Eskom	Standard	Technology

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This document is **STABILISED.** The technical content in this document is not expected to change because the document covers: *(Tick applicable motivation)*

1	A specific plant, project or solution	
2	A mature and stable technical area/technology	X
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Content

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1. Introduction

This document describes the technical requirements for the digital fault recorder (DFR) scheme for use within Eskom Transmission substations.

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

This standard describes Eskom's requirements for digital fault recorder schemes. It provides potential suppliers with a framework against which their offered products will be adjudicated and shall form the technical basis for any supply contract so awarded.

2.1.2 Applicability

This document shall apply to Eskom Transmission and PTM&C (Group Technology).

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] ISO 9001, Quality Management Systems.

[2] IEC 60255-5 Electrical relays – Part 5: Electrical relays – Insulation coordination for measuring relays and protection equipment – Requirements and tests

[3] Network Code: The South African Grid Code (Revision 8.0)

[4] 240-64685228 Generic Specification for protective Intelligent Electronic Devices (IEDs)

[5] 240-42066934 IEC61850 Protocol Implementation Document for the Purposes of Substation Automation

[6] 240-68107841 Eskom IEC61850 Standard Requirements for PICS, PIXIT and TICS

[7] 240-64038621 Remote Device Communication Standard for Data Retrieval and Remote Access

[8] 32-373 Information Security – IT/OT Remote Access Standard

[9] 240-55410927 Cyber Security Standard for Operational Technology

[10] 240-64636794 Standard for wiring and cable marking in substations

[11] 240-62629353 Specification for panel labelling standard

[12] 240-64100247 Specification for PTM&C equipment earthing in substations

[13] 240-62773019 Specification for low voltage electrical auxiliary components

[14] 240-70413291 Specification for electrical terminal blocks

[15] TSP41-1043 Specification for Control, Selector, Isolation and Test Switches

[16] TST-41634: Drawing standard

[17] 240-60725641 Specification for Standard (19-inch) Equipment Cabinets

2.2.2 Informative

[18] 240-65336348 Specification for Transmission and Distribution protection schemes Common requirements

[19] 240-61701192 User Requirement Specification for the Automatic Fault Analysis System

[20] 240-68111223 Goods information for Standard networking devices for the substation environment standard

[21] 240-55863502 Definition of OT/IT collaboration accountabilities.

2.3 Definitions

2.3.1 General

Definition	Description
Bay/ Bay Protection Scheme	Protection scheme of the feeder, transformer, reactor, SVC, etc. bay that the DFR is monitoring.
Bay-type combination/Group	This refers to a combination of analog and binary data input card channels used for the monitoring of different primary plant bay configurations (e.g. feeder bay, transformer bay).
Disturbance Recorder	The term most commonly used within Eskom to refer to 'Digital Fault Recorders' (DFRs).
IEC61850-ready substations	This term is used to refer to substations that have the required infrastructure/equipment for collection and publishing of GOOSE and MMS messages. At this point, none of Eskom's substations are ready for the acquisition of analog signals as sampled measured values (SMVs) from CTs and VTs via merging units. Therefore, the term 'IEC61850-ready' as used in this document does not apply to (the acquisition of) analog input signals.
Legacy substations	Substations that are not IEC61850-ready i.e. with no IEC61850 infrastructure (PIUs, process bus, station bus, etc.)
Panel not healthy	An alarm condition indicating that the fault recording system is not able to perform part or all of its intended function.
Scheme	A set of components that work together in order to execute a specific behavior under predefined power system conditions sensed through the scheme interface (Cigré Working Group B5.27). In the context of this document, a DFR scheme shall refer to a complete fault recording system inclusive of one or more DFR devices, Ethernet switch, DC-DC convertor and all other auxiliary equipment required for the effective and intended functioning of the system. A single scheme may be contained within a single panel or more.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
A	Ampere
AC	Alternating Current
ACF	Alternating Current Fail

Abbreviation	Description
ASCII	American Standard Code for Information Interchange
Brkr&1/2	Breaker-and-a-half
CAD	Computer-Aided Drafting
CID	Configured IED Description
COMTRADE	Common format for Transient Data Exchange
CPU	Central Processing Unit
CT	Current Transformer
CTTB	Current Transformer Test Block
DC	Direct Current
DCI	Direct Current Isolator
DFR	Digital Fault Recorder
DR	Disturbance Recorder
EHV	Extra High Voltage
FIFO	First In, First Out
FTP	File Transfer Protocol
GB	Gigabyte
GOOSE	Generic Object Oriented Substation Event
GUI	Graphical User Interface
HTTP	Hyper Text Transfer Protocol
HV	High Voltage
ICD	IED Capability Description
IEC	International Electrotechnical Committee
IED	Intelligent Electronic Device
IP	Ingress Protection
IRIG-B	Inter-Range Instrumentation Group – time code B
ISW	Isolating Switch
JB	Junction Box
LC	Lucent Connector
LED	Light Emitting Diode
MCB	Miniature Circuit Breaker
MMS	Manufacturing Message Specification
OS	Operating System
PC	Personal Computer
PNH	Protection Not Healthy
PVC	Polyvinyl chloride

Abbreviation	Description
QA	Quality Assurance
RAM	Random Access Memory
REF	Restricted Earth Fault
RMS	Root Mean Square
SCADA	Supervisory Control And Data Acquisition
SCD	Substation Configuration Description
SHEQ	Safety, Healthy, Environment and Quality
SMV	Sampled Measured Values
SNTP	Simple Network Time Protocol
SS	Secure Supply
SSL	Secure Sockets Layer
ST	Straight Tip
SVC	Static VAr Compensator
TLS	Transport Layer Security
UTC	Coordinated Universal Time
V	Voltage
VT	Voltage Transformer

2.5 Roles and responsibilities

Protection design shall utilise this document as the basis for the enquiry process and during the product development phase.

2.6 Process for monitoring

The protection technology & support manager and the custodian will monitor the compliance to this standard.

2.7 Related/supporting documents

See normative and informative references.

3. Requirements

3.1 Introduction

This standard describes the requirements for digital fault recorder (DFR) scheme solutions. The DFR scheme shall interface with bay protection schemes of feeders, transformers, reactors, etc. of both double busbar and breaker-and-a-half busbar configurations.

This standard is written based on a ‘one-box’ type DFR solution (i.e. where all the processing and control cards/units as well as analog and binary data input cards/units are integrated within a single device, however a complete scheme may consist of multiples of these ‘one-box’ type DFRs). However, other solutions including modular type solutions (i.e. where the entire DFR scheme has one common set of processing and control cards/units and where analog and binary data input cards/units can be added as separate modules to expand the number of bay-type combinations/groups that can be monitored) are also acceptable.

Eskom is in the process of migrating to IEC61850 based substation automation solutions. However, due to the large size of the Transmission network and the different technologies used across the various substations, this migration will take a reasonable amount of time to complete. Therefore, Eskom still remains with Transmission substations that do not have the required IEC61850 infrastructure and are therefore not IEC61850-ready. Such substations shall be referred to as 'legacy substations' in the remainder of this document.

It is important to note that the term 'IEC61850-ready' as used in this document refers to substations that have the required infrastructure/equipment for collection and publishing of GOOSE and MMS messages. At this point, none of Eskom's substations are ready for the acquisition of analog signals as sampled measured values (SMVs) from CTs and VTs via merging units, or otherwise. Therefore all CT and VT inputs to the DFR shall be hardwired irrespective of whether a substation is IEC61850-ready or not (i.e. legacy substations).

To cater for the different types of substations (with respect to IEC61850 'readiness' for GOOSE and MMS messages), three different options of DFRs shall be considered with respect to interfacing of inputs and outputs to and from the DFR (excluding CT and VT inputs). Suppliers shall offer either both Option A and Option B or Option C (only) as a solution:

a) Option A: a DFR device/solution that supports the IEC61850 standard and that can subscribe to GOOSE and broadcast MMS messages.

b) Option B: a DFR device/solution that supports the IEC61850 standard but allows for hardwired binary input interfacing. It shall be possible to easily upgrade this DFR device/solution as required such that the DFR can subscribe to GOOSE and broadcast MMS messages (i.e. Option B shall be upgradeable to Option A).

c) Option C: a DFR device/solution that supports the IEC61850 standard and allows for both hardwired binary input interfacing and subscription to GOOSE and broadcasting of MMS messages.

d) All three options (A, B and C) shall have a minimum of eight (8) hardwired binary outputs.

3.2 Scheme Variants and Model Numbers

Each scheme type and variant shall be assigned a unique model number. The number shall be allocated as per Eskom's numbering system (see section 3.2 of 240-65336348 Specification for Transmission and Distribution protection schemes: Common requirements) and shall be approved by an Eskom protection representative. The scheme type number shall be utilised to identify the solution, use for codification, applied to the scheme diagrams and all relevant documentation.

All scheme permutations shall cater for both 110 VDC and 220 VDC applications.

3.2.1 Scheme Hardware Identification

The DFR scheme identification codes shall be as follows:

Scheme description	Generation of scheme (Phase)	Scheme group code (Type)		Manufacturer code (Vendor ID)	Series number (Scheme Type)	Major revision number (Scheme design revision)
Digital Fault Recorder Scheme	6	DR	-	#	1	00

3.2.2 Generation of Scheme

This generation of DFR schemes shall be identified by using phase number 6.

3.2.3 Scheme Group Code

The applicable scheme group codes for the DFR schemes shall be as follows:

Disturbance Recorder	=	DR

3.2.4 Manufacturer Code

The scheme manufacturer will be identifiable by a number following the scheme group code. Additional numbers will be assigned on contract award:

Code	Manufacturer
0	[Vacant]
1	Actom
2	Siemens
3	ABB
4	[Vacant]
5	Powertech System Integrators
6	VAMP Solutions
7	Consolidated Power Projects (CONCO)

3.2.5 Series Number (Scheme Type)

The series number for all DFR schemes shall be = 1 as there are no scheme variations.

3.2.6 Major Revision Number (Scheme Design Revision)

The starting number for the first approved production schemes shall be 00. This number shall be incremented for any major scheme design change or DFR hardware change.

3.2.7 Voltage Level

Eskom utilise the following standard station DC voltage supplies:

- 110 VDC (Code = 1);
- 220 VDC (Code = 2).

3.2.8 Option 1 Selection

The selectable options within this standard scheme design shall be:

Option description		
DFR with Ethernet interfacing (IEC61850-ready substations)	=	01
DFR with hardwired binary input interfacing (legacy substations)	=	02

3.3 Performance Requirements

The DFR shall operate in accordance with the prescribed performance requirements irrespective of the number of functions enabled within the device.

3.3.1 Dependability

Dependability is defined as the probability of not having a failure to operate under given conditions for a given time interval.

a) The DFR shall have as high dependability as possible. The supplier shall specify the expected dependability as a percentage of a 365-day period.

3.3.2 Availability

a) For high equipment availability, the design shall allow fault location, rectification (possibly by replacement sub-units) and returning to service to be performed as quickly as possible, preferably with the equipment in service and in situ.

b) Further, the DFR shall be able to communicate with and record multiple bay-type combinations/groups concurrently.

3.3.3 Reliability

Failure of any component shall not result in:

a) loss of functions except for those for which the component is directly needed. In particular, failure of a component at one location shall not cause loss of functions at different locations.

b) an undetected loss of functions, nor multiple and cascading component failures.

3.3.4 Maintainability

a) The DFR shall be designed so that a minimum or no routine maintenance is required, in terms of total accumulated time and frequency.

b) Provision to enhance the maintainability of the DFR should include the following:

i. equipment self-tests

ii. diagnostics; and

iii. troubleshooting procedures to localise any failure or malfunction to the lowest replaceable unit level.

3.3.5 Expandability

a) The DFR shall be able to accommodate adaptations or extensions of the power network during its lifetime.

b) The supplier shall specify the maximum number of expandable modules that can be added to any one DFR with reference to analog and binary modules or a combination of both.

c) These changes shall require a minimum rearrangement of existing cards/units, auxiliary equipment and software.

d) It shall furthermore not degrade reliability and the availability of the DFR.

3.3.6 Longevity

a) The DFR scheme shall be designed for a minimum operational life of 20 years. Written guarantees to this effect shall be made available on request.

3.4 Scheme Interfaces

3.4.1 Auxiliary Supplies

3.4.1.1 230V AC Supply

The 230V AC supply for the DFR scheme shall be supplied from the station AC board. AC supplies shall be 230 V phase-to-neutral and 400 V phase-to-phase. The frequency shall be 50 Hz nominal, variable between 47 Hz and 51 Hz. Total harmonic distortion including all harmonics up to the order of 40, shall not exceed 8 %.

a) The 230V AC supply miniature circuit-breaker and supply rail monitoring shall be done within the DFR scheme.

b) The 230V AC supply shall be routed via a 10A miniature circuit-breaker (MCB(AC)) for isolation and protection purposes and shall be used to illuminate the red alarm 'panel not healthy' lamp in the event of any DC supply failure or equipment failure. The 10A rating provides co-ordination with upstream 20A devices and proves adequate protection for 1.5mm^2 and 2.5mm^2 panel wiring.

c) AC MCBs shall have rated breaking capacities of 5kA.

d) The MCB(AC) shall be wired with the source supply to the top, and load supply from the bottom.

e) The scheme shall make provision for two separate AC entry points i.e. one for the plug point and another for alarm monitoring.

A separate 230V AC supply for the 230V AC single socket plug point on the DFR scheme shall be supplied from the station AC board.

3.4.1.2 DC Supply

The DC circuits on each DFR scheme shall be supplied with dual redundant 110-220 VDC supplies (i.e. Main 1 and Main 2) from the station DC board for the DFR, indications, auxiliary equipment and the secure supply circuit. The DC supplies shall feed the DFR scheme via 32A fuses located on the DC boards.

a) On the DFR scheme, the Main 1 and Main 2 DC supplies shall be routed via two 2-pole 10A MCB(DCI(M#)) to a secure supply circuit within the DFR scheme .

b) The main 1 DC supply circuit shall be the preferred supply, chopping over to the Main 2 circuit if the Main 1 DC supply voltage drops below 80% of rated.

c) The chop-over relay shall include hysteresis to prevent contact bounce at the threshold of coil operation.

d) Thereafter, the DC supply shall be routed:

   i. to each DFR via a 2-pole 6A MCB; e.g. DCI(DFR1), DCI(DFR2)……DCI(DFRn);

   ii. to the Ethernet switch via a DCI(ETHSW) 6A MCB;

   iii. to DC fail monitoring (connected in the last loop); and,

   iv. via a 24 VDC DC-DC convertor to provide the wetting supply for each DFR's binary inputs. The output from the DC-DC convertor shall be individually isolated using a 2-pole 6A Isolating Switch (ISW) per DFR; e.g. ISW(24VDC_DFR1), ISW(24VDC_DFR2) SW(24VDC_DFRn) (only required for legacy substations).

e) All MCBs shall be wired with the source supply to the top, and load supply from the bottom.

3.4.2 Current Transformer Circuits

The standard current transformer secondary inputs are 1 A, with a continuous rating of 2 A. The standard practice is to earth the neutral (4th wire) where the CT cable is connected to the terminals within the panel/module. Dedicated 4mm^2 cables shall be used for the CT secondary connections between the CTs and the DFR scheme.

The DFR scheme shall obtain its current signals from a protection class CT core. The CT connections to the DFR will be routed through a dedicated DFR four-way current transformer test block, CTTB, on the protection panel of the bay it is monitoring.

a) In the DFR scheme, the CT connections shall be routed through a point of testing within the DFR panel with a solution to provide for shorting of the CTs to the DFR device.

b) The current transformer star point shall be applied at the terminals of the DFR device (preferable) or at the terminal rail in the DFR panel.

c) Hardwired inputs for all CT inputs to the DFR shall be provided for IEC61850-ready as well as legacy substations (i.e. Options A, B and C as per section 3.1).

3.4.3 Voltage Transformer Circuits

The standard voltage transformer secondary inputs are 63.5 volt per phase (110 volt, phase-phase). The standard practice is to earth the neutral (4th wire) in the VT JB. Dedicated 4mm^2 cables shall be used for the VT secondary connections between the VTs and the DFR scheme.

The DFR scheme shall obtain its voltage signals from a protection class VT core. The VT connections to the DFR will be routed from the protection panel of the bay it is monitoring.

a) In the DFR scheme, the VT connections shall be routed via single phase 2A MCBs through sliding-link type terminals (see clause 3.3.3 in 240-70413291 Specification for Electrical Terminal Blocks) to the DFR device.

b) The voltage transformer star point shall be applied at the terminals of the DFR device (preferable) or at the terminal rail in the DFR panel.

c) The synchronising ‘running volts’ shall be fed from the protection panel to the DFR (for recording purposes) via a 2A MCB on the DFR scheme.

d) Hardwired inputs for all VT inputs to the DFR shall be provided for IEC61850-ready as well as legacy substations (i.e. Options A, B and C as per section 3.1).

3.4.4 Binary Signals and GOOSE/MMS Messaging

a) For IEC61850-ready substations, the DFR shall subscribe to GOOSE messages from and broadcast/publish MMS messages to the IEC 61850 station bus/other devices (i.e. Options A and C as per section 3.1).

b) Suppliers shall provide a MICS (Model Implementation Conformance Statement) document with their tender submissions to describe the logical nodes available/used.

c) For legacy substations, the DFR shall have hardwired binary inputs and outputs (i.e. Options B and C as per section 3.1). In the case of hardwired interfacing, the binary inputs will be routed from the bay protection scheme or other device to the DFR and binary outputs shall be routed to relevant interface/device.

3.4.4.1 DFR Binary inputs

a) Hardwired binary inputs shall be required on the DFR for legacy substations (i.e. Options B and C). Refer to Table 1: Bay-type combinations/Groups in section 3.5.2 for the minimum requirements with respect to binary inputs for triggering and recording purposes.

b) Any additional hardwired binary inputs that shall be required for other functional purposes (such as that specified in section 3.5.6 d) for example) shall be finalised during the product development phase.

c) All binary input contacts from external devices shall be wetted with a 24 VDC supply from a DC-DC convertor within the DFR scheme, but external to the DFR.

d) Hardwired binary channels shall have the option to be purchased according to the voltage levels 24V DC, 48V DC, 110V DC or 220V DC.

3.4.4.2 DFR Binary outputs

a) A minimum of eight (8) hardwired binary outputs shall be required on the DFR for both legacy and IEC61850-ready substations (i.e. Options A, B and C as per section 3.1).

b) The assignment of the binary outputs shall be finalised during the product development phase.

3.4.4.3 GOOSE messaging

The GOOSE data is utilised to communicate information between the DFR and protection IEDs.

a) The vendors shall use IEC 61850 as “purely” as possible (e.g. defined logical node names and data attributes).

b) The DFR shall use IEC 61850 standard naming conventions and semantics, to ensure interoperability with the various IEC 61850 compliant devices used by Eskom.

c) The vendor shall comply with the IEC61850 standards and Eskom’s requirements as per document 240-42066934 IEC61850 Protocol implementation document for the purposes of substation automation.

The following data will in general be sent via a GOOSE message:

- primary plant status and trip signals
- teleprotection signals;
- protection signals.

d) The DFR shall be able to subscribe to receive GOOSE messages from other devices.

3.4.4.4 MMS messaging

The MMS data is utilised to communicate remote alarming information between the DFR and station gateway device(s).

a) The vendors shall comply with the IEC61850 standards and use IEC 61850 as “purely” as possible (e.g. defined logical node names and data attributes).

b) The DFR shall act as an MMS server and be able to broadcast/publish MMS data to the IEC61850 station bus/other devices.

3.4.5 Human and Machine Interface to the DFR Panel

3.4.5.1 Local controls

a) Local controls shall be required on the DFR/scheme.

b) The preferred method of providing local controls is via integrated programmable push buttons with indications on the DFR, or as an alternative, the required local controls can be provided for (push buttons with indications) on the panel.

c) The following local controls shall be available on the DFR or on the panel:

i. Manual trigger

ii. Acknowledge/Reset alarm

iii. Select/Change operating mode (as specified in section 3.5.6)

3.4.5.2 Local indications

a) Local indications shall be required on the DFR/scheme for local reporting purposes.

b) The preferred method of providing local indications is via integrated programmable LEDs (light emitting diodes) on the DFR, or as an alternative, the required local indications can be provided for using a separate LED annunciator system on the panel.

c) A combination of using the LEDs available on the DFR and an external LED annunciator is permissible.

d) All latched alarm indications shall remain displayed until reset by a push button.

e) All indications shall be visible by default, that is, no external influence shall be required to view any indication. The status of all locally and remotely controllable functions shall be indicated on the DFR/scheme.

f) LED colours shall be as follows:

i. Green: ‘Normal’ operating statuses (e.g. Device OK, ‘Normal’ operating mode)

ii. Red: Errors, not healthy conditions, alarm conditions (e.g. Hard drive error)

iii. Amber: ‘Abnormal’ operating statuses (e.g. ‘Maintenance’ and ‘Test’ operating modes, Memory low)

g) The following minimum indications shall be available on the DFR or on the panel:

i. Device OK

ii. Memory low

iii. CPU error

iv. Data input card/unit faulty (grