

**User Requirement Specifications**  
**Portable Multi-Phase Test System for Protective Relays, Measurement Transducers**

No	Description	Requirement
1	Introduction	
2	Supporting Clauses	Scope
3	Test Set Hardware Specification	Multi phase injection test set casing and carry handle. Front panel connections Voltage outputs Current Outputs Synchronising of MPTS current and voltage channels across test sets Low level voltage outputs Binary inputs Binary outputs Analogue DC Inputs Auxiliary power supply output Input and output terminals Rear panel Power Supply Ethernet ports Test set control by computer
4	Detailed Technical and Software Specification	
4.1	Power Supply	230 V, Single Phase
	Nominal Voltage	90 V - 260 V
	Permissible Voltage Range	50 Hz
	Nominal Frequency	45 Hz - 65 Hz
	Permissible Frequency Range	Max 3450VA at 230VAC
	Power Consumption	15A at 230VAC
	Rated Current	Standard AC sockets: Connector (SANS 60320-1, C13) and Inlet (SANS 60320-1, C14)
	Connection	
4.2	Dimensions and Weight	
	Volume	max. 30 litre
	Weight	max. 20 kg

4.3	Environment	
	Operating Temperature	0 °C ... 50 °C
	Storage Temperature	-25 °C ... 70 °C
	Humidity	5 % ... 95 % r.h. (non-condensing)
4.4	Certificates	IEC 60068-2-6
	Vibration	IEC 60068-2-27
	Shock	Yes
	CE	The product adheres to the electromagnetic compatibility (EMC) Directive 2004 / 108 / EC (CE conform)
	EMC	IEC 61326-1 Class A; IEC61000-6-4; IEC61000-3-2/3; FCC Subpart B of Part 15 Class A
	EMC - Emissions	IEC 61326-1; IEC 61000-6-2; IEC 61000-4-2/3/4/5/6/11
	EMC - Immunity	
	Safety	The product adheres to the low voltage Directive 2006 / 95 / EC (CE conform)
		IEC 61010-1; Insulation of PC and SELF Interfaces complies with EN 60950-1
	Independant Test Laboratory	Copies of test certificates from independent test laboratories proving compliance with the above standards are to be supplied together with the tender
4.5	Hardware	
	4.5.1 General	All functions should be combined in one hardware unit The unit shall be of a robust and sturdy construction PC card design: Wire jumpers on a single printed circuit board are not premissable Electronic components: No potentiometers are allowed No moving elements or elements that are susceptible to damage, i.e. control elements or displays on the face plate are permissible
4.5.2	Output Amplifiers	
		The amplifier stages are to be fully electronic, i.e. not via transformer



	Independent amplifiers	amplifier combination plug (3xV and 3xI) The six current amplifiers are to be independent from the four voltage amplifiers. The neutrals between the two current output groups are to be galvanically isolated (up to 2kV) to allow for series connection of the two groups in order to boost the compliance voltage
	Connection	4mm Banana sockets
4.5.5	Low-level signal Generators	6 additional analog low level signals to control external amplifiers or to test relays with low-level input, e.g. from Rogowski coils, linear voltage or linear current sensors must be provided. To allow for expandable options from 6 to 12 outputs. Full simulation of Rogowski coil signal (i.e. first order differential of signal) to be performed in hardware. Testing the Sub Synchronous Resonance (SSR) numerical relays at Koeberg and for the injection of White Noise signals into the AVR for grid compliance testing. Together with 10 internally used signal generators the system should provide 16 independent signal channels in total
	Output settings range	0 ... 10 Vpk
	Accuracy	<0.025%
	Overload Protection	Yes
		The quantities displayed in the software must be saleable for primary or secondary voltages (or currents). Should be able to couple to other auxiliary devices or possible synchronising function.
4.5.6	Signal Generation	All outputs to be continuously and independently adjustable in amplitude, phase (0 to +/- 360°) and frequency. Able to generate continuous sine waves with a frequency between 10 and 1kHz and to generate transient files with a bandwidth from dc up to 3 kHz. Frequency error to be less than 0.5 ppm.
		Phase error to be less than 0.02°
4.5.7	Binary Inputs	10 in at five galvanic isolated groups (2kV insulation voltage)
	Number of inputs	Pick-up and drop-out of potential-free contacts or dc voltages of up to 600Vdc. Trigger levels to be adjustable
	Mode/Trigger criteria	600V
	Max. Input Voltage	< 100 µs
	Max. error	

	Counting function	Inputs capable of counting number of pulses up to 3kHz.
	Connection	4mm Banana sockets
4.5.8	Analogue Inputs for Measurement	
	Number	10 in five galvanic isolated groups (2KV insulation voltage)
	Input ranges	100mV, 1V, 10V, 100V, 600V
	Accuracy	<0.06%
	Bandwidth	dc, 10kHz
	Sampling frequency	3kHz to 28kHz
	Overload protection	Yes
	Recording buffer	300s for 1channel at 3kHz, 3.5s for 10 channels at 28kHz
	Connection	4mm Banana sockets
4.5.9	Analog low level measuring inputs for transducer testing	
	Direct current range	Range 1: 0 ... $\pm 1$ mA
		Range 2: 0 ... $\pm 20$ mA
	Direct voltage range	0 ... $\pm 10$ V
	Max. error	< 0.003%
	Connection	4mm Banana sockets
4.5.10	Auxiliary DC supply to power test objects	
	Range	Range 1: 0 ... 264 Vdc, 0.2A
		Range 2: 0 ... 132 Vdc, 0.4A
		Range 3: 0 ... 66 Vdc, 0.8A
	Power	max. 50W
	Max. error	< 2%
4.5.11	Binary output contacts	
	Number	Minimum 4
	Breaking capacity	300V, 8A, 2000VA or 50W
	Type	Dry contacts that can be used to switch ac or dc
4.5.12	Time Synchronization	
		The test set should be able to synchronise to a GPS clock via a 1pps or IRIG B signal.
		Timing accuracy for 1pps / IRIG-B: 1 $\mu$ s.
		Maximum distance between GPS receiver and test equipment for 1pps signal: 40m.
		Test set needs to be synchronise to the IEEE 1588 Precision Time Protocol (PTP) via Ethernet.
		Timing accuracy for PTP: 100ns.
		Maximum distance between GPS receiver and test equipment for PTP: 2000m.

		IEEE 1588 / PTP clock to be powered over Ethernet (PoE), i.e. no separate power supply should be necessary.
4.5.13	Interface to PC / Laptop	Interface to the IBM compatible PC via Ethernet interface OR USB 10/100Mbit/s copper (autosensing, auto crossover) via RJ45 connector  Note: Centronics parallel port (Lpt) and/or serial RS232 ports are not permissible as modern laptops do not provide such ports.  Two Ethernet communications ports to support communication on a process bus (IEC 61850-8-2 (GOOSE), IEC 61850-9-2LE (Sampled Values) and UCA2.0) AND station bus at the same time.  Communications card to support IEEE 1588 / Precision Time Protocol (PTP) to synchronize the test set to a PTP enabled Grandmaster clock in the substation for End-to-end tests / Synchro phasor tests.
4.6	Software	Download test templates created to the test set Display all test set parameters. Create graphs from relay test results
4.6.1	General	Windows 10 (32bit and 64bit) software. Long filenames, tool tip help, context sensitive menu function (right mouse click) and an integrated help browser must be provided.  All software functions, options and actions should be easily available by click of a button and/or shortcut key to avoid having to navigate through complicated menu structures and having to drill through multiple menu levels. The Microsoft ribbon based menu structure used in Office 365/ Office 2010 / Office 2013 is an example of sorting all functions, options and actions and making all easily accessible in the right place.  No programming to be necessary to test an application - entry of setting parameters to be all that is required to set up and perform a test  Future expansions in functionality by means of software updates. Firmware updating to be handled by the software, i.e. exchange of any hardware components is not permissible. Generation of reports on paper or file. All graphics and text to be printable.  Test report must be configurable to include custom information in graphical format (e.g. logos, wiring diagrams) and text format (tester, date of test, substation, reminders)

		<p>The test set software should be able to import relay settings records from relay setting softwares (or relay settings databases) in a text file and/or XML format. An example is the XRIIO file format for the transfer of relay setting parameters for all types of relays.</p>
		<p>It must be possible to test multi-function relays / panels with one test routine / document.</p>
		<p>Test sequence to be pausable at pre-defined points in the test sequence, by popping up a custom instruction dialogue (with or without audible warning), instructing the user to change either a setting on the relay, change of hard wiring or to record a specific measurement / status from the relay / scheme.</p>
		<p>All testing to be in closed loop.</p>
		<p>On Line Pass/ Fail assessment for ALL tests. This is particular important for automatic testing.</p>
		<p>Full automatic testing must be possible, i.e. without launching various test modules manually.</p>
		<p>Test software to be future proof to allow the complete testing of any new relay, both in form of entry of relay settings as well as testing all functions of such a relay.</p>
4.6.2	Manual Control Function	<p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. set I1 to 110% of I&gt;&gt;) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual and independent adjustment of amplitude, phase angle and frequency for all generator outputs.</p> <p>Graphical display of natural voltages and currents in a vector diagram.</p> <p>Direct entry sequence components and graphical display in a vector diagram</p> <p>Direct entry of impedances and graphical display in a R/X diagram</p> <p>Direct entry of power and graphical display in P/Q diagram</p>
		<p>Ramping and stepping of any of the above quantities: one, two or three phases at the same time</p>
		<p>Pulse ramping function for any of the above quantities</p>
		<p>Synchronized switching of multiple variables at the same instance in time.</p>
		<p>Timing function for pick-up and drop-out measurements.</p>
		<p>On-line Reporting Function</p>
		<p>Synchronise generator outputs to any third party signal, e.g. mains frequency.</p>

4.6.3	State Sequencer Function	<p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. set I1 to 110% of I&gt;&gt;) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual testing</p> <p>Fully automatic testing</p> <p>Ability to generate test sequences from any number of states. Each state consists of any combination of voltage, current, frequency and any binary output state.</p> <p>Graphical display of natural voltages and currents in a vector diagram.</p> <p>Graphical display of voltages, currents and binary signals over time.</p> <p>Direct entry sequence components and graphical display in a vector diagram</p> <p>Direct entry of impedances and graphical display in a R/X diagram</p> <p>Direct entry of power and graphical display in P/Q diagram</p> <p>Define trigger conditions for each state either in fixed time or dependant upon a logical combination of the binary inputs for accurate timing measurements.</p> <p>Synchronization to GPS / PTP and other digital timing pulses.</p> <p>Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.</p>
4.6.4	Linear Ramping and Pulse Ramping Functions	<p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. set I1 to 110% of I&gt;&gt;) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual testing</p> <p>Fully automatic testing</p> <p>Ability to linearly ramp up to two independent variables (e.g. voltage and frequency) at the same time, while keeping the other quantities at a defined constant value.</p> <p>quantity shall be set back to a predefined value between every step</p> <p>Graphical display of natural voltages and currents in a vector diagram.</p> <p>Graphical display of voltages, currents and binary signals over time.</p> <p>Define trigger conditions for pick-up / drop-out measurements upon a logical combination of the binary inputs.</p> <p>Synchronization to GPS / PTP and other digital timing pulses.</p> <p>Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.</p>



