 Roles and responsibilities

The requirements stated in this document shall be used for issuing and evaluating tenders for digital transducer based measurement systems.

2.6 Process for monitoring

The Metering and Measurements Study Committee shall ensure that this standard is implemented

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2.7 Related/supporting documents

Not applicable.

3. Categorization of equipment and products into items

The equipment and products required are categorized into the following items:

- a) Item 1: Digital transducer only. No analogue outputs.
- b) Item 2: Digital transducer with a minimum of four galvanic isolated analogue outputs. The analogue outputs should not share a single common.
- c) Item 3: Digital transducer with a minimum of six galvanic isolated analogue outputs. The analogue outputs should not share a single common.
- d) Item 4: Digital display
- e) Item 5: 1 x Digital transducer (item 1) fitted inside a 19" rack with a digital display.
- f) Item 6: 1 x Digital transducer (item 2) fitted inside a 19" rack with a digital display.
- g) Item 7: 1 x Digital transducer (item 3) fitted inside a 19" rack with a digital display.
- h) Item 8: 2 x Independent digital transducers (item 1) fitted inside a 19" rack with 2 x independent digital displays.
- i) Item 9: 2 x Independent digital transducers (item 2) fitted inside a 19" rack with 2 x independent digital displays.
- j) Item 10: 2 x Independent digital transducers (item 3) fitted inside a 19" rack with 2 x independent digital displays.

4. Physical / Mechanical Requirements

4.1 General

- a) All equipment and options shall be designed to meet the requirements for safety, applicable to the equipment specified (refer to [6] SANS/IEC 61010-1).

4.2 Digital transducer only

- a) This option requests the supplier to provide a digital transducer to support the functionality as described in this standard.
- b) The digital transducer shall support a 35 mm DIN-rail (top hat profile) fitting.
- c) The transducer housing shall have at least an IP40 rating as specified in [7] SANS/IEC 60529, and shall be made of a self-extinguishing, non-dripping material.

4.3 Digital display (Item 4)

- a) This option requires the supplier to provide a panel mount digital display.
- b) The display can be either on the transducer itself (items 1, 2 and 3 in 4.1.2.1) or supported separately.
- c) The display shall be serially interfaced / Ethernet to the digital transducers when the display is supported separately.
- d) The digital display shall have at least an IP40 rating as specified in [7] SANS/IEC 60529, and shall be made of a self-extinguishing, non-dripping material.

4.4 19" rack options

- a) This option requires the supplier to provide digital transducer(s), mounted in a single 19" rack, digital display(s), milliamp outputs and terminal blocks. The layout of this option can be found in Annex A; and [9] DIN 43807. The terminal layout is discussed in 4.6.

4.5 Physical requirements for digital transducer

4.5.1 Transducer input terminals

- a) Terminal blocks used shall meet the following requirements and conventions:
- 1) Terminals for Current Instrument Transformer (CT), Voltage Instrument Transformer (VT) and auxiliary supplies shall be the screw type and shall conform to [8] SANS/IEC 60947-7-1.
 - 2) Fastening of the supply wiring shall either be by means of two securing screws on each terminal, or by means of a clamp terminal using at least one screw.
 - 3) Terminal identification shall be provided and shall be subject to Eskom's written approval.

4.5.2 Transducer output terminals

- a) Terminal blocks used shall meet the following requirements and conventions:
- 1) Analogue output terminals shall be the screw type and shall conform to [8] SANS/IEC 60947-7-1.
 - 2) Terminals shall be capable of receiving blade- or pin-type crimp connectors.
 - 3) Clamping screws shall not bear directly onto the lugs.

4.5.3 Interfacing ports

- a) The transducer shall have ports for the following:
- 1) A dedicated interface port for Supervisory Control and Data Acquisition (SCADA) purposes that is configurable for RS232/RS485/Ethernet. It shall be possible to communicate to multiple transducers from a single SCADA device (multi-dropping/cascading). Multi-dropping should be easily accomplished by an appropriate multi-dropping communications cable between successive transducers, thereby ensuring a single communications cable between the first transducer and the SCADA device.
 - 2) An engineering port RS232/RS485/Ethernet/Universal Serial Bus (USB) for configuring and maintenance purposes.
 - 3) A port to support a local display (item 4 in 3.1.2.2), if the display is supported separately.

