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TABLES

1. Introduction

This document details the Functional Design Specification (FDS) for the Global Positioning System (GPS) clock and peripherals offered on contract 4600060000 for the Development of Transmission Protection, Telecontrol and Substation Automation Solution.

2. Supporting Clauses

2.1 Scope

2.1.1 Purpose

The purpose of this document is to fulfil the deliverables attached to Phase 1 of specification 474-283, for contract 4600060000 for the Development of Transmission Protection, Telecontrol and Substation Automation Solutions. This document provides technical responses to the requirements listed in specification 474-283. To synchronise the response in this document to the requirements listed in specification 474-283, this document maintains the same structure and chronological numbering as the specification. Consequently, certain sections not applicable to this FDS which exists in the specification 474-283 are retained in this document to maintain the consistency and structure of the document and facilitate ease of reference.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/Informative References

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

2.2.1 Normative

[1] 474-283: Technical Specification for GPS Time Synchronising Unit.

[2] 240-75757022: Overview of Requirements for Transmission Protection, Telecontrol and Substation Automation Equipment.

2.2.2 Informative

[1] ISO 9001 Quality Management Systems.

[2] SEL-2488 Satellite-Synchronized Network Clock Instruction Manual.

[3] SEL-2488 Type Test Certificate, 13 May 2016.

2.3 Definitions

Definition	Description
100Base-TX	Ethernet over twisted pair copper cable supporting speeds of 10 and 100 Mbit/s.
100Base-FX	Ethernet over optic fibre supporting speeds of 100 Mbit/s.
Cable delay compensation	Removal of time delay due to cable distance.
DB-9	9-pin D-sub connector.
Duty cycle	Ratio between the pulse duration and the period of a rectangular waveform.
Form A	Normally open contract in the de-energized state.
Form C	Contact comprising of a normally open and a normally closed contact pair, both sharing the same common.
GPS Spoofing	Malicious attack to deceive a GPS receiver by broadcasting counterfeit GPS signals.

Holdover Mode	Output timing based on GPS internal reference oscillator.
IP rating	Ingress Protection Rating used to classify the degrees of protection against both solids and liquids in electrical enclosures according to IEC 60529.
Relative humidity	A percentage expressing how close the air is to being saturated due to moisture content.

2.4 Disclosure Classification

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

2.5 Abbreviations

Abbreviation	Description
BNC	Bayonet Neil-Concelman
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Immunity
FDS	Functional Design Specification
GLONASS	Russian Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HTTPS	Hypertext Transfer Protocol Secure
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Ingress Protection
IRIG-B	Inter-Range Instrument Group
kPPS	Kilo Pulse Per Second
LC	Lucent Connector
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
NTP	Network Time Protocol
OCXO	Oven-Controlled Crystal Oscillator
PPHH	Pulse Per Half Hour
PPM	Pulse Per Minute
PPS	Pulse Per Second
PTP	Precision Time Protocol
RF	Radio Frequency (3 kHz to 300 GHz)
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
ST	Straight Tip
TNC	Threaded Neill-Concelman
UTC	Coordinated Universal Time

2.6 Roles and Responsibilities

Not Applicable.

2.7 Process for monitoring

Not Applicable.

2.8 Related/Supporting Documents

Not Applicable.

3. Project Programme

Not Applicable.

4. Functional Requirements

4.1 Environmental Requirements

The SEL-2488 GPS time synchronizing clock will meet the following environmental requirements:

4.1.1 Operate within a temperature range of -40 °C to 85 °C.

4.1.2 Operate in conditions subjected to non-condensing relative humidity of 0-95% for indoor equipment. The GNNS outdoor antenna will operate reliably in conditions subjected to 100% relative humidity.

4.1.3 The SEL-2488 clock will comply with Power Frequency Disturbances as per section 5.7.3 of IEC 61850-3:2002. Furthermore, the device will comply with the environmental standards listed in Table 1 [3].

Table 1: SEL-2488 Environmental Type Tests.

Test	Severity Level	Standard
Cold	16 hours at -40 °C	IEC 60068-2-1:2007
Damp Heat, Cyclic	25 °C to 55 °C,6 cycles, relative humidity of 95 %	IEC 60068-2-30:2005
Dry Heat	16 hours at +85 °C	IEC 60068-2-2:2007
Free Fall	100 mm	IEEE 1613-2009
Vibration	Class 2 endurance, Class 2 response	IEC 60255-21-1:1988
Shock and Bump	Class 1 shock withstand, Class 1 bump, Class 2 shock response	IEC 60255-21-2:1988
Seismic	Class 2 (quake response)	IEC 60255-21-3:1993

4.1.4 The SEL-2488 will comply with IEEE 1613 - 2009 + A1 -2011 Class 2, communications for substation equipment.

4.1.5 The SEL-2488 will operate reliably for altitudes ranging between of 0 – 2500 m.

4.2 Enclosure Protection

The SEL-2488 will meet the following enclosure protection requirements:

4.2.1 IP3X with dust covers on the front management port to protect the device against damage from dripping water. These dust covers shall be made available to Eskom at no additional cost.