4.6.5	Transient Playback Function	<p>IEEE COMTRADE (C37.111-1991) compatible (ASCII and binary formats).</p> <p>Synchronization to GPS / PTP and other digital timing pulses.</p> <p>Timing accuracy 1µs.</p> <p>signals and relay responses.</p> <p>Editing of signals: Extending (repeating) and deleting portions of the recorded signal.</p> <p>Ability to generate composite harmonic wave shapes.</p> <p>Ability to edit own digital signals OR to select recorded binary signals to play back via binary outputs.</p> <p>Unlimited length (in time) of Comtrade file to play back.</p>
4.6.6	Overcurrent Relay Testing	<p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual testing.</p> <p>Fully automatic testing.</p> <p>Testing of the operating characteristic (triptime vs. Itest) for all types of fault (earth faults, phase faults, negative sequence and zero sequence faults)</p> <p>Display of overcurrent characteristic and testpoints in I/t diagram.</p> <p>Determination of the pick-up and drop-out current for all fault types.</p> <p>Determination the pick-up and drop-out of directional characteristic for directional overcurrent relays.</p> <p>Breaker simulation: Simulate the 52a and 52b auxiliary contacts of a breaker with the binary outputs, switch the currents off at zero crossing of current after a trip signal has been received.</p> <p>Characteristic formulae: IEC255-4, BS142 and IEEE PC37.112-1995, I<sup>2</sup>t characteristics to be supported. Definition of custom characteristics must be possible.</p> <p>Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.</p>
4.6.7	Frequency and Voltage Relays Testing	<p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual testing.</p> <p>Fully automatic testing.</p> <p>Generation of ramps for amplitudes, phase angles and frequency.</p> <p>Pick-up, timing and stability tests.</p> <p>Graphic and tabular display of relay pick-up and drop-out vs. time.</p>

		Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.
4.6.8	Distance Relay Testing	<p>Testing of line impedance relays and field failure characteristics on generator protection relays.</p> <p>Direct entry of the actual relay settings of an IED into the test software must automatically generate the trip characteristic. Any new differential algorithm that is introduced shall be accommodated in a reasonable time period; typically this should be at no cost to the purchaser.</p> <p>Impedance characteristics supported: Quadrilateral, Mho, Tomato or Lens characteristic.</p> <p>Manual testing.</p> <p>Fully automatic testing.</p> <p>Test the trip time at specific fault impedances. Fault impedances must be specifiable in relation to zone reaches, e.g. 90% Z1.</p> <p>Automatic assessment of whether the tested trip time is passed or failed.</p> <p>Check the reach of a relay by placing a fault shot at the inner and outer tolerance border (i.e. theoretical reach minus and plus the defined reach tolerance of the relay). Automatic assessment of whether the tested reach is Passed or Failed.</p> <p>Automatically test the characteristic in the impedance plane (R/X diagram) and/or in the time grading diagram (Z/t diagram).</p> <p>Automatic assessment of whether the tested reach is passed or failed.</p> <p>Test models supported: constant test current, constant test voltage and constant source impedance.</p> <p>DC offset simulation: Control of angle of fault incidence, time constant of dc offset to be calculated on-line from system parameters (R/L).</p> <p>The separate arc resistance algorithm is to be supported for both earth faults and phase faults (as implemented on numerical distance relays).</p> <p>Apply Pre-fault voltage, i.e. duration settable.</p> <p>Breaker simulation: Simulate the 52a and 52b auxiliary contacts of a breaker with the binary outputs, switch the currents off at zero crossing of current after a trip signal has been received.</p> <p>Graphical display of analog voltages and currents plus relay contact responses vs. time.</p> <p>Display of injected voltages and currents on a vector diagram in natural and/or in symmetrical components.</p> <p>Testing of auxiliary functions: Manual close, power swing, Auto-reclose function, VT fuse fail.</p>

		Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.
4.6.9	Differential Relay Testing	<p>Testing of transformer differential relays, line differential relays, motor / generator differential and busbar differential relays.</p> <p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual testing.</p> <p>Fully automatic testing.</p> <p>Simulation of two and three winding transformers for all possible vector groups (e.g. YY0, YD1, YD11, etc.).</p> <p>Testing the operating characteristic (Idiff vs. Ibias) for all types of fault: earth fault, phase faults and three phase faults.</p> <p>The various types of bias formulae (<math>I_{bias} = ( I_p  +  I_s )/k</math>; <math>I_{bias} = \max( I_p ,  I_s )</math>; etc; numerical zero sequence elimination and both reference side have to be supported.</p> <p>Testing the harmonic restraint characteristic (Idiff vs. %I harmonic) for second harmonic (inrush restraint) and fifth harmonic (overfluxing restraint).</p> <p>Testing of the inrush restraint characteristic for relays which utilize the gap detection technique.</p> <p>fault.</p> <p>group correction, CT mismatch correction and zero sequence</p> <p>Apply pre-fault current, i.e. through fault current condition. Test current and duration settable.</p> <p>Apply voltage in addition to six currents - according to HV or LV voltage</p> <p>GPS / PTP synchronized End-to-end tests to test the operating characteristic of line differential relays, i.e. by simulating either the local or remote end of a line.</p> <p>Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.</p>
4.6.10	Synchronising Devices and Synchronising Check Devices	<p>Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.</p> <p>Manual testing.</p> <p>Fully automatic testing.</p> <p>Adjustment control mode to be tested closed loop.</p> <p>Graphical of quantities in a <math>\Delta V/\Delta f</math> diagram as well as relative phase angles in a synchroscope.</p>

		Feedback signals: closing pulse and adjustment pulses (V+, V-, f+, f-). Display of adjustment controls vs. time and deviation from nominal.
4.6.11	Testing with GOOSE Messages	All the above protective relay test modules must be support testing for IEC 61850-8-2, i.e. be able to trigger on GOOSE message as well as simulate GOOSE message (if need be). Import of SCD, ICD of GOOSE sniffer files to configure the triggering / simulation of GOOSE messages. Sensing of up to 360 simultaneous GOOSE message must be possible.
4.6.12	Testing with Sampled Values	All the above protective relay test modules must be support testing for IEC 61850-9-2LE, i.e. be able to simulate all voltages and currents as Sampled Value signals. Simulation of up to THREE sets of IEC 61850-9-2LE signals must be possible.
4.6.13	Testing Single and Three Phase Transducers	Manual testing. Automatic testing. Generation of sweeps for amplitudes, phase angles, frequency, power (W, VA, Var). Individual setting of voltages and currents (its amplitude, phase angle and frequency) should be possible per test point. For single phase transducers phase injected should be selectable. L-L voltage transducers to be tested with full three phase voltage system. On-line calculation of error (absolute, percentage and full-scale). Display of transducer output and absolute, percentage and full-scale errors vs. sweep quantity graphically and/or as table. Feedback signal: Low-level analog voltage (0. +/- 10V) or current (0. +/- 20mA) Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.
4.6.14	Energy meter testing according to IEC 62053	Manual testing. Automatic testing. Load test, No-load test, creep test, mechanism test, Injection test. Ability to generate automatic load profiles, i.e. test the meter for different load conditions. On-line display of error.

		Feedback signal via optical pick-up / scanning head: Meter pulses of up to 100 KHz Third Harmonic Test DC test Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.
4.6.15	Power Quality Signal Generator	Testing of Power Quality measurement devices as per the standards to NRS 048-2 / SANS/IEC 61000-4-30; SANS/IEC 61000-4-7; BS EN/IEC 61000-4-15 and IEC 62586
4.6.16	On-line Multimeter Measurement Function	Up to 10 independent inputs Software to display amplitudes and phase angles of ac voltages and currents, symmetrical components of voltages and currents, line to line voltages, frequencies, power (active, reactive and apparent) and cos(phi) independently for each input All ac measurements to be true RMS. On-line vector diagram for voltages and currents as well as power. On-line measurement of Vdc, Idc and dc power for each input On-line display of harmonics measured both numerically (in a table per harmonic frequency) and graphically in a bar graph.
4.6.17	Transient Recording Function	The recording function should enable recordings at the specified sampling frequency. Any recordings done, should automatically be uploaded to the controller PC. The recordings should be saved in COMTRADE format on the PCs harddrive. Trigger conditions: amplitude, swell and sag, harmonic, frequency, frequency change, notch as well as any combination of these triggers. A pre-trigger buffer should be definable. Analysis software should be provided to analyze the recorded waveshapes in terms of analog waveshapes (RMS and instantaneous values), vector diagram, impedance plots (L-N and L-L fault loops) as well as harmonics. For impedance plots, the relays impedance characteristic should be displayable in relation to the impedance trajectory measured by the relay.
4.6.18	System-based testing of relays	

	Provide a power systems based simulation software to test the function of a relay in the primary power system, i.e. by specifying the primary power system topology (e.g. from a single line diagram) and power systems parameters (network source impedances, line and transformer impedances, CT and VT parameters). Allow definition of power system events, e.g. any type of fault (L-N, L-N, L-L-N and L-L-L faults) as well as switching event (opening of closing of breakers) Full Transient simulation simulating power system phenomena such as DC offset, saturation of CTs, power swings, series compensated lines, transformer in-rush, etc. Distributed testing, i.e. injecting multiple test set simulating voltages and currents and different points in the network from ONE PC - even when the test sets are physically NOT in the same location (e.g. at different ends of a line) Special applications: Line impedance protection scheme on series compensated lines with tele-protection
	Line differential protection system testing (up to three terminals) Power transformer differential relay testing with internal winding faults Bus zone system testing for out-of-zone through faults, in-zone faults, dead-zone faults as well as isolator transition faults
4.6.19	ARC flash simulation
4.7	Standard Accessories Generator combination cable Measurement leads Other accessories:  to combine 3xV and 3xI into one test lead, 8x 4mm banana plugs 12 x 2 m; 2 mm <sup>2</sup> South African power cord Connection lead from test set to PC Various connection accessories Hardcover carrying cases for test hardware (with retractable handle and wheels if available) Soft bag for test set and accessories Instruction Manual Software for report downloading and configuration as well as offline test sequence generation.

<b>4.8</b>	<b>Software Licensing</b>	<p>A software license shall not depend on a hardware dongle to be used. The License shall be imbedded in the software and the Eskom license shall be imbedded in the software package such that any Eskom user may control a test set of another Eskom user using his / her own computer and test set software, it is accepted modules are registered per test set and that certain functions may not be available to another user.</p> <p>Dedicated software for use with say an IEC61850 package shall also not use a dongle. The license shall be applied such that a user can transfer the license to other computers.</p>
<b>4.9</b>	<b>Local Support</b>	<p>Local telephonic support to be offered in the hours of 07h00 - 20h00 South African time.</p> <p>Email support to be offered with a guaranteed turnaround time of 1 business day.</p> <p>10 units in SA (separate list of users with contact details to be provided)</p> <p>2</p> <p>Yes</p> <p>&lt; 5 working days for local and 14 working days for ending units offshore.</p> <p>standard training offered every three months in Johannesburg</p> <p>In-house / On-site training to be offered on request</p> <p>FIVE years from date of delivery</p>
<b>4.10</b>	<b>External integrated antenna PTP clock (GPS)</b>	<p>The device should consist of a GNSS Antenna, GNSS Receiver and CPU combined in one unit and be weatherproof.</p> <p>The device should be easily setup.</p> <p>No RF cabling shall be required.</p> <p>The device should operate using an Ethernet cable up to 100 meters.</p> <p>The device should use extremely low power.</p> <p>To power up the device no additional power supply will be needed and should use powered over Ethernet (POE).</p>

		<p>Multiple time protocols shall be supported e.g. PTP and NTP timing networks.</p> <p>The device should fully support the following PTP profiles:</p> <p>IEEE 1588 default profile</p> <p>IEEE C37.238-2011</p> <p>IEEE C37.238-2017</p> <p>IEC/IEEE 61850-9-3:2016</p>
4.11	Standalone Software Interrogation and Investigation of IEC 61850 Devices	See IEC 61850 Software Tool Excel sheet tab
5	MPTS hardware configurations	
6	Software	
7	Accessories	
8	Calibration, Repair and Annual Reports	
9	Training and Support	<p>Training shall be offered on both the software and the hardware.</p> <p>Preference shall be that the training is registered with Eskom as an official training course. Training to be offered at the respective Eskom premises where the training requirement exceeds 7 trainees. The minimum charge in such cases will be for 8 trainees.</p> <p>Courses are to be done by trainee attending with the Eskom supplied Laptop and correct version of software. Currently a pre-built software image is setup by Eskom and checked to work.</p> <p>Software upgrades are introduced to the business as Eskom receives notices of upgrades, the software is placed on the Eskom server and the location on the supplier web page is also given.</p> <p>Laptops used by test personal should allow removal and installation of software. Where training is offered locally to Eskom trainees, trainees may be requested to bring with their test set to speed up practical training, however test sets cannot be flown from a region to another distant venue.</p> <p>The training shall be offered in three modules:</p> <ul style="list-style-type: none"> <li>- Basic training course</li> <li>- Intermediate training course</li> <li>- Metering and measurement training course</li> </ul>




10	Guarantee	<p>The unit and accessories shall be guaranteed for a period of at least 5 years. The guarantee may exclude any damage or failure that is deemed to have occurred due to negligence or abuse</p>
11	URS Excel Sheet	
12	Demonstration	<p>The tender evaluation will include a physical demonstration of the TPTS and software by the supplier to the Eskom technical team on how to setup the software test module and physically testing the supplied product or products.</p> <p>The demonstration shall be done by the local representative of the vendor; the local representative shall not be supported by an offshore specialist either at the preparation or demonstration stage. All suppliers will be given the same product to test and the same time slot</p> <p>Each supplier where possible will be given the opportunity to familiarise themselves with the product. The product will be located in a laboratory and be powered up with the requisite circuit breaker simulator if applicable. In addition the setting sheet, the schematic and the IED software will be available on the day.</p> <p>The supplier will be responsible for any damage of the product. Eskom will only provide limited support.</p> <p>An Eskom technical panel will evaluate the demonstration which will form a substantial part of the technical compliance assessment.</p>

## ers and Energy Meters

### **Tenderer Proposal / Comments**

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	<b>USER REQUIREMENT SPECIFICATION</b>	<b>NUCLEAR ENGINEERING</b>
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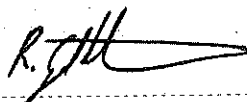
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## **1. Introduction**

This User Requirement Specification (URS) describes the Eskom requirements in respect of the procurement of a portable multi-phase test system, software modules and accessories as required by test personnel for the testing of protection relays, synchronising devices, measurement transducers and energy meters at Koeberg Power Station.

## **2. Supporting Clauses**

### **2.1 Scope**

This specification defines the minimum user requirements for a highly accurate and fully automated and portable multi-phase injection test system with accessories.

The portable multi-phase injection test system shall include the following main features:

- a) Four independent voltage outputs, AC and DC adjustable from 0 to 300V<sub>rms</sub> (Line to Neutral) or 0 to 520V (Line to Line). The outputs to be continuously and independently adjustable in amplitude, phase (0 to +/- 360°) and frequency.
- b) Six independent current outputs, AC and DC adjustable from 0 to 30A<sub>rms</sub>. The outputs to be continuously and independently adjustable in amplitude, phase (0 to +/- 360°) and frequency. This is to test, for example, a transformer differential application scheme.
- c) Highly accurate low-level signal generator capable of producing at least six additional analogue low-level signals to control external amplifiers, to test relays and transducers, and to be able to inject white noise signals into a generator AVR for grid compliance testing.
- d) Binary inputs for start, trip and triggering indications and may include additional functions such as counters, AC and DC measurement/recording capability.
- e) Binary outputs to simulate plant conditions during testing and commissioning.
- f) Analogue low-level DC-measuring inputs for transducer testing.
- g) Auxiliary DC supply to power test objects.
- h) Capability for testing various types of protection relays on e.g. Distance-, Generator-, Motor-protection systems.
- i) Capability for testing of synchronising and synch-check devices.
- j) Power-system-based simulation software / module to test the function of a relay in the primary power system.
- k) Power quality signal generator software / module for testing power quality measuring devices. Generation of all kinds of Power Quality events according to IEC 61000-4-30
- l) Analysis software for recording and analysing transient recordings.
- m) Should have IEC 61850 protocol, USB and Ethernet interfaces.
- n) Capable of end-to-end testing with GPS or IRIG-B time synchronisation.
- o) Local support (repair, calibration, training, application support) with a five year warranty.
- p) The test set shall be compatible with the existing Koeberg testing modules for the protection relays, synchronising devices, measurement transducers and energy meters.

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The scope of supply comprises the following:

- Supply of a portable multi-phase injection test system that complies with all requirements in this document and in Attachment A.
- Supply of a mobile workstation and a wheeled hardcover transport case.
- Supply of a carry bag, power lead and measurement / test leads.
- Supply of power-system-based simulation software / module to test the function of a relay in the primary power system.
- Supply of power quality signal generator software / module for testing power quality measuring devices.
- Supply of standalone software for the interrogation and investigation of IEC 61850 devices. The software shall be able to browse and discover the IED's data models, network sniffer function, monitor IEC 61850 activity and work with SCL files. The software should also be able to publish and receive GOOSE messages, both monitored and simulated.
- Supply of an external integrated antenna PTP clock for end-to-end testing.
- Instruction and maintenance manuals.
- End-user training on the multi-phase test system functions and the power-system-based simulation software.
- Shipping of all requested equipment to Koeberg Nuclear Power Station.

### **2.1.2 Purpose**

To document the minimum user specifications for the procurement for a portable multi-phase test system for the testing of protection relays, measurement transducers and energy meters at Koeberg Nuclear Power Station.

### **2.1.3 Applicability**

This document shall apply throughout Nuclear Project Management (NPM).

### **2.1.4 Effective date**

This document shall become effective from the date of authorisation by the Nuclear Complex Projects Manager.

## **2.2 Normative/Informative References**

Parties using this document shall apply the most recent edition/revision of the documents listed in the following paragraphs.

### **2.2.1 Normative**

- |     |           |   |
|-----|-----------|---|
| [1] | OHS Act:  | Occupational Health and Safety Act No. 85 of 1993 |
| [2] | ISO 9001: | Quality Management Systems                        |

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- [3] SANS 603201: Appliance couplers for household and similar
- [4] Low Voltage: Directive 2006/95/EC
- [5] SANS/IEC 60950-1: Information technology equipment – Safety; Part 1: General requirements
- [6] 240-76624513: Standard for the calibration of test instruments used by field staff.
- [7] 240-77224537: Standard for calibration and limits of errors for single- and multi-phase energy meters.
- [8] 240-95637584: Work instruction for control of monitoring and measuring equipment.
- [9] BS EN/IEC 61000-4-15: Testing and measurement techniques — Flicker meter — Functional and design specifications
- [10] BS EN 62053-24:2015. Part 24: Static meters for reactive energy at fundamental frequency (classes 0,5 S, 1 S and 1)
- [11] BS EN/IEC 62586-1: Power quality measurement in power supply systems, Part 1: Power quality instruments (PQI)
- [12] BS EN/IEC 62586-1: Power quality measurement in power supply systems, Part 1: Power quality instruments (PQI)
- [13] IEC 61588: Precision clock synchronisation protocol for networked measurement and control systems
- [14] IEC 61850-5: Communication networks and systems for power utility automation; Part 5: Communications requirements for functions and device modules
- [15] IEC 61850-7-1: Communication networks and systems for power utility automation; Part 7-1: Basic communication structure – Principles and models
- [16] IEC 61850-7-2: Communication networks and systems for power utility automation; Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)
- [17] IEC 61850-7-3: Communication networks and systems for power utility automation; Part 7-3: Basic communication structure – Common data classes
- [18] IEC 61850-7-4: Communication networks and systems for power utility automation; Part 7-4: Basic communication structure – Compatible logical node classes and data object classes
- [19] IEC 61850-7-410: Communication networks and systems for power utility automation; Part 7-410: Hydroelectric power plants – Communication for monitoring and control
- [20] IEC 61850-7-420: Communication networks and systems for power utility automation; Part 7-420: Basic communication structure – Distributed energy resources logical nodes
- [21] IEC 61850-8-1: Communication networks and systems for power utility automation; Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3

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- [22] IEC 61850-9-2: Communication networks and systems for power utility automation;  
Part 9-2: Specific communication service mapping (SCSM) – Sampled Values over ISO/IEC 8802-3
- [23] UCA GUIDELINE IEC 61850-9-2LE: Implementation guideline for digital interface to instrument transformers using IEC 61850-9-2
- [24] IEC 61869-9: Instrument transformers – Part 9: Digital Interface for Instrument Transformer (Incorporates the 9-2LE Guide and is due for publication in 2016)
- [25] IEC 61850-9-3: Communication networks and systems for power utility automation;  
Part 9-3: Precision time protocol profile for power utility automation
- [26] IEEE C37.238-2011: IEEE Standard Profile for Use of 1588™ Precision Time Protocol in Power System Applications
- [27] NRS 048-2: Voltage characteristics, compatibility levels, limits and assessment methods
- [28] SANS 164-0: Plug and socket-outlet systems for household and similar purposes for use in South Africa (Includes all normative references as applicable referenced within SANS 164-0)
- [29] SANS 603201: Appliance couplers for household and similar.
- [30] SANS/IEC 60950-1: Information technology equipment – Safety; Part 1: General requirements
- [31] SANS/IEC 61000-3-2: EMC Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
- [32] SANS/IEC 61000-4-2: EMC Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
- [33] SANS/IEC 61000-4-3: EMC Part 4-3: Testing and measurement techniques – Radiated, radio- frequency, electromagnetic field immunity test.
- [34] SANS/IEC 61000-4-4: EMC Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test.
- [35] SANS/IEC 61000-4-5: EMC Part 4-5: Testing and measurement techniques – Surge immunity test.
- [36] SANS/IEC 61000-4-6: EMC Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio frequency fields.
- [37] SANS/IEC 61000-4-07: EMC Part 4-07: Testing and measurement techniques – General guide on harmonics and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto.

These documents are indispensable for the application of this document, i.e. documents to be used together with this document.

## **2.2.2 Informative**

- [38] IEC 61850 Sampled Values – Technology Promise, Open Issues, and the State of International Standardization (Cigre Study Committee B5 Colloquium, August 25-31. 2013 Belo Horizonte, Brazil).

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[39] KSA-011: Requirements for Controlled Documents

## 2.3 Definitions

### 2.3.1 General

Definition	Description
<b>Analogue input</b>	This is a hardwired input and supports current and voltage inputs which typically are DC and have a positive – zero – negative range.
<b>Binary input</b>	This is a hardwired input and shall support both a dry or wetted voltage (typically up to 220Vdc) type input. This must be configurable via the test set operating software/interface.
<b>Binary output</b>	This is a controllable contact output that is used to control certain aspects of the test object. The contacts shall have a practical specification allowing switching of at least 220Vdc with a realistic current switching capability.
<b>Ethernet port</b>	This is typically a copper based RJ45 female Ethernet port which allows connection to process equipment including PC's, routers, switches and IED's to allow for full control of the test set and testing of IED's typically supporting IEC61850. The connector should also provide options for two or more RJ45 and fibre optic Ethernet ports.
<b>Multi-phase test set</b>	This is an instrument that has current and voltage outputs which may provide single to multi-phase current and voltage outputs which are controllable in terms of magnitude, phase angle and frequency, binary inputs and outputs, analogue inputs and may include Ethernet and USB ports for connecting to a controlling computer using the Microsoft Windows operating system. The Ethernet ports shall also support testing of devices compliant with IEC61850. The multi-function test set is controlled using the vendor supplied software and/or hardware interface and may include other features useful in testing of Secondary Plant IED's.
<b>USB port</b>	This is a port typically used to connect a controlling PC to the test set to allow full control of the test set properties.
<b>Acceptance Criteria</b>	Specified limits placed on the performance, results, or other characteristics of an item, process, or service defined in codes, standards, or other requirements documents.
<b>Certification</b>	The act of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with specified requirements.

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Definition	Description
<b>Confidential</b>	The classification given to information that may be used by malicious/opposing/hostile elements to harm the objectives and functions of Eskom Holdings Limited.
<b>Contractor</b>	Service provider, consultant or supplier that has been deemed successful (via a tender process) to provide the required service.
<b>Controlled disclosure</b>	Controlled disclosure to external parties (either enforced by law, or discretionary).
<b>Requirement</b>	A condition or capability needed by a user to solve a problem or achieve an objective.
<b>Scope of Supply</b>	The sum of the products, services, and results to be provided as a project.
<b>Shall, should, may</b>	"Shall" is used to denote a requirement, "should" a recommendation and "may" to denote permission.
<b>System</b>	An interdependent group of people, objects and procedures constituted to achieve defined objectives or some operational role by performing specified functions. A complete system includes all of the associated equipment, facilities, material, computer programs, firmware, technical documentation, services and personnel required for operations and support to the degree necessary for self-sufficient use in its intended environment.
<b>Testing</b>	An element of verification for the determination of the capability of an item or SSC to meet specified requirements by subjecting the item / SSC to a set of physical, chemical, environmental, accidental or operating conditions.

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## 2.4 Abbreviations

Abbreviation	Description
AC	Alternating current
AVR	Automatic Voltage Regulator
BI	Binary input
BO	Binary output
DC	Direct current
EMC	Electromagnetic compatibility
GOOSE	Generic object-oriented substation events
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
IEC	International Electrotechnical Commission
IED	Intelligent electronic device
IBM	International Business Machines
ICD	IED capability description
IRIG-B	Inter-range instrument group time code
LAN	Local Area Network
mA	Milli ampere
mm	Milli-metre
NTP	Network time protocol
OE	Operating Experience
OEM	Original Equipment Manufacturer
PC	Personal Computer (typically a Windows-based desktop or laptop computer)
PTP	Precision time protocol (IEC61588; IEC61850-9-3 and IEEE1588)
QA	Quality Assurance
QC	Quality Control
SANAS	South African National Accreditation System
SCD/L	Substation configuration description / language
SELV	Safety Extra Low Voltage
MPTS	Multiphase test set
UCA	Utility Communication Architecture
USB	Universal serial bus
URS	User Requirement Specification
V	Voltage (Usually Vac or Vdc, denotes alternating or direct current voltage)
VLAN	Virtual local area network

## 2.5 Roles and Responsibilities

This URS will be used to procure the three-phase secondary injection test set utilising the standard procurement or "List of accepted products" processes within Eskom.

Refer to the URS Excel spreadsheet in Attachment 1.

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## **2.6 Process for Monitoring**

Not Applicable

## **2.7 Related/Supporting Documents**

Not Applicable

## **3. Test Set Hardware Specification**

The test set hardware specification is defined here. All specifications detailed herein are deemed the minimum acceptable requirement.

### **3.1 Multiphase injection test set casing and carry handle.**

The casing may be metallic or reinforced plastic or a combination of both. The casing shall be durable and provide protection to the innards from ingress of dust, debris and mechanical forces imparted to the unit during transport and normal usage in a substation environment.

The test set shall have a sturdy carrying handle with a comfortable nonslip grip. The handle is to be adjustable when placed on a floor or desk to facilitate easy connection to the input and outputs.

All test inputs/outputs shall be placed in a logical layout on the front/top (hereafter termed "front") plate of the device. Some outputs may be on the back of the unit. The rear panel is not an absolute requirement but should be separate to the usual test input and output terminals, typically the rear panel houses communication ports, 230 Vac power supply input plug and specialised inputs/ outputs such as GPS, low level input/output or synchronising plugs (synchronising of test set current and voltage channels). The MPTS shall make available any other safety earth connection on the rear of the unit as determined necessary by the test set manufacturer and standards body. The ethernet and USB ports shall preferably be located on the rear of the device.

The test set ON/OFF switch shall preferably be located on the front panel and must be illuminated when ON. The ON/OFF switch must be readily accessible by the test set operator.

The casing shall at minimum be protected by a sturdy carrying bag with pockets to contain the power supply lead, ethernet/USB cables and some test leads. The bag shall have a carrying sling with non-slip shoulder pads that allow for easy and safe transport of the test set by one person. The casing shall have sturdy replaceable protective feet on all deemed standing sides, typically the bottom and back side. The casing vents should be on the non-exposed sides to minimise the possibility of debris or liquid ingress. Thus, in the normal working position the test set should be the least vulnerable to dust and spillage.

### **3.2 Front panel connections**

The front panel connections shall be seen to be the following:

- Voltage outputs
- Current outputs
- Analogue / Binary inputs
- Binary outputs
- Auxiliary power supply

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### **3.2.1 Voltage outputs**

The terminal physical attributes shall be as described under terminals.

The voltage outputs shall be in various configurations as per test set offering.

A multiphase test set must at minimum have three phases and a neutral. It shall be preferred that a multiphase test set to have at least an additional and separately controlled output with a live and a neutral. Multiple multiphase voltage outputs will be a deciding advantage. It is expected that a MPTS voltage channel can be controlled in terms of voltage amplitude, phase shift and frequency. The test set voltage outputs shall be capable of supplying DC voltage at the specified AC rating.

The voltage outputs must have short circuit and overload protection. These conditions shall be flagged by the test set control and/or the PC software package. The flagging method should be such that the flag will not go unnoticed by the MPTS operator. The voltage outputs shall have protection against inadvertent application of external voltage. The level of protection shall be technically quantified by each supplier.

The voltage outputs shall be clearly marked with the phase's colour and the neutral black. When supplying DC voltage the polarity will be designated such that red coloured terminal shall be the positive terminal and the black coloured terminal the negative terminal. The voltage output group shall have a visual indication (LED or similar) when energised.

The minimum output capability of the test set is detailed in section 4.0 in terms of rating and accuracy for all the variable components like amplitude, phase angle and frequency.

### **3.2.2 Current Outputs**

The terminal physical attributes shall be as described under terminals.

Current output configurations shall again be dictated by the MPTS offerings. A multiphase test set shall have at least one set of terminals with three phases and one neutral. Additional multiphase outputs are an advantage. The most common requirement is two sets of multiphase outputs. Where voltage or current channels can be converted from say current to voltage or vice versa it is seen as an added benefit.

It is expected that a MPTS current channel can be controlled in terms of current amplitude, phase shift and frequency.

The current outputs must have short circuit and overload protection. These conditions shall be flagged by the test set control and/or the PC software package. The flagging method should be such that the flag will not go unnoticed by the test set operator. The current outputs must have protection against inadvertent application of external voltage. The level of protection shall be technically quantified by each supplier at tender stage.

The mentioned inputs and outputs shall preferably all be arranged on the front panel. However, some may be placed elsewhere on the test set if space is an issue on the front panel.

The minimum output capability of the test set is detailed in section 4 in terms of the rating and accuracy of all the variable components like amplitude, phase angle and frequency. The test set current outputs shall be capable of supplying DC current at the specified AC rating.

### **3.2.3 Synchronising of MPTS current and voltage channels across test sets**

Synchronising current and voltage channels of test sets with the following four possibilities:

- 1) Slaving together of test sets via electrical connection or ethernet.

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- 2) Via common mains frequency, thus allowing synchronised testing usually within the confines of a substation.
- 3) Via an external GPS unit which would allow two or more tests sets to be synchronised either locally or geographically separated between two substations or distributed control cubicles.
- 4) Via ethernet based PTP locally at a substation or geographically displaced.

The basic requirement is GPS synchronisation (item 3) with items 1, 2 and 4 being a distinct advantage.

#### **3.2.4 Low level voltage outputs**

It shall be advantageous if a test set has low level outputs for the testing of non-conventional IED's that accept inputs from other voltage sensors like a Rogowski coil. These outputs may also be used to test the Sub Synchronous Resonance (SSR) numerical protection relays at Koeberg Power Station and for the injection of white noise signals into the AVR for grid compliance testing. The test set must have the required resolution and accuracy when testing at these low voltages. These outputs may also be used to drive other accessories.

#### **3.2.5 Binary inputs**

The terminal physical attributes shall be as described under terminals.

The binary inputs shall be clearly marked and where polarity sensitive be marked as such with positive red and negative black. Where binaries are in any way physically connected this must be clearly indicated on the front panel.

The maximum input voltage shall be clearly indicated on the front panel. The preference is that all binary inputs are high impedance inputs.

The binary inputs may have additional functions such as counters, AC and DC measurement/recording capability. This capability may be specific to some brands and will be seen as an advantage for specific applications.

#### **3.2.6 Binary Outputs**

The terminal physical attributes shall be as described under terminals.

Each output and output group must be clearly marked in terms of function and output. The terminals must preferably be marked black or a colour agreed with by Eskom.

The maximum AC and DC voltage and current capability of each output shall be clearly marked on the front panel.

#### **3.2.7 Analogue DC Inputs**

The terminal physical attributes shall be as described under terminals.

The analogue DC inputs will be  $\pm 20\text{mA}$  and  $\pm 10\text{V}$ . The inputs would typically be for transducer testing and/or process feedback.

The inputs shall be protected from inadvertent over voltage or current to the level specified by the manufacturer.

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The input terminals shall be clearly marked in terms of function and input quantity.

### **3.2.8 Auxiliary power supply output**

The test set shall have an auxiliary DC output controllable from at least 0 to 220 Vdc. This power supply shall be able to power up typical modern day IED's. The output shall have a visual indication (LED or similar) when energised. The output shall be short circuit and overload protected.

### **3.2.9 Input and output terminals**

The input/output terminals shall be suitable to accommodate the standard banana plug connector with a nominal plug diameter of 4 mm and a length of 20 mm. These plugs are an international standard and widely used in the electrical test industry. The input/outputs shall be female and of a solid construction. An inadvertent accidental tug by a test set operator should not damage the receptacle. The receptacle shall be insulated from the casing at 1000 Vac. Any dangerous voltage present on the front panel outputs should indicate such by a lit indicator clearly associated with the grouped input or output. All these terminals shall have the same physical and electrical properties irrespective of function. The terminal shall be a blind terminal not allowing any object including dust to enter the test set via the female terminal.

Each output and output group must be clearly marked in terms of function and where polarity is important. The preferred colour code will be positive (+) = RED and negative (-) = BLACK.

For AC outputs typical descriptors such as L1, L2, L3, N / 1, 2, 3, N / A, B, C, N which must be configurable in software shall be preferred. The phases shall all be the same colour and neutral shall be black. An exception with Eskom approval is possible.

When connectors/receptacles are commonly connected internally it shall be clearly indicated on the front plate. All inputs shall clearly indicate the maximum voltage input allowed.

The connector/receptacle design must be such that inadvertent contact with the live part of the plug is not possible by the test set operator using bare hands. The terminals shall preferably be flush with the casing.

## **3.3 Rear panel**

The rear panel of the test set should preferably house the power supply receptacle, ethernet ports, USB connector and additional input/outputs as required. The input power supply level shall be clearly marked and separated from other inputs and outputs. The test set design may deviate from this requirement if the deviation is not impractical.

Any assisted cooling devices must be located here. It must be noted in the event of an operator error whereby the operator causes a catastrophic failure of the test set that the test set design should ensure that any gases generated are expelled at the rear of the device and away from the operator. The front panel usually facing the operator may not allow the ejection of any gas or material towards the operator.

The sides of the test set shall be free from any connectors, inputs, and outputs. This is to allow mounting in a rack.

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### **3.4 Power Supply**

The power supply to the test set shall be a single phase 230Vac, 50Hz supply rated at 15 A maximum. The test set shall have a suitable on/off switch preferably mounted on the front panel where it is easily accessible by the test set operator in the event of an unsafe situation and the switch must clearly indicate that it is either ON or OFF. The power supply lead shall plug into a standard South African 3 pin socket outlet and be separable from the test set via a suitable plug. This lead and plug arrangement shall include an integral earth wire. The power supply lead shall be at least 2 meter in length. The lead and insulation shall be flexible and rugged and not easily damaged. An added safety requirement is that the test set checks the integrity of the integral earth lead of the test set supply. The test set shall signal the absence of such an earth connection and indicate that the application of an external earth lead is required. The signal may be via the controlling software and/or any other control interface offered.

The power supply receptacle shall preferably be located on the rear of the test set.

All aspects of the power supply, plugs and leads shall meet the relative SANS specification.

### **3.5 Ethernet ports**

The preference is RJ45 copper ethernet ports.

The test set must have two RJ45 ethernet port to allow synchronising of multiple test sets or to conduct an IEC 61850 session.