4.6 Physical requirements and layout for 19" rack options

4.6.1 Rack dimensions

- a) The transducer, display, terminals and ports shall be fitted inside a 19" rack ([4] IEC 60297-3-100) with a height of three units (3U) and maximum depth of 300 mm.

4.6.2 Material

- a) Bare copper or brass alloys shall not be used on aluminium racks.
- b) Aluminium-plated copper or tinned copper/brass materials shall be used.

4.6.3 Transducer input terminals

- a) Terminal blocks used shall meet the following requirements and conventions:
- 1) Terminals for CT, VT and auxiliary supplies shall be Eskom-approved screw-type, spring-loaded and shall conform to [8] SANS/IEC 60947-7-1.
 - 2) Terminals shall be capable of receiving hooked blade crimp connectors, 4,5 mm wide and 14 mm long, for CT, VT and auxiliary supplies.
 - 3) Clamping screws shall not bear directly onto the lugs.
 - 4) The terminal arrangements shall be fitted to the rear of the rack.
 - 5) Terminal identification shall be provided and shall be subject to Eskom's written approval.
 - 6) An earth terminal shall be provided on the rear of the rack.

4.6.4 Transducer output terminal

- a) Terminal blocks used shall meet the following requirements and conventions:
- 1) Analogue output terminals shall be Eskom-approved screw type and shall conform to [8] SANS/IEC 60947-7-1.
 - 2) Terminals shall be capable of receiving blade- or pin-type crimp connectors.
 - 3) Clamping screws shall not bear directly onto the lugs.

4.6.5 Interfacing ports

- a) The transducer rack shall have ports for the following:
- 1) A dedicated interface port for Supervisory Control and Data Acquisition (SCADA) purposes that is either a serial port configurable for RS232/RS485 or an Ethernet port. If the SCADA port is a serial port, it shall be possible to communicate to multiple transducers from a single SCADA device (multi-dropping/cascading).
 - 2) An engineering port RS232/RS485/Ethernet/Universal Serial Bus (USB) for configuring and maintenance purposes.

4.6.6 Terminal block layout

- a) The wiring to the input terminals on the DIN-rail shall be in accordance with the following convention:
- 1) Red phase – current in, voltage, current out.
 - 2) White (yellow) phase – current in, voltage, current out.
 - 3) Blue phase – current in, voltage, current out.
 - 4) Neutral voltage
 - 5) Ground
 - 6) Auxiliary supply
- b) The wiring of the output terminals (milliamp outputs) on the rack or DIN-rail shall be in accordance with the following convention and order:
- 1) Analogue output 1 (items 6, 7, 9 and 10) – positive terminal, negative terminal.
 - 2) Analogue output 2 (items 6, 7, 9 and 10) – positive terminal, negative terminal.
 - 3) Analogue output 3 (items 6, 7, 9 and 10) – positive terminal, negative terminal.
 - 4) Analogue output 4 (items 6, 7, 9 and 10) – positive terminal, negative terminal.
 - 5) Analogue output 5 (items 7 and 10) – positive terminal, negative terminal.

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- 6) Analogue output 6 (items 7 and 10) – positive terminal, negative terminal.

The physical layout of the terminal block shall be as shown in Annex A.

4.6.7 Wiring

- a) The wiring between the transducer terminals and rack terminals shall be 2,5mm² multi-strand for the CT, VT and auxiliary circuits.
- b) The wiring between the transducer and rack for all other circuits shall be at least 1 mm² multi-strand.

5. Electrical / Technical requirements

5.1 Internal transducer circuits

- a) No common wiring connection shall be made internally in the transducer (excluding the neutral voltage).
- b) Any internal circuits carrying current from the current terminals of the transducer shall be multi-strands, with a rating of at least 3 A/mm². Specifically, no circuits that carry current from instrumentation current transformers under normal operating conditions shall be routed by way of a printed circuit board.