4.2.2 The SEL-2488 has a conformal coating ordering option which protects it against corrosion in accordance with SANS/IEC 61850-3 Ed. 1 Section 5.6. This option has been excluded from this contract as per Eskom's request.

4.3 Power and Earthing Requirements

4.3.1 The SEL-2488 will support two power supply options, i.e. a 24/48 VDC and 125/250 VDC option. The low voltage supply unit will have an input voltage range extending from 19.2 to 57.6 VDC. The 125/250 VDC unit will have an input voltage range between 88 and 300 VDC.

4.3.2 The SEL-2488 will include a second slot for an optional second supply. The optional supply is however not available as an ordering option on this contract.

4.3.3 An external surge arrestor for lightning protection will be provided.

4.3.4 The surge arrestor will be equipped with an earth stud allowing it to be bonded to the substation earth mat.

4.3.5 The external surge arrestor will be replaceable and repositionable.

4.3.6 The surge arrestor will have an insertion loss of less than 0.2 dB.

4.3.7 The SEL-2488 complies with IEC 61000-4-5:2005. This standard does not apply to the surge arrestor as it is an RF component.

4.4 System Alarms

The SEL-2488 will provide the following alarm functionality:

4.4.1 Internal Clock Failure.

4.4.2 Holdover Alert: When the SEL-2488 experiences a loss of GNSS and enters into holdover operation.

4.4.3 The SEL-2488 has a single Form C output alarm contact which will operate for major alarms. Both alarms listed above are major alarms and will operate the output alarm contact.

4.4.4 All alarms will be available over SNMP v2c.

4.5 Timing Output Requirements

The SEL-2488 will provide the following timing output functionality using its single Form A timer output contact:

4.5.1 Pulse per minute with adjustable duty cycle.

4.5.2 Pulse per second with adjustable duty cycle.

4.5.3 The timer contact output will be electrically isolated through an isolation transformer. The timer contact will require an external power source to provide an output pulse to an end device. This source will range from between 12 and 250 VDC.

4.5.4 The timing accuracy for the timer contact will be ±100 ns from UTC.

4.5.5 When configured for pulse per half hour (PPHH), the timing accuracy for the timer contact will be ±1 ms from UTC.

4.5.6 The SEL-2488 will support IRIG-B in the following formats:

4.5.6.1 IRIG-B122

4.5.6.2 IRIG-B002

4.5.7 The accuracy of the IRIG-B timing output will be no more than ±1 µs for modulated IRIG-B and ±100 ns for demodulated IRIG-B from UTC.

4.5.8 The SEL-2488 will provide NTP version 4 server functionality.

4.5.9 The SEL-2488 will provide SNTP version 4 server functionality.

4.5.10 The SEL-2488 will support the ability to output time based on local time or UTC time. The local time zone offset from UTC will be configurable.

4.5.11 IEEE 1588 version 2 and IEEE C37.238-2011 will be supported but not offered on this contract. Precision Time Protocol is an add-on and will require a software upgrade.

4.6 GPS Receiver and Clock Requirements

4.6.1 The SEL-2488 will primarily use GPS signals for synchronization to UTC.

4.6.2 The GPS receiver will have an internal real time clock that will maintain accurate time if the communication to the GPS satellites is lost or is of bad quality.

4.6.3 There are two variations of the SEL-2488 with different internal reference oscillators. The SEL-2488 will include the oven-controlled crystal oscillator (OCXO). This oscillator will provide a maximum time drift when in holdover operation amounting to 5 µs per day.

4.7 Interface Requirements

The SEL-2488 will provide the following physical interfaces. These are not modular and will come standard with the unit. They will however be configurable to be enabled/disabled in software:

4.7.1 A single timer contact which will be configurable for PPS, PPM or PPHH, terminating onto a Phoenix connector.

4.7.2 Eight BNC connectors, each supporting IRIG-B002 TTL.

4.7.3 IRIG-B002 over RS-485 will be achieved using a Tekron isolated timing repeater connected to a BNC port of the SEL-2488. The adaptor will be supplied to Eskom on a need basis.

4.7.4 IRIG-B002 over fibre will be achieved using a Tekron isolated timing repeater connected to a BNC port of the SEL-2488. The adaptor will be supplied to Eskom on a need basis.

4.7.5 Four BNC ports, each supporting IRIG-B122.

4.7.6 Four Ethernet ports which will comprise of two 100Base-TX and two 100Base-FX (with LC connectors).

4.7.7 A summary of the ports which will be provided are listed in Table 2 together with each ports timing output functionality and output drive levels.

Table 2: Time output formats and output drive levels available on the SEL-2488.

Port	Time output	Output Drive Levels
Timer contact	PPS, PPM or PPHH	250 VDC, 100 mA
BNC Ports (1-8)	IRIG-B002, IRIG-B004, kPPS, PPS	5 V, 250 mA max
BNC Ports (1-4)	IRIG-B122, IRIG-B124,	6.2 Vpp nominal
DB-9 (Pin4, Pin6)	IRIG-B002, IRIG-B004, kPPS, PPS	5 VDC, 5 mA

4.8 Display Requirements

4.8.1 The SEL-2488 will be equipped with a backlit front-panel liquid crystal display (LCD) as well as front-panel LED indications to indicate the following:

4.8.1.1 Time of day in either 12-hour or 24-hour local time format.

4.8.1.2 Date in display format Day/Month/Year.

4.8.1.3 Status of clock.

4.8.1.4 Satellite Lock to indicate good signal strength.

4.8.1.5 Number of satellites tracked by the device.

4.8.1.6 Time quality.

4.8.1.7 Satellite lock.

4.8.1.8 Holdover operation.

4.8.2 The SEL-2488 will be 1U in height and will be designed to fit in a 19-inch rack.

4.9 GPS Antenna Requirements

4.9.1 The antenna will be an active antenna.

4.9.2 The antenna will be powered through the same cable connecting the antenna to the SEL-2488.

4.9.3 An antenna will be supplied with an antenna mounting bracket.

4.9.4 The antenna will operate from a distance of up to 100m from the indoors unit.

4.9.5 The antenna cable will be screened coaxial cable.

4.9.6 The antenna will be designed for outdoor use in accordance with IEC 61000-4-3, electromagnetic compatibility.

4.9.7 The antenna will be housed in a shielded IP68 rated enclosure.

4.9.8 Third party 4-way antenna splitters are available but will not be supplied as part on this contract.

4.10 Security

4.10.1 The SEL-2488 will support satellite signal verification to protect it against GPS spoofing.

4.11 Configuration Tool

4.11.1 The configuration of the unit will be password protected while the configuration information will be read only to all users.

4.11.2 Cable delay compensation will be user configurable.

4.11.3 Management access will be available through the front panel Ethernet management port.

4.11.4 The SEL-2488 will be configurable via its HTTPS web server interface.

5. General Specification

5.1 Software Licence

Configuration and management of the SEL-2488 will be done through the device's web interface which can be accessed using any standard web browser (Microsoft® Internet Explorer®, Google™ Chrome™, Mozilla® Firefox®, etc.). No enterprise configuration software license will be required.

5.2 Documentation

Not applicable.

5.3 Training

Not applicable.

5.4 Spares and Maintenance

Not applicable.

5.5 System Durability

5.5.1 The SEL-2488 will be supplied with a 10-year warranty from SEL with an expected lifetime exceeding 10 years.

5.6 Quality Assurance

5.6.1 The SEL-2488 will be designed and manufactured under an ISO 9001 certified quality management system

5.7 Testing and Approval

Not applicable.

6. Acceptance

This document has been seen and accepted by:

Name	Designation
Sagar Dayabhai	Systems Control Manager
Peter Diamandis	Systems Engineer

7. Revisions

Date	Rev.	Compiler	Remarks
July 2016	0	F. Ismail	Functional design specification for the SEL-2488 offered as the GPS for contract 4600060000
August 2016	1	F. Ismail	Updates with Eskom comments
November 2016	2	F. Ismail	Updates with Eskom comments
November 2016	3	F. Ismail	Updates with Eskom comments
January 2017	4	F. Ismail	Updates with Eskom comments
March 2017	5	F. Ismail	Updates with Eskom comments. Replaced the SEL2812 with the Tekron Isolated Timing Repeater.
April 2017	6	F. Ismail	Updates with Eskom comments.

8. Development team

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

- Fareed Ismail
- Sagar Dayabhai
- Peter Diamandis

9. Acknowledgements

The information provided in this document has been largely derived from equipment instruction manuals and datasheets obtained from Schweitzer Engineering Laboratories Inc. and Telegartner.