Ethernet ports have three possible functions:

- 1) Test set control by PC and vendor software over ethernet.
- 2) Time synchronisation over PTP.
- 3) Testing of IEC 61850 based systems using both GOOSE and sampled values.

It is accepted that not all test sets may have the full described functionality however, this would be the preferred functionality.

The ethernet copper ports should be capable of supporting 10/100BASE-T or better, especially where the test set generates IEC 61850 derived sampled values, a 10/1000BASE-T will be preferred. A 1 Gbit capability shall be seen as essential for high end test sets with sampled value capability. For copper ethernet the standard RJ45 8P8C female connector should be supplied. This connector imbedded in the test set should be resistant to damage by personnel inadvertently tugging on the ethernet cable plugged into the female ethernet port located on the test set. The point of damage should be the RJ45 plug on the ethernet cable.

Power over ethernet is an essential requirement, this would be used to power PTP time synchronisation based units and other ethernet based accessories requiring a power supply.

Lead lengths for copper ethernet cables would be as per test set model specification in section 4.

An option with fibre optic ethernet which supports all common standards would be advantageous. A multimode fibre cable would suffice. All popular connectors shall be supported.

#### **3.5.1 Test set control by computer**

Only ethernet and/or USB communication shall be acceptable.

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#### 4. Detailed technical and software specification.

The specification list details the minimum requirement for each specification type. This specification shall be the minimum acceptance criteria. The specification is based on the most used test set in Eskom.

Detailed Technical Specifications for a Portable Test System for Protective Relays, Measurement Transducers & Energy Meters		
<b>4.1 Power Supply</b>		
a)	Nominal Voltage	230 VAC
b)	Permissible Voltage Range	90 V - 260 VAC
c)	Nominal Frequency	50 Hz / 60 Hz
d)	Permissible Frequency Range	45 Hz - 65 Hz
e)	Power Consumption	Max 3450VA at 230VAC
f)	Rated Current	15A at 230VAC
g)	Connection	Standard AC sockets: Connector (SANS 60320-1, C13) and Inlet (SANS 60320-1, C14) Other SANS approved connectors and inlets may be considered.
<b>4.2 Dimensions and Weight</b>		
a)	Volume	max. 30 litre
b)	Weight	max. 20 kg
<b>4.3 Environment</b>		
a)	Operating Temperature	0 °C ... 50 °C

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b)	Storage Temperature	-25 °C ... 70 °C
c)	Humidity	5 % ... 95 % RH, non-condensing
<b>4.4 Certificates</b>		
a)	Vibration	IEC60068-2-6
b)	Shock	IEC60068-2-27
c)	CE Mark	Yes/No
d)	EMC	The product adheres to the electromagnetic compatibility (EMC) Directive 2004 / 108 / EC (CE conform)
e)	EMC Emissions	- IEC 61326 Class A; IEC 61000-6-4; SANS 61000-3-2/3; FCC Subpart B of Part 15 Class A
f)	EMC Immunity	- IEC 61326; IEC 61000-6-2; IEC 61000-4-2/3/4/5/6/11
g)	Safety	The product adheres to the low voltage Directive 2006 / 95 / EC (CE conform) IEC61010-1: Safety requirements for electrical equipment for measurement, control, and laboratory use; Insulation of PC and SELV Interfaces complies with SANS 60950-1 (Also EN)
h)	Independent Test Laboratory	Copies of test certificates from independent test laboratories proving compliance with the above standards are to be supplied together with the tender
<b>4.5 Hardware</b>		
<b>4.5.1 General</b>		
a)		All functions should be combined in one hardware unit
b)		The unit shall be of a robust and sturdy construction
c)		PC card design: Wire jumpers on a single printed circuit board are not permissible
d)		Electronic components: No potentiometers are allowed

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e)		No moving elements or elements that are susceptible to damage, i.e. controls elements or displays on the face plate are permissible
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#### 4.5.2 Output Amplifiers

a)		The amplifier stages are to be fully electronic, i.e. not via transformer
b)		All current amplifiers must be fully protected and proof against any open-circuit-, overload-, overburden- and over-temperature- condition. Any such condition is to be immediately displayed in all active software modules or test set specific controller. Except for an over-temperature condition an automatic shutdown of the amplifiers is not permissible. The withstand capability of the outputs when inadvertently connected to an external supply to be defined. What level of protection is offered?
c)		All voltage amplifiers must be fully protected and immune against any short-circuit-, overload-, overburden- and over-temperature- condition. Any such condition is to be immediately displayed in all active software modules or test set specific controller. Except for an over-temperature condition an automatic shutdown of the amplifiers is not permissible
d)		All amplifiers to use linear amplification elements and to be dc-coupled. The neutrals of the voltage and current amplifiers shall be galvanically isolated (up to 2kV) from the ground/chassis of the test set. This is for the safety of the test set operating personnel and will ensure that the test set casing does not inadvertently subject the operator to any electrical shock.
e)		Ability to generate DC and AC signals
f)		The amplifiers, low level outputs, measurement inputs and the main power supply must be galvanically isolated from each other and earth (2kV insulation voltage)

#### 4.5.3 Voltage Amplifiers

a)	Setting range	4x 0..300V <sub>rms</sub> (L-N), 3x 0..520V <sub>rms</sub> (L-L)
b)	Single phase operation	1x 0..600V <sub>rms</sub> (L-L)
c)	Output power	3x 100VA at 100..300V (L-N) or
d)		1x 200VA at 100..300V (L-N) or
e)		1x 275VA at 200..600V (L-L)

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f)	Minimum load current	3x 1A <sub>rms</sub> ; 1x 2A <sub>rms</sub>
g)	Accuracy	error < 0.05% of reading (0..300V) + 0.02% of range
h)	THD+N	< 0.015%
i)	Phase error	<0.05°
j)	Connection	4mm Banana sockets
<b>4.5.4 Current Amplifiers</b>		
a)	Setting range	6x 0..32A <sub>rms</sub>
b)		3x 0..64A <sub>rms</sub>
c)	Single phase operation	1x 0..128A <sub>rms</sub>
d)	Output power	6x 430VA at 25A
e)		3x 860VA at 50A
f)		1x 1000VA at 80A (LL-LN) or
g)		1x1740VA at 25A (L-L-L-L)
h)	Maximum compliance voltage	6x 35V <sub>pk</sub> ; (higher is better.)
i)		1x 140V <sub>pk</sub> (higher is better.)
j)	Accuracy	error < 0.05% of reading (0..32A) + 0.02% or range
k)	THD+N	< 0.015%
l)	Phase error	<0.05°
m)	Independent amplifiers	The six current amplifiers shall be independent from the four voltage amplifiers. The neutrals between the two current output groups are to be galvanically isolated (up to 2kV) to allow for series connection of the two groups to boost the compliance voltage.
n)	Connection	4mm Banana sockets

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#### 4.5.5 Low-level signal Generators

a)		6 additional analogue low level signals to control external amplifiers or to test relays with low-level input, e.g. from Rogowski coils, linear voltage or linear current sensors must be provided
b)		Full simulation of Rogowski coil signal (i.e. first order differential of signal) to be performed in hardware.
c)		Testing the Sub Synchronous Resonance (SSR) numerical protection relays at Koeberg and for the injection of white noise signals into the AVR for grid compliance testing.
d)		Together with 10 internally used signal generators the system should provide 16 independent signal channels in total
e)	Output range	0 ... 10 Vpk
f)	Accuracy	<0.025%
g)	Overload Protection	Yes
h)		The quantities displayed in the software must be scalable for primary or secondary voltages or currents.
i)		Couple to other auxiliary devices or possible synchronising function.

#### 4.5.6 Signal Generation

a)		All outputs to be continuously and independently adjustable in amplitude, phase (0 to +/- 360°) and frequency.
b)		Able to generate continuous sine waves with a frequency between 10 and 1kHz and to generate transient files with a bandwidth from dc up to 3 kHz.
c)		Frequency error to be less than 0.5 ppm.
d)		Phase error to be less than 0.02°

#### 4.5.7 Binary Inputs

a)	Number of inputs	10 galvanic isolated (2 kV insulation voltage)
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b)	Mode/Trigger criteria	Pick-up and drop-out of potential-free contacts or dc voltages of up to 600 V. Trigger levels to be adjustable
c)	Max. Input Voltage	600 V
d)	Max. error	< 100 $\mu$ s
e)	Counting function	Inputs capable of counting number of pulses up to 3 kHz.
f)	Connection	4 mm Banana sockets

#### **4.5.8 Analogue Inputs for Measurement**

a)	Number	10 galvanic isolated (2 KV insulation voltage)
b)	Input ranges	100mV, 1V, 10V, 100V, 600V
c)	Accuracy	<0.06%
d)	Bandwidth	dc.10kHz
e)	Sampling frequency	3 kHz to 28 kHz
f)	Overload protection	Yes
g)	Recording buffer	300 s for 1channel at 3kHz, 3.5s for 10 channels at 28kHz
h)	Connection	4 mm Banana sockets

#### **4.5.9 Analogue low level measuring inputs for transducer testing**

a)	Direct current range	Range 1: 0 ... $\pm$ 1 mA
b)		Range 2: 0 ... $\pm$ 20 mA
c)	Direct voltage range	0 ... $\pm$ 10 V
d)	Max. error	< 0.003%

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e)	Connection	4mm Banana sockets
<b>4.5.10 Auxiliary DC supply to power test objects</b>		
a)	Range	Range 1: 0 ... 264 Vdc, 0.2 A
b)		Range 2: 0... 132 Vdc, 0.4 A
c)		Range 3: 0... 66 Vdc, 0.8 A
d)	Power	Max. 50 W (higher is better)
e)	Max. error	< 2%
<b>4.5.11 Binary output contacts</b>		
a)	Number	Minimum 4
b)	Breaking capacity	300 V, 8 A, 2000 VA or 50 W
c)	Type	Dry contacts that can be used to switch ac or dc
<b>4.5.12 Time Synchronization</b>		
a)		The test set should be able to synchronise to a GPS clock via a 1pps or IRIG B signal.
b)		Timing accuracy for 1 pps / IRIG-B: 1 $\mu$ s.
c)		Maximum distance between GPS receiver and test equipment for 1pps signal: 40m.
d)		Test set needs to be synchronised to the IEEE 1588 Precision Time Protocol (PTP) via ethernet and conform to IEC 61850-9-3, IEEE C37.238-2011 and IEC 61588.
e)		Timing accuracy for PTP: 100 ns.
f)		Maximum distance between GPS receiver and test equipment for PTP: 2000 m.
g)		IEEE 1588 / PTP clock to be powered over ethernet (PoE), i.e. no separate power supply should be necessary.

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<b>4.5.13 Interface to PC</b>		
a)		Interface to the IBM compatible PC via ethernet interface or USB
b)		10/100 Mbit/s copper (auto sensing, auto crossover) via RJ45 connector alternatively USB. (10/1000 Mbit/s shall be preferred and is essential where the test set processes sampled values)
c)		Two Ethernet communication ports to support communication on a process bus (IEC 61850-8-1 (GOOSE), IEC 61850-9-2 (Sampled Values) and UCA 2.0 and station bus at the same time. PTP to IEEE 1588 and IEC 61850-9-3.
d)		Communication card to support IEEE 1588 / Precision Time Protocol (PTP) and IEC61850-9-3 to synchronize the test set to a PTP enabled Grandmaster clock in the substation for end-to-end tests / Synchro phasor tests.
<b>4.6 Software</b>		
<b>4.6.1 General</b>		
a)		Windows 10 (32 bit & 64 bit) software, upgradeable to the latest version available from Microsoft, currently Windows 11. Long filenames, tool tip help, context sensitive menu function (right mouse click) and an integrated help browser must be provided. All future versions of Windows operating systems to be supported.
b)		All software functions, options and actions should be easily available by click of a button and/or shortcut key to avoid having to navigate through complicated menu structures and having to drill through multiple menu levels. The Microsoft ribbon based menu structure used in Office 365 is an example of sorting all functions, options and actions and making all easily accessible in the right place.
c)		No programming should be necessary to test an application - entry of setting parameters shall be all that is required to set up and perform a test
d)		Future expansions in functionality by means of software updates. Firmware updating to be handled by the software, i.e. exchange of any hardware components is not permissible.
e)		Generation of reports on paper or file. All graphics and text shall be printable.
f)		Test report must be configurable to include custom information in graphical format (e.g. logos, wiring diagrams) and text format (tester, date of test, substation, reminders)

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g)		The test set software should be able to import relay settings records from relay setting software (or relay settings databases) in a text file, Microsoft Excel and/or XML format. Excel compatibility is essential.
h)		It must be possible to test multi-function relays / scheme with one test routine / document.
i)		Test sequence must allow for a pause in the test sequence at pre-defined points, by popping up a custom instruction dialogue (with or without audible warning), instructing the user to change either a setting on the relay, change of hard wiring or to record a specific measurement / status from the relay / scheme.
j)		All testing to be in closed loop.
k)		Online Pass/Fail assessment for ALL tests. This is important for automatic testing.
l)		Fully automatic testing must be possible, i.e. without launching various test modules manually.
m)		Test software to be future proof to allow the complete testing of any new relay, both in form of entry of relay settings as well as testing all functions of such a relay.

#### **4.6.2 Manual Control Function**

a)		Direct entry of actual relay settings into test software. Test specific parameters (e.g. set I1 to 110% of I>>) must be automatically re-adjusted according to the entered relay settings.
b)		Manual and independent adjustment of amplitude, phase angle and frequency for all generator outputs.
c)		Graphical display of natural voltages and currents in a vector diagram.
d)		Direct entry sequence components and graphical display in a vector diagram.
e)		Direct entry of impedances and graphical display in a R/X diagram.
f)		Direct entry of power and graphical display in P/Q diagram.
g)		Ramping and stepping of any of the above quantities: all phases at the same time.
h)		Pulse ramping function for any of the above quantities.
i)		Synchronized switching of multiple variables at the same instance in time.
j)		Timing functions for pick-up and drop-out measurements.

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k)		Online reporting function.
l)		Synchronise generator outputs to any third party signal, e.g. mains frequency.
m)		Full control of voltage and current. Full control of amplitude and frequency. Any test required by a MPTS shall be possible using manual control.

#### 4.6.3 State Sequencer Function

a)		Direct entry of actual relay settings into test software. Test specific parameters (e.g. set I1 to 110% of I>>) must be automatically re-adjusted according to the entered relay settings.
b)		Manual testing.
c)		Fully automatic testing.
d)		Ability to generate test sequences from any number of states. Each state consists of any combination of voltage, current, frequency and any binary output state.
e)		Graphical display of natural voltages and currents in a vector diagram.
f)		Graphical display of voltages, currents and binary signals over time.
g)		Direct entry of sequence components and graphical display in a vector diagram.
h)		Direct entry of impedances and graphical display in a R/X diagram.
i)		Direct entry of power and graphical display in P/Q diagram.
j)		Define trigger conditions for each state either in fixed time or dependent upon a logical combination of the binary inputs for accurate timing measurements.
k)		Synchronization to GPS / PTP and other digital timing pulses.
l)		Automatic assessment of test results (Pass / Fail) with actual results and deviation from nominal.

#### 4.6.4 Linear Ramping and Pulse Ramping Functions

a)		Direct entry of actual relay settings into test software. Test specific parameters (e.g. set I1 to 110% of I>>) must be automatically re-adjusted according to the entered relay settings.
b)		Manual testing.
c)		Fully automatic testing.

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d)		Ability to linearly ramp up to two independent variables (e.g. voltage and frequency) at the same time, while keeping the other quantities at a defined constant value.
e)		Ability to ramp a single variable in a pulsed fashion i.e. ramped quantity shall be set back to a predefined value between every step to allow the relay to reset.
f)		Graphical display of natural voltages and currents in a vector diagram.
g)		Graphical display of voltages, currents and binary signals over time.
h)		Define trigger conditions for pick-up / drop-out measurements upon a logical combination of the binary inputs.
i)		Synchronization to GPS/PTP and other digital timing pulses.
j)		Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.
<b>4.6.5 Transient Playback Function</b>		
a)		IEEE COMTRADE (C37.111-1991) compatible (ASCII and binary formats).
b)		Synchronization to GPS/PTP and other digital timing pulses.
c)		Timing accuracy 1 $\mu$ s.
d)		Graphical display of voltage and current traces as well as digital signals and relay responses.
e)		Editing of signals: Extending (repeating) and deleting portions of the recorded signal.
f)		Ability to generate composite harmonic wave shapes.
g)		Ability to edit own digital signals or to select recorded binary signals to play back via binary outputs.
h)		Unlimited length (in time) of Comtrade files to play back. Thus limited only by the available storage capacity on the controlling PC's hard drive.
<b>4.6.6 Overcurrent Function Testing</b>		
a)		Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.
b)		Manual testing.

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c)	Fully automatic testing.
d)	Testing of the operating characteristic (trip time vs. I test) for all types of faults (earth faults, phase faults, negative sequence and zero sequence faults).
e)	Display of overcurrent characteristic and test points in I/t diagram.
f)	Determination of the pick-up and drop-out current for all fault types.
g)	Determination the pick-up and drop-out of directional characteristic for directional overcurrent relays.
h)	Breaker simulation: Simulate the 52a and 52b auxiliary contacts of a breaker with the binary outputs, switch the currents off at zero crossing of current after a trip signal has been received.
i)	Characteristic formulae: IEC 255-4, BS142 and IEEE PC37.112-1995, I <sup>2</sup> t characteristics to be supported. Definition of custom characteristics must be possible.
j)	Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.

#### **4.6.7 Frequency and Voltage Function Testing**

a)	Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.
b)	Manual testing.
c)	Fully automatic testing.
d)	Generation of ramps for amplitudes, phase angles and frequency.
e)	Pick-up, timing and stability tests.
f)	Graphic and tabular display of relay pick-up and drop-out vs. time.
g)	Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.

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#### 4.6.8 Impedance Function Testing

Testing of line impedance relays and field failure characteristics on generator protection relays.

a)		Direct entry of the actual relay settings of an IED into the test software must automatically generate the trip characteristic. All new IED's should be fully supported by the MPTS supplier.
b)		Impedance characteristics supported: Quadrilateral, Mho, Tomato or Lens characteristic.
c)		Manual testing.
d)		Fully automatic testing.
e)		Test the trip time at specific fault impedances. Fault impedances must be specifiable in relation to zone reaches, e.g. 90% Z1. Automatic assessment of whether the tested trip time is passed or failed.
f)		Check the reach of a relay by placing a fault shot at the inner and outer tolerances border (i.e. theoretical reach minus and plus the defined reach tolerance of the relay). Automatic assessment of whether the tested reach is Passed or Failed.
g)		Automatically test the characteristic in the impedance plane (R/X diagram) and/or in the time grading diagram (Z/t diagram). Automatic assessment of whether the tested reach is passed or failed.
h)		Test models supported: constant test current, constant test voltage and constant source impedance.
i)		DC offset simulation: Control of angle of fault incidence, time constant of dc offset to be calculated online from system parameters (R/L).
j)		The separate arc resistance algorithm is to be supported for both earth faults and phase faults (as implemented on numerical distance relays).
k)		Apply pre-fault voltage, i.e. duration settable.
l)		Breaker simulation: Simulate the 52a and 52b auxiliary contacts of a breaker with the binary outputs; switch the currents off at zero crossing of current after a trip signal has been received.
m)		Graphical display of analogue voltages and currents plus relay contact responses vs. time.
n)		Display of injected voltages and currents on a vector diagram in natural and/or in symmetrical components.

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o)		Testing of auxiliary functions: Power swing and VT fuse fail.
p)		Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.
<b>4.6.9 Differential Function inclusive of Restricted Earth Fault Testing</b> Testing of transformer differential relays, line differential relays, motor differential relays, generator differential relays and busbar differential relays.		
a)		Direct entry of the actual relay settings of an IED into the test software must automatically generate the trip characteristic. Any new differential algorithm that is introduced shall be accommodated within a reasonable time. Typically this should be at no cost to the purchaser.
b)		Manual testing.
c)		Fully automatic testing.
d)		Simulation of two and three winding transformers for all possible vector groups (e.g. YY0, YD1, YD11, etc.).
e)		Testing the operating characteristic ( $I_{diff}$ vs. $I_{bias}$ ) for all types of fault: earth faults, phase faults and multi-phase faults.
f)		The various types of $I_{bias}$ formulae ( $I_{bias} = ( I_p  +  I_s )/k$ ; $I_{bias} = \max( I_p ,  I_s )$ etc, numerical zero sequence elimination and both reference sides have to be supported.
g)		Testing the harmonic restraint characteristic ( $I_{diff}$ vs. %I harmonic) for second harmonic (inrush restraint) and fifth harmonic (over fluxing restraint).
h)		Testing of the inrush restraint characteristic for relays which utilize the gap detection technique.
i)		Testing the trip time characteristic (trip time vs. $I_{diff}$ ) for all types of fault.
j)		Test the stability of the relay to confirm the correctness of the vector group correction, CT mismatch correction and zero sequence elimination.
k)		Apply pre-fault current, i.e. through fault current condition. Test current and duration settable.
l)		Apply voltage in addition to six currents - according to HV or LV voltage.
m)		GPS/PTP synchronized end-to-end tests to test the operating characteristic of line differential relays i.e. by simulating either the local or remote end of a line.

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n)		Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.
<b>4.6.10 Automatic Synchronising and Synchronising Check Devices</b>		
a)		Direct entry of actual relay settings into test software. Test specific parameters (e.g. test points) must be automatically re-adjusted according to the entered relay settings.
b)		Manual testing.
c)		Fully automatic testing.
d)		Adjustment control mode to be tested closed loop.
e)		Graphical display of quantities in a $\Delta V/\Delta f$ diagram as well as relative phase angles in a synchronoscope.
f)		Feedback signals: closing pulse and adjustment pulses (V+, V-, f+, f-). Display of adjustment controls vs. time.
g)		Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.
<b>4.6.11 Testing with GOOSE Messages</b>		
a)		All the above protective relay test modules must support testing for IEC 61850-8-2 i.e. be able to trigger on GOOSE messages as well as simulate GOOSE messages if required. Test set to support subscription to logical nodes as per IEC 61850-7 (All sub-parts).
b)		Import of SCD, ICD or GOOSE sniffer files to configure the triggering/simulation of GOOSE messages.
c)		Simulation and subscription of up to 360 simultaneous GOOSE message must be possible.
d)		GOOSE performance to IEC 61850-5 and processing time to network and to test set better than 1 ms.
e)		VLAN support (selectable priority and VLAN-ID).

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#### **4.6.12 Testing with Sampled Values**

a)		All the above protective relay test modules must support testing for UCA guideline IEC 61850-9-2LE, IEC 61869-9 and IEC 61850-9-2 i.e. be able to simulate all voltages and currents as sampled value signals.
b)		Simulation of up to three sets of IEC61850-9-2LE signals must be possible.

#### **4.6.13 Testing Single and Multi-phase Transducers**

a)		Manual testing.
b)		Automatic testing.
c)		Generation of sweeps for amplitudes, phase angles, frequency, power (W, VA, Var).
d)		Individual setting of voltages and currents in terms of amplitude, phase angle and frequency should be possible per test point.
e)		For single phase transducers phase injected should be selectable.
f)		L-L voltage transducers to be tested with full multi-phase voltage system.
g)		Online calculation of errors for absolute, percentage and full-scale.
h)		Display of transducer output and absolute, percentage and full-scale errors vs. sweep quantity graphically and/or as table.
i)		Feedback signal: low level analogue voltage (0 +/- 10V) or current (0 +/- 20mA).
j)		Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.

#### **4.6.14 Energy meter testing according to IEC 62053**

a)		Manual testing.
b)		Automatic testing.
c)		Load test, no-load test, creep test, mechanism test, injection test.
d)		Ability to generate automatic load profiles, i.e. test the meter for different load conditions.

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e)		Online display of error.
f)		Feedback signal: meter pulses of up to 100 KHz.
g)		Third harmonic test.
h)		DC test.
i)		Automatic assessment of test results (Pass/Fail) with actual results and deviation from nominal.
j)		<p>The test set shall have the required accuracy to test class 0.2 metering devices. The Eskom document and the IEC standard refers, the supplier shall prove the suitability of the MPTS to test a class 0.2 metering device:</p> <p>[1] 240-77224537: STANDARD FOR CALIBRATION AND LIMITS OF ERRORS FOR SINGLE- AND MULTI-PHASE ENERGY METERS</p> <p>[2] BS EN 62053-24:2015. Part 24: Static meters for reactive energy at fundamental frequency (classes 0,5S, 1S and 1)</p>
<b>4.6.15 Power Quality Signal Generator to NRS 048-2 / SANS/IEC 61000-4-30; SANS/IEC 61000-4-7; BS EN/IEC 61000-4-15 and IEC 62586</b>		
a)		Testing of power quality measurement devices as per the NRS 048 standard.
<b>4.6.16 Online Multimeter Measurement Function</b>		
a)		Up to 10 independent inputs.
b)		Software to display amplitudes and phase angles of ac voltages and currents, symmetrical components of voltages and currents, line to line voltages, frequencies, active power, reactive power, apparent power and cos(phi) independently for each input.
c)		All ac measurements to be true RMS.
d)		Online vector diagram for voltages and currents as well as power.
e)		Online measurement of Vdc, Idc and dc power for each input.
f)		Online display of harmonics measured both numerically (in a table per harmonic frequency) and graphically in a bar graph.

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#### 4.6.17 Transient Recording Function

a)		The recording function should enable recordings at the specified sampling frequency.
b)		Any recordings done should automatically be uploaded to the controller PC.
c)		The recordings should be saved in COMTRADE format on the PC's hard drive.
d)		Trigger conditions: amplitude, swell and sag, harmonic, frequency, frequency change, notch as well as any combination of these triggers.
e)		A pre-trigger buffer should be definable.
f)		Analysis software should be provided to analyse the recorded wave shapes in terms of analogue wave shapes (RMS and instantaneous values), vector diagram, impedance plots (L-N and L-L fault loops) as well as harmonics.
g)		For impedance plots, the relay impedance characteristic should be displayable in relation to the impedance trajectory measured by the relay.

#### 4.6.18 System based testing of relays

a)		Provide power system based simulation software to test the function of a relay in the primary power system i.e. by specifying the primary power system topology (e.g. from a single line diagram) and power system parameters like network source impedances, line and transformer impedances, CT and VT parameters.
b)		Allow definition of power system events and fault conditions e.g. any type of fault (L-N, L-L, L-L-N and L-L-L faults) as well as switching events (opening of closing of breakers).
c)		Full transient simulation simulating power system phenomena such as DC offset, saturation of CT's, power swings, series compensated lines, transformer inrush etc.
d)		Distributed testing i.e. injecting multiple test set simulating voltages and currents at different points in the network from one PC even when the test sets are physically not in the same location e.g. at different ends of a line.
e)		Test all impedance functions used in the generator protection scheme.
f)		Line differential protection system testing i.e. up to three terminals.

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g)		Power transformer differential function testing with internal winding faults as well as restrictive earth fault functions.
h)		Bus zone system testing for out-of-zone through faults, in-zone faults, dead-zone faults as well as isolator transition faults.
<b>4.6.19 ARC Flash Simulation</b>		
a)		Facility to simulate an arc flash with a high intensity flash bulb inside medium voltage switchgear for triggering the arc flash sensor units of IED's using both point sensors as well as linear fibre sensors.
<b>4.7 Standard Accessories</b>		
a)	Test leads	2 m x 2 mm <sup>2</sup> of sufficient quantity to populate all input and output terminals on the test set.
b)	Combination Test lead	A combination test lead with the 4 current and voltage leads thus 8 leads in total clearly marked for current and voltage application and suitably colour coded. This lead shall be long enough to plug into the current and voltage channels and reach the current and voltage test points on a typical protection or metering scheme.
c)	Other accessories:	Power cord.
d)		Connection lead from test set to PC, cables for all supported protocols to be provided for all package options.
e)		Various connection accessories like crocodile clamps and terminal connectors sufficient to service all supplied leads.
f)		Quality carrying bag or bags with padded shoulder sling and storage pockets for accessories, alternatively a quality case or cases with quality handles to ease carrying by one person.
g)		Instruction manual. Electronic copy is preferred.
<b>4.8 Software Licensing</b>		
a)		A software license shall cover all operating system versions where the functionality is similar.

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		A software license shall not depend on a hardware dongle to be used. The license shall be imbedded in the software and the Eskom license shall be embedded in the software package such that any Eskom user may control a test set of another Eskom user using his/her own computer and test set software. It is accepted that modules are registered per test set and that certain functions may not be available to another user. Dedicated software for use with an IEC 61850 package shall also not use a dongle. The license shall be applied such that a user can transfer the license to other computers.
<b>4.9 Local Support</b>		
a)	Hotline support hours	Local telephonic support to be offered in the hours of 07h00 - 20h00 South African time.
b)	Email and Fax support	Email support must be offered with a guaranteed turnaround time of 1 business day.
c)	Number of units in operation in South Africa	10 units in South Africa. A separate list of users with contact details shall be provided.
d)	No of back-up units available in South Africa	2 x full specification test sets.
e)	SANAS registered calibration facility available in South Africa	Yes
f)	Guaranteed turnaround time for repairs and calibration	< 14 working days. Sending units offshore for repair shall be the exception.
g)	Product training offered in South Africa	Standard training offered on request. In-house / On-site training to be offered on request. Standard training to be offered as a registered course with Eskom Academy of Learning.

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h)	Warranty on Hardware	Five years from date of delivery.
<b>4.10 External Integrated Antenna PTP Clock (GPS)</b>		
a)		<p>The device should consist of a GNSS Antenna, GNSS Receiver and CPU combined and be weatherproof.</p> <p>The device should be easily setup.</p> <p>No RF cabling shall be required.</p> <p>The device should operate using an Ethernet cable up to 100 meters.</p> <p>The device should use extremely low power.</p> <p>To power up the device no additional power supply will be needed and should use power over ethernet (POE).</p>
b)		<p>Multiple time protocols shall be supported e.g. PTP and NTP timing networks.</p> <p>The device should fully support the following PTP profiles:</p> <p>IEEE 1588 default profile</p> <p>IEEE C37.238-2011</p> <p>IEEE C37.238-2017</p> <p>IEC/IEEE 61850-9-3:2016</p>
<b>4.11 Standalone and IED Independent Software For Interrogation and Investigation of IEC 61850 Devices</b>		
a)	General	The software shall be able to browse and discover the IED's data models, network sniffer function, monitor IEC 61850 activity and work with SCL files. The software should also be able to publish and receive GOOSE messages, both monitored and simulated.
b)	Standard	<p>IEC 61850 Edition 1: Communication networks and systems in substations. The device should fully support the following PTP profiles:</p> <p>IEC 61850 Edition 2: Communication Networks and Systems in Power Systems IEEE C37.238-2011</p> <p>IEC 61850-7-41:-:2013</p> <p>IEC 61850-7-420: 2009</p> <p>IEC 61400-25-1:2006...-6:2010</p>
c)	Software	Universal client for IEC 61850 servers.

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		Unveil the inside of IEC 61850 devices via navigation view, detail view and an activity monitor. Discover IED's via sniffing function. Import, analyse and save SCL files. Browse IED according to the IEC 61850 data attributes. Writing data and control structures. Analysing Client/Server traffic on ASCII level. GOOSE sniffing. Simulate IEC 61850 Ed.1 and Ed.2 IED.
d)	PC requirements	Software shall be able to work on Windows 10 (32bit or 64bit), with the possibility to upgrade to Windows 11. The software shall work on a PC with 4GB RAM and hard disk space of at least 2GB. Software is licensed to the CPU via the internet. USB software dongles are NOT permissible. Transfer of licenses from one PC to another via internet.

## **5. MPTS hardware configurations**

The following test set configurations must be catered for:

**Note:** Supplier shall offer a test set that meets or exceeds a particular category. It is understood that different suppliers will have similarities and differences to what Eskom requests. Eskom shall have to categorise test sets deemed suitable for end users to procure. The end user will select test sets on offer based on own technical requirement and budget.

### **5.1 Universal Multi-phase Test Set**

Comprising of a 3 phase voltage and current output (L1, L2, L3, N) plus 4 binary outputs, auxiliary DC supply, analogue input for  $\pm 10V$  and  $\pm 20mA$ , 10 binary and analogue inputs with preference for additional single phase voltage channels.

## **6. Software**

The software is detailed in paragraph 4, "Detailed technical and software specification". This section complements paragraph 4.

The software shall be compatible with Microsoft Windows 10, 64bit and all newer versions as released by Microsoft in the future. Where complementing software is available such as for mobile computing platforms and the software performs the same or similar function as the Windows licensed software this should be seen as part of the licensed software and inclusive with the software license cost.

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The software shall be available on the manufacturer's web site. The manufacturer or local agent shall keep Eskom abreast of all changes and detail the reason for a change. Eskom favours free software maintenance updates, thus minor function and/or interface enhancements shall not necessarily indicate a new module. Usually updated versions of software are released to correct software errors, accommodate newer operating systems and to streamline and enhance the MPTS operator user interface. New modules are excluded. A new module is seen as new test functionality and not as an enhancement or bug fixes. Each supplier shall detail all aspects of the software and when changes to the end user will become necessary.

Should a software module require a specific hardware accessory or multiple accessories this shall be included in the price of that specific module.

The communication link between the PC, the controlling software and the test set shall be in order of preference or a combination thereof:

- 1) Ethernet via RJ45 Copper
- 2) USB cable

Software packages which have built in security such that if a test set is stolen and reported to the manufacturer by the customer, complete with the necessary security checks, the test set function shall be invalidated after a user defined period. Preference shall be given during evaluation stages for this functionality. A reasonable period is defined as 90 days. Thus a user of the test set software communicates via the internet every three months to validate the use of the software with the specific test set by way of the serial number of that test set. The software shall not need the test set connected to it. The period may be user selectable.

If an alternative operating system of the test software is available and the software has the same functionality as the Windows version this should be available as part of the of the Windows based software package. With the volatility of the operating system market this allows users to adopt alternative software early. Typically this would be mobile based operating systems. The supplier shall price independently each software module in addition to the basic and intermediate software packages. This will also include any advanced software packages such as network simulation software that may or may not run independently from the traditional MPTS software suite.

Where the software is sold separately from the hardware package the software should be packaged in the following manner:

#### **6.1 Basic software package**

- a) Manual control as defined in item 4.
- b) Overcurrent and Earth fault module as defined in item 4.

**Note:** Additional functionality may be included.

#### **6.2 Intermediate software – the same as the basic version but the following modules shall be included:**

- a) Ramping module as defined in item 4.
- b) State Sequencer as defined in item 4.
- c) Line and Transformer Differential module as defined in item 4.
- d) Line Distance module as defined in item 4.

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- e) Frequency and voltage relay testing as defined in item 4.
- f) Transducer (single and three phase) testing as defined in item 4.

**6.3 Additional advanced modules (separate from the intermediate package, procured as required by the end user.)**

- a) Dedicated recloser testing modules.
- b) Synchronising devices as defined in item 4.
- c) Transient playback of Comtrade files as defined in item 4.
- d) Transient recording function as defined in item 4.
- e) Online multimeter function as defined in item 4.
- f) Energy meter testing according to IEC 62053 as defined in item 4. Testing of class 0.2 accuracy meters shall be a requirement.
- g) Power quality measurement device testing based on NRS048-2 / SANS/IEC 61000-4-30; SANS/IEC 61000-4-7; BS EN/IEC 61000-4-15 and IEC 62586. NRS 048 is the standard followed in South Africa and the supplier must state whether the test module is fully compliant with this standard.
- h) In accordance with IEC 61850, GOOSE trigger and simulation as defined in item 4.
- i) In accordance with IEC 61850, Sampled Values simulation as defined in item 4.

Note: The above modules shall be purchased individually or as a composite of any other module. For example, a metering test set may comprise of the basic module and the relevant metering related modules. The purchaser shall therefore have the option of purchasing test modules as required with a hardware option. For example, a metering compliant version of a test set only the manual control module and the dedicated metering related software modules.

**6.3.1 Other advanced software**

Any other module available shall be detailed and offered. The two packages and advanced modules are offered to provide a useful compilation of packages at a competitive price. The advanced options as required and where available. Examples of modules not listed are network simulation software and software modules testing distributed protection relays using multiple test sets.

In the detailed technical section and when evaluating the hardware pricing, the advanced features will not be factored into the pricing evaluation.

The benefit of the advanced modules would be that the MPTS system is given priority as it will benefit specialist MPTS users in certain parts of the organisation.

**7. Accessories**

Test sets come with multiple accessories and thus all options will not be detailed. The following items must be in the accessory basket:

- a) Standard accessory package with a MPTS:

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- Each test set to be equipped with a set of 2m (minimum length) test leads sufficient to populate all inputs/outputs.
  - A combination test lead with the 4 current and voltage leads, thus 8 leads in total clearly marked for current and voltage application and suitably colour coded. This lead shall be long enough to plug in the current and voltage channels and reach the current and voltage test points on a typical protection or metering scheme.
  - Connectors for each lead to allow a sound connection to the devices under test.
  - A quality carry bag made of a durable material with carrying strap or other quality case. The bag or container shall easily house all the leads and accessories.
  - The required communication cables.
  - Manual, the manual may be part of the software module or a software copy. The manual must be fully detailed. The manual is to cover both the hardware and the software. The manuals must be fully detailed. The manuals may be two separate software documents. The Test set manuals shall preferably be imbedded in the test set control software and have an auto update facility when connected to the Internet.
  - Should a software module require a specific accessory to complete execute a test the test set package shall come equipped with the required accessory and be accordingly priced.
  - A calibration certificate. See the details under the calibration section.
- b) Examples of other Accessories or services:
- The listed examples are currently used by Eskom, however ALL useful software modules and accessories on offer to be listed and priced in terms of the contract pricing structure and period.
  - A hardened transport case with wheels to facilitate easy transport and sufficiently sturdy to be used for multiple shipping events. Lockable.
  - Clamps, crocodile clips, terminal connectors.
  - Clip on current transducers for test sets with current measurement/recording capabilities.
  - GPS time synchronisation devices and all accessories required to execute the time synchronisation function. All offerings such as dedicated units and PTP based units.
  - ARC sensor light emitter. (electrical arc protection scheme testing)
  - Sensors to accommodate measurement of all types of meters. (pulsing LED signals)
  - Additional communications cables and other specialised cables.
  - Software modules.
  - Calibration service to SANAS requirement, priced for all test set offerings including return shipping.
  - Repair/calibration return shipping, however this is usually included in the repair/calibration cost and shall be the preferred method.
  - High voltage testing protective devices (e.g. power transformer testing) such as metrosil/varistor type protection.

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- Switch boxes.
- Test set controllers with on board software (not a PC)
- Dedicated cables to match reclosers etc.
- Dedicated recloser test software.
- Hardware upgrades.
- Any other useful accessory or software module.

## **8. Calibration, Repair and Annual Reports**

Test set suppliers shall offer a local calibration and repair service for all test set equipment and accessories. Repairs may include upgrades that need supplier installation.

### **8.1 Calibration**

The manufacturer of the test equipment shall provide a letter for each item of hardware requiring calibration indicating a realistic interval in years between calibrations. The end user is responsible to assess whether the recommended interval needs to be shortened due to the criticality of the test process or possible early hardware failure.

Calibration shall be a standard contract item and shall cover the calibration service and the return transportation of the test set to the user. The transportation service shall include insurance should the device be lost or damaged in transit. The device will be shipped in a secure container.

A certificate of calibration shall be supplied with the returned test set. The calibration certificate must reference the laboratory number and company name with the SANAS accreditation. The test set shall also have a dated calibration sticker attached including a recommended future calibration date. This sticker should be applied such that any interference with the test set innards shall damage the sticker. Preference shall be for two stickers situated at opposite sides of case opening seam. The calibration certificate shall at minimum detail the following:

- Name of calibration facility.
- Certificate number.
- Calibration date.
- MPTS description.
- MPTS serial number.
- Instrument(s) used for calibration.
- Calibration detail of reference instrument.
- Table of calibration results for instruments.

### **8.2 Repair**

Repairs shall be done locally where possible.

A loan test set shall be made available on request by an end user. The loan test set shall be a contract item and the loan cost shall be determined by the seller. The price should include return shipping costs, fair wear and tear and capital recovery. The cost shall be on a per day basis.

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The end user shall ship the faulty unit to the supplier. The supplier shall assess the damage and provide a quotation to the end user. The end user shall be responsible to accept or reject the quotation. Upon acceptance the end user shall generate a purchase order for the repair cost. The supplier shall not proceed with the repair before an official Eskom order is received for the quoted repair. Eskom personnel are not permitted to send a test set in for calibration or repair without a valid purchase order or commercial approval.

A calibration verification test shall be performed after any electrical repair. Repairs to the casing, terminals, communication modules or any other repair not affecting the accuracy of the test set may waive calibration. Where a unit is within 3 months of the next calibration the supplier should recommend a calibration service.

### **8.3 Annual Reports**

The supplier shall keep accurate record of all calibration and repair services performed regardless of the unit guarantee status. This means that defective/damaged devices within the guarantee period are included in all reports. An annual report shall be made available to the Testing Care Group. The report shall include all historical failures associated with Eskom. The Care Group may request a report at any time. However, this would be the exception.

The supplier is encouraged to engage with Eskom at his/her discretion any time to take up issues such as abuse of test sets.

The report shall detail at minimum the following:

- The make.
- The model.
- The serial number.
- The age of the device.
- In or out of guarantee.
- Guarantee honoured (Yes/No).
- Reason for not honouring a guarantee claim.
- The end user by name, employee number, the Eskom Group and Section.
- The condition of the device as received relative to age (Excellent, Good or Poor).
- The nature of the failure.
- The turnaround time in days.
- Repair cost.
- Any other remarks.
- The number of units of each type sold in each calendar year.

## **9. Training and Support**

Training shall be offered on both the software and the hardware. Preference shall be that the training is registered with Eskom as an official training course. Training to be offered at the respective Eskom premises where the training requirement exceeds 7 trainees. The minimum charge in such cases will be for 8 trainees.

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Courses are to be done by trainee attending with the Eskom supplied laptop and correct version of software. Currently a pre-built software image is setup by Eskom and checked. Software upgrades are introduced to the business as Eskom receives notices of upgrades. The software is placed on an Eskom server and the location on the supplier web page is also given. Laptops used by test personnel should allow removal and installation of software. Where training is offered locally to Eskom trainees, trainees may be requested to bring their test set to speed up practical training. However, test sets cannot be flown from a region to another distant venue.

The training shall be offered in three modules:

### **9.1 Basic Training Course**

Manual operation of the test set via the PC based software module and/or hardware controller is conducted. Testing of over current and earth fault relays as per basic test set configuration. Training shall be comprised of a hardware overview, safety aspects, emphasis on hardware cost and how to take good care of a test set. Causes of test set failures which will result in loss of use, repair and transport costs. Discuss calibration and repair aspects and why this is necessary. Provide software training on the software installation process and lastly the licensing aspects of the test system.

As a minimum test set training shall be provided on the manual testing of a modern overcurrent IED using the manual testing software module and the overcurrent software module. Each student shall do hands on testing with a test set and an IED, preferably using an example of an Eskom contract reticulation feeder IED. The training shall also include directional overcurrent elements and explore the differences in terms of directionality by different vendors. Typical protection functions found in a modern direction overcurrent IED shall also be covered in as far as the manual software allows. Typical examples are under frequency, under and over voltage, thermal over current and ARC flash protection testing shall also be covered. ARC flash protection is a commonly used feature with modern over current IED's and is relatively widely used in Eskom.

### **9.2 Intermediate Training Course**

As per the intermediate software package all intermediate modules as specified in the intermediate software package. Hardware setup and hands on testing of all the modules. It is accepted that the students have done the basic training. The course may be split into two manageable time slots.

### **9.3 Metering and Measurements Training Course**

This course shall cover the basic course detailed above but exclude the overcurrent relay testing. The course shall focus on the testing of energy meters both electromechanical and digital devices as well as the testing of digital transducers.

### **9.4 Support**

Support shall be a key determining factor when doing tender evaluation. The following support items shall be a definite requirement:

- Local repair and calibration with a turnaround time typically better than 14 days.
- Formalised training courses as described. Training shall take place at or near Eskom regional offices when sufficient student numbers justify this.

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- Technical support shall be available locally via email and telephone by technically competent support staff. Technical competent would mean personnel with tertiary electrical engineering qualifications and having hands on testing experience on protection IED's that are used in Eskom Transmission, Distribution and Generation.
- Capability and capacity to develop automated testing templates on request. This service shall be done on request by Eskom with a detailed scope of work supplied by Eskom and then a quotation for the development of the automated test set to be supplied to Eskom. Typically a test template will extract settings from an Eskom setting sheet and make it available to the test set software by some software importing method. The template will detail all wiring requirements and setting and wiring alterations as the template testing progresses. The test template would on all schemes also involve IEC 61850 based testing. The template shall run with the minimum of operator intervention and focus on all aspects of personnel and hardware safety. The test template shall generate a formal report with a detailed test report. On handover of the template training to Eskom personnel may be a requirement.
- The supplier must provide proof of the required support functions. This will be a list of technical staff and a short CV of each member, courses provided in the past and to which companies. Physical examples of automated templates and the end customer must be included.

## **10. Guarantee**

The unit and accessories shall be guaranteed for a period of at least 5 years. The guarantee may exclude any damage or failure that is deemed to have occurred due to negligence or abuse.

## **11. URS Excel Sheet**

A Microsoft Excel spreadsheet URS schedule is available for this standard. Each supplier shall be issued with this document as part of the procurement document package. It is important to complete the schedule accurately and provide references for each response, detailing the section and page number of this document so that the response can be verified. Where the supplier cannot comply or meet the specific criteria this must be stated as such. The Excel URS schedule is a mandatory part of the procurement/tender offer.

## **12. Demonstration**

The tender evaluation will include a physical demonstration of the MPTS and software by the supplier to the Eskom technical team on how to setup the software test module and physically testing the supplied product or products.

The demonstration shall be done by the local representative of the vendor. The local representative shall not be supported by an offshore specialist either at the preparation or demonstration stage. All suppliers will be given the same product to test and the same time slot.

Each supplier where possible will be given the opportunity to familiarise themselves with the product. The product will be in a laboratory and be powered up with the requisite circuit breaker simulator if applicable. In addition the setting sheet, the schematic and the IED software will be available on the day.

The supplier will be responsible for any damage of the product. Eskom will only provide limited support.

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An Eskom technical panel will evaluate the demonstration which will form a substantial part of the technical compliance assessment.

### **13. Acceptance**

This document has been seen and accepted by:

<b>Name and surname</b>	<b>Designation</b>
Murray Van Niekerk	PTM Technical Support – Senior Consultant
Jacques Strydom	PTM Technical Support – Chief Technologist
Jean-Pierre Oosthuizen	PTM Koeberg – Section Manager
Eric Odendaal	Koeberg Electrical System Engineering – Electrical Engineer

### **14. Revisions**

<b>Date</b>	<b>Rev</b>	<b>Compiler</b>	<b>Remarks</b>
July 2024	0	Thehrick Meyer.	First issue.

### **15. Development Team**

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

- N/A

### **16. Acknowledgements**

- The information contained in this URS is based on the Eskom Standard 240-102634558.

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**Attachment 1**

# **User Requirement Specification Multi- Phase Injection Test Set Excel Spreadsheet**

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