5.2 CT and VT inputs

- a) The standard nominal voltage for the transducer is 110 V phase to phase.
- b) The standard nominal current is 1 A for a 1 A transducer and 5 A for a 5 A transducer.
- c) All transducers using one or more CT input(s) shall withstand 120% of the nominal value of the current continuously.
- d) All transducers using one or more CT input(s) shall withstand 20 times the nominal value of the current for 1 s and repeated 5 times at 300s intervals.
- e) The maximum burden on the CT inputs shall not be more than 0,3 VA for 1 A rating and 0,9 VA for 5 A rating.
- f) Under no circumstances shall the CT inputs be open-circuit while connected to the transducer. If the transducer can be withdrawn from a rack, then the rack must provide for shorting of the current inputs.
- g) All transducers using one or more VT input(s) shall withstand and not be adversely affected by the input(s) rising to 120% of the nominal value of voltage continuously.
- h) All transducers using one or more VT input(s) shall withstand 200% of the nominal value of the voltage applied for 1s and repeated 10 times at 10s intervals.
- i) The maximum burden on the VT inputs shall not be more than 0,5 VA.

5.3 Auxiliary supply

- a) The transducer shall operate normally on an AC auxiliary supply ranging from 95 V to 265 V, 50 Hz and/or a DC auxiliary supply ranging from 100 V to 230 V.
- b) The digital transducer's auxiliary supply input shall have a maximum burden of 10 VA.

5.4 Milliamp outputs

- a) This specification specifies two ranges for the mA outputs: A 0 mA to 5 mA output and a 4 mA to 20 mA output. Preference shall be given to a transducer which can support both of these ranges.
- b) Under no circumstances shall the output current exceed twice the nominal value.
- c) The analogue outputs shall be able to drive a maximum 2 k Ω resistive load at nominal output current of 5 mA or 500 Ω resistive load at nominal output current of 20 mA.

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- d) Any variation in the burden resistance within the limits of 0 kΩ and 2 kΩ shall not cause the output to change by more than 0,1%.
- e) The open-circuit voltage of the analogue outputs shall not exceed 15 V.
- f) Ripple content: The maximum ripple content in the output signal shall not exceed twice the class index.
- g) Response time: The analogue output shall have reached 90% of the nominal output value in < 500 ms for a step input of zero to nominal.

5.5 Wiring between transducer and rack/DIN-rail terminal

- a) The complete current circuit (terminals and wiring to the transducer) shall withstand 20 times the nominal value of the measured current applied for 1 s and repeated 5 times at 300 s intervals.
- b) The minimum dielectric strength between transducer terminals shall be 2 kV.
- c) The maximum contact resistance between rack material and the earth terminal shall be < 0,1 Ω.

5.6 Accuracy classification

5.6.1 Accuracy class requirements

- a) The accuracy class of all transducers shall be as detailed in 1 to 8.

Table 1: Maximum allowable error for measurand on the analogue and display output of digital transducer

Digital transducer output		
Measurand	Analogue (% of FSD)	Display (% of FSD)
True rms voltage	± 0,5	± (0,5% + 1 LSD)
True rms current	± 0,5	± (0,5% + 1 LSD)
Active power (Watt)	± 0,5	± (0,5% + 1 LSD)
Reactive power (var)	± 0,5	± (0,5% + 1 LSD)
Frequency	± 0,5	± (0,1% + 1 LSD)
Power factor	± 1,0	± (1% + 1 LSD)
Phase Angle	± 1,0	± (1% + 1 LSD)

Table 2: True rms current specific measurement requirement

True rms current		
Effective Range (referred to nominal) (Range over which accuracy class holds)	10% to 120%	
Operating Range	0% to 150%	
Nominal Output Range	0 mA to 5 mA or 4 mA to 20 mA	
Accuracy Class Index Table 1:	Analogue (% of FSD)	± 0,5
	Digital (% of FSD)	± (0,5% + 1 LSD)

Table 3: True rms voltage specific measurement requirement

True rms voltage		
Effective Range (referred to nominal) (Range over which accuracy class holds)	80% to 120%	
Operating Range	0% to 120%	
Nominal Output Range	0 mA to 5 mA or 4 mA to 20 mA	
Accuracy Class Index (over accuracy range 80% to 120%)	Analogue (% of FSD)	± 0,5
	Digital (% of FSD)	± (0,5% + 1 LSD)

Table 4: Active power specific measurement requirement

Active power		
Effective Range (referred to nominal) (Range over which accuracy class holds)	Voltage	80% to 120%
	Current	10% to 120%
	Active Power	10% to 120%
Principle of Operation	DSP	
Nominal Output Range	-5 mA to 0 mA to 5 mA or 4 mA to 12 mA to 20 mA	
Calibration	± 200 W = ± 5 mA, (export = +5 mA)	
Measuring Method	Three element	
Measuring Formula	$E.I.\cos(\varphi).\sqrt{3}$	
Accuracy Class Index Table 1:	Analogue (% of FSD)	± 0,5
	Digital (% of FSD)	± (0,5% + 1 LSD)

Table 5: Reactive power specific measurement requirement

Reactive power		
Effective Range (referred to nominal) (Range over which accuracy class holds)	Voltage	80% to 120%
	Current	10% to 120%
	Reactive Power	10% to 120%
Principle of Operation	DSP	
Nominal Output Range	-5 mA to 0 mA to 5 mA or 4 mA to 12 mA to 20 mA	
Calibration	± 100 var = ± 5 mA, (lag = +5 mA)	
Measuring Method	Three element	
Measuring Formula	$E.I.\sin(\varphi).\sqrt{3}$	
Accuracy Class Index Table 1:	Analogue (% of FSD)	± 0,5
	Digital (% of FSD)	± (0,5% + 1 LSD)

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Table 6: Power factor specific measurement requirement

Power factor		
Effective Range (referred to nominal) (Range over which accuracy class holds)	Voltage input	80% to 120%
	Current	10% to 120%
Principle of Operation		DSP
Nominal Output Range		0 mA to 5 mA or 4 mA to 20 mA
Calibration		0,001 lag to 1 to -0,001 lead = 0 mA to 2,5 mA to 5 mA
Measuring Formula		$pf = \arccos(P/S)$, where $S = \sqrt{P^2 + Q^2}$
Accuracy Class Index Table 1:	Analogue (% of FSD)	± 1,0
	Digital (% of FSD)	± (1% + 1 LSD)

Table 7: Phase angle specific measurement requirement

Phase angle		
Effective Range (referred to nominal) (Range over which accuracy class holds)	Voltage input	80% to 120%
	Current	10% to 120%
Principle of Operation		DSP
Nominal Output Range		-5 mA to 0 mA to 5 mA or 4 mA to 12 mA to 20 mA
Calibration		-90 to 0 to 90 = -5 mA to 0 mA to 5 mA
Measuring Formula		$\varphi = \arccos(P/Q)$
Accuracy Class Index Table 1:	Analogue (% of FSD)	± 1,0
	Digital (% of FSD)	± (1% + 1 LSD)

Table 8: Frequency-specific measurement requirement

Frequency		
Effective Range		45 Hz to 55 Hz
Principle of Operation		DSP
Nominal Output Range		45 Hz to 50 Hz to 55 Hz = 0 mA to 2,5 mA to 5 mA or 4 mA to 12 mA to 20 mA
Accuracy Class Index Table 1:	Analogue (% of FSD) 48 Hz to 52 Hz	± 0,5
	Digital (% of FSD) 48 Hz to 52 Hz	± (0,1% + 1 LSD)

5.6.2 Permissible intrinsic errors

- a) When the transducer is under the reference conditions given in 10, 11 and 12, and is used between limits of the effective range, the error shall not exceed the limits of the intrinsic error expressed as a percentage of the fiducial value, given in 9 as a function of the class index.

Table 9: Limits of intrinsic error of transducers expressed as a percentage of the fiducial value

Class index	0,5	1
limit of error	± 0,5%	± 1%

5.6.3 Conditions under which intrinsic errors of transducers shall be determined

- a) The transducer shall be at the ambient temperature. This temperature shall be the reference temperature (refer to 11) within the stated tolerances.
- b) The transducer shall be left in-circuit under the conditions and for the time specified in 10.
- c) For transducers with reversible output current (voltage), intrinsic errors shall be determined separately for each output polarity.
- d) The transducer conditions relative to each of the influence quantities are given in 11. The reference conditions relative to voltage, current and power factor of the measured quantity are given in 12.

Table 10: Preconditioning

Test conditions	Class 0,5	Class 1
Voltage	Rated	Rated
Current	Rated	Rated
Frequency	Reference	Reference
Minimum time between connection into circuit and determination of errors	15 min	30 min

Table 11: Reference conditions of influence quantities

Influence quantity	Reference conditions unless otherwise marked	Tolerance permitted for testing purposes applicable to a single reference value
Ambient temperature	23 °C	Class 0,5 °C ± 1 °C Class 1 °C ± 2 °C
Frequency of measured quantity	50 Hz	± 2% or ± 1/10 of nominal range of use (whichever is the smaller)
Waveform	Sinusoidal	Distortion factor 1%
Output load	Rated values	+ 1% of the rated value
Auxiliary supply	Rated values	Voltage or current: ± 1% of rated value Frequency ± 2% of rated value

Table 12: Reference conditions relative to voltage, current and power factor of measured quantity

Reference conditions			
Measured quantity	Voltage	Current	Power factor
Active power (Watt)	Rated voltage $\pm 2\%$	Any current up to the rated current or up to the upper limit of the reference range, if any.	$\cos\phi = 1$ (tolerance 0,01) or rated $\cos\phi \pm 0,01$.
Reactive power (var)	Rated voltage $\pm 2\%$	Any current up to the rated current or up to the upper limit of the reference range, if any.	$\sin\phi = 1$ (tolerance 0,01) or rated $\sin\phi \pm 0,01$.
Phase angle and power factor	Rated voltage $\pm 2\%$	Any current within the reference range. If not otherwise marked (stated?) the reference range is 40% to 100% of rated current	
Frequency	Rated voltage $\pm 2\%$ or any voltage within the reference range		
Polyphase quantities	Symmetrical voltages (Refer to note 1)	Balanced current (Refer to note 2)	
<p>Note 1: Each of the voltages (between any two lines, or between any line and neutral) of a polyphase symmetrical system shall not differ by more than 1% from the average of the voltages (line-to-line or line-to-neutral) of the system.</p> <p>Note 2: Each of the currents in the phases shall not differ by more than 1% from the average of the currents. The angles between each of the currents and the corresponding phase-to-neutral voltages shall not differ by more than 2°.</p>			

5.6.4 Influence of harmonics on measurements

- a) The accuracy of the transducer outputs shall not be adversely affected by the presence of harmonic components in the current and voltage circuits.
- b) The requirements under these conditions shall be at least according to the limits as specified by [2] IEC 60688, clause 6.10.

5.6.5 Digital output signals

- a) The digital output signals chosen shall correspond with the requirements for transducers concerning accuracy and response time as well as with the requirements of the communication system.
- b) For the digital output the class index shall be in conformity with the performance class described in [3] IEC 61557-12.

6. Functional requirements

6.1 Measurands

- a) The transducer shall be able to measure the following quantities:
 - 1) True rms voltage
 - 2) True rms current
 - 3) Active power
 - 4) Reactive power
 - 5) Frequency

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- 6) Power factor
- 7) Phase angle

6.2 Wiring configuration

- a) The transducer shall at least support the following network connections:
 - 1) three-phase, three-wire system; and
 - 2) three-phase, four-wire with unbalanced load system.
- b) These configurations will depend on the application of the transducer and shall be supported externally and/or by software configuration.

6.3 Transducer outputs

- a) The digital transducer shall have the following interfacing ports:
 - 1) A dedicated interface port for Supervisory Control and Data Acquisition (SCADA) purposes that is either a serial port configurable for RS232/RS485 or an Ethernet port. If the SCADA port is a serial port, it shall be possible to communicate to multiple transducers from a single SCADA device (multi-dropping/cascading).
 - 2) The transducer shall support multiple baud rates (2400 to 115200) and multiple parity/stop bit settings (8N1, 8N2, 8E1, 8E2, 8O1 and 8O2) for serial communications to SCADA. The serial communication settings shall be software configurable.
 - 3) An engineering port RS232/RS485/Ethernet/Universal Serial Bus (USB) for configuring and maintenance purposes,
 - 4) A port to support a local display if the display is supported separately.
- b) For item 2 (as from 3.1.2.1d) the transducer shall have a minimum of four galvanic isolated analogue outputs, which shall be configurable as a milliamp output.
- c) For item 3 (as from 3.1.2.1d) the transducer shall have a minimum of six galvanic isolated analogue outputs, which shall be configurable as a milliamp output.
- d) When no signal input is present, but with the auxiliary supply connected, the transducer unit shall produce a zero output for the 0 mA to 5 mA option, or a 'live zero' 4 mA output for the 4 mA to 20 mA option.
- e) All output circuits shall be capable of operating for an indefinite period in an open circuit condition.

6.4 Local display

- a) This display can be either on the transducer itself, or supported separately.
- b) If a display forms part of the transducer, then the following requirements shall be met:
 - 1) The digital display shall have a minimum count of 19 999.
 - 2) The display shall have anti-glare and non-flickering properties. Filters shall have a non-reflective finish and be suitable for use in direct sunlight.
 - 3) The intensity of the display shall not be sensitive to variations in auxiliary supply voltage and frequency, for variations of $\pm 20\%$ for the voltage and $\pm 5\%$ for the frequency.
- c) Display sequences shall be programmable to the user's requirements.
- d) It shall be possible to manually or automatically scroll through the display sequence to access any register value or the present transducer status.
- e) The display shall have an indicator showing the nominal value on the displayed reading. This can be done either by a bar-graph indication, or by indicating the nominal value next to the measured quantity.

- f) The display shall have a refresh rate of not less than 1 s to prevent flickering and with a maximum refresh rate of 2,5 s.
- g) The display indication shall have a maximum temperature drift coefficient of 0,02%/°C.
- h) It shall be possible to do a decimal point adjustment on any displayed reading.
- i) The display shall, even if no graphical display is supported, provide some facility to indicate over-range conditions.

6.5 Protocol

- a) The digital transducer shall support an interface to a SCADA (Remote Terminal Unit (RTU)) system.
- b) The interface and protocol shall be in accordance with an internationally recognized standard, with the following recommended:
 - 1) Modbus RTU that support signed and unsigned 16 bit integer data formats
 - 2) DNP 3.0;
 - 3) IEC 61850.

6.6 Software

- a) The measurement system (digital transducer) shall be supplied with the configuration software.
- b) The Supplier shall provide Eskom with a corporate licence agreement for all configuration-specific software provided.
- c) All software supplied with the system shall be documented comprehensively, including all the features and functions discussed, and a procedure on how to configure the transducers for the various applications (transformer bay, feeder bay, bus-coupler etc.). The documentation shall include a list of possible problems and how to solve them.
- d) Calibration functions shall only be available on authorized request with security (password) control.
- e) Calibration functionality shall be able to support functionality as described and specified in 7.3.
- f) Future revisions of software shall be supplied in terms of a contract, but shall be submitted in accordance with Eskom standard [11] 240-76624509.

6.7 General

- a) All inputs and outputs to the digital transducer shall be clearly marked.
- b) The labelling on the digital transducer shall display the following information:
 - 1) current and voltage ratings;
 - 2) auxiliary supply;
 - 3) interfacing ports with their respective functions;
 - 4) digital transducer serial number;
 - 5) manufacturer's name;
 - 6) model/revision number;
 - 7) calibration label with date/s and relevant of calibration details; and
 - 8) name of the configured scheme (transformer, feeder, bus-coupler etc.).

6.8 Maintenance and training requirements

- a) The supplier shall submit details on proposed training courses. The information shall include:
 - 1) course outline;
 - 2) type of training offered;
 - 3) location of the training centre;
 - 4) duration and cost for each training course;
 - 5) maximum/minimum number of delegates per course; and
 - 6) course material.
- b) The supplier shall state its willingness to present training courses at Eskom premises.

6.9 Documentation

- a) Drawings, manuals and documentation are an essential part of the contract.
- b) Information and wording on drawings shall be in English.
- c) The following drawings shall be submitted when a contract is awarded:
 - 1) Outline drawings and fixing details.
 - 2) Functional block diagrams showing the overall operation of the equipment.
 - 3) Connection diagrams for different configurations.
 - 4) Service manuals, which shall be provided before delivery, and shall contain all information and procedures necessary for maintenance personnel to:
 - 5) understand the functioning of the equipment and software;
 - 6) trace and eliminate faults; and
 - 7) carry out routine preventative maintenance.
 - 8) Service manuals shall be in hardcover, loose-leaf form and electronic Acrobat .pdf form. Any modifications thereto shall be described in detail, as a supplement to the service manual.
- d) Copies of each manual shall be supplied to each Eskom group as requested.

7. Tests

7.1 Type testing

- a) The transducers shall be type tested according to either requirements specified in [2] IEC 60688, [12] IEC 62053 or a relevant, applicable ANSI standard at an approved test facility (test facility accredited by a full member facility which is listed at the International Laboratory Accreditation Cooperation (ILAC).
- b) A copy of the test certificates and full type test reports shall be submitted to Eskom as part of a tender submission.
- c) Type test certificates are to be provided in English or accompanied by a National Regulator for Compulsory Specifications (NRCS) Regulatory Compliance Certificate (RCC), if not in English.

7.2 Testing procedures

- a) Eskom reserves the right to appoint a representative to inspect the equipment at any stage in the manufacturing process and to witness any tests.

7.3 Calibration requirements

- a) Software calibration shall be provided to permit the readjustment of full scale and zero, if applicable.
- b) All transducers shall be calibrated before delivery at test facility accepted by Eskom. The transducer supplier/calibration facility shall apply a 'TESTED' sticker to the transducer before delivery.
- c) A calibration certificate shall also be provided, which will provide test results at the test points indicated in 13.
- d) The calibration results shall also be available to Eskom in an electronic format as an import file compatible with Microsoft Windows software.

Table 13: Calibration test points

Output	Pf	Test points		
Voltage	1	80% V _n	100% V _n	120% V _n
Current	0,866	10% I _n	50% I _n	120% I _n
Watt (100% V _n)	0,866	10% I _n	50% I _n	120% I _n
Var (100% V _n)	0,866	10% I _n	50% I _n	120% I _n
Frequency (100% V _n)	-	45 Hz	50 Hz	55 Hz
Power Factor (I _n & V _n)	0,866	10% I _n	50% I _n	100% I _n

8. Spares and support

8.1 Spares

- a) The *Supplier* shall supply a comprehensive schedule of spares to be held, relating to all the transducer schemes and or part thereof. The *Supplier* is encouraged to include in this list any or all items recommended for the routine maintenance of the offered transducer schemes in service.
- b) All spares shall be priced individually and shall be unambiguously referenced and described in the schedule.
- c) The *Supplier* shall commit to being able to supply spares for all the transducer schemes and/or parts thereof locally for a minimum period of ten (10) years, subsequent to the expiry of the supply contract.
- d) The delivery time of locally held spares shall not exceed 24 h, ex-works, on receipt of a bona fide order.

8.2 Support

- a) Dedicated local expertise shall support all transducer schemes or parts thereof offered by the *Supplier*.
- b) If any of the transducer schemes or parts thereof is sourced from overseas, Eskom requires the maximum transfer of technology from the *Supplier's* principals, to enhance local expertise capacity.
- c) The *Supplier* shall make the necessary arrangements in this regard.

9. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Andre de la Guerre	Middle Manager: Tx Protection, Metering and DC Technology & Support
Nelson Luthuli	Senior Manager: Tx PTM&C Engineering

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Johan Pieterse	Chief Engineer – TX Secondary Plant, Work Planning and Centralised Services
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10. Revisions

Date	Rev	Compiler	Remarks
April 2023	3	M Omar	Modified protocols to be supported including detailed serial communication settings to SCADA
April 2018	2	M Omar	Type test requirements amended Included requirements and reference standard for digital output signals CT,VT Inputs and response times amended to align with IEC 60688 Included additional rack mounted items
April 2013	1	H Groenewald	DNP 3.0 specified as preferred protocol. Type test requirements amended.

11. Development team

The following people were involved in the development of this document:

- Henri Groenewald
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12. Acknowledgements

Not applicable.

Annex A – 19” rack options

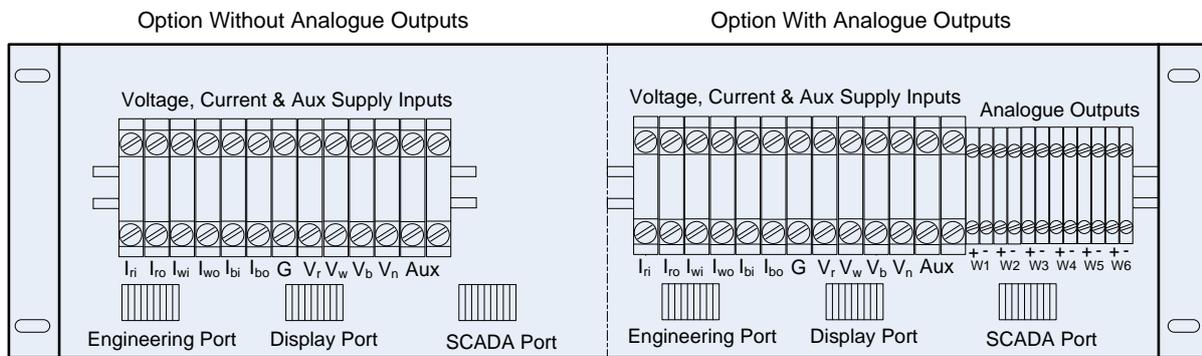
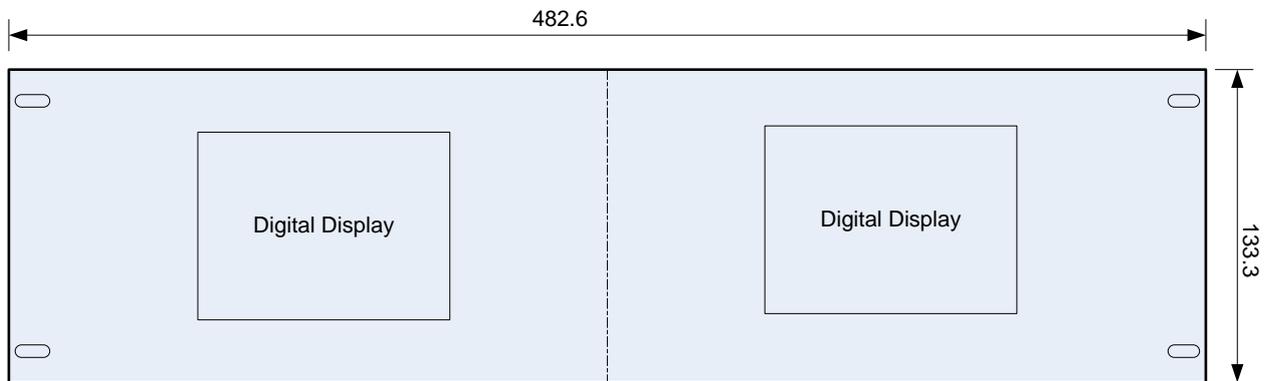


Figure A.1: Rack options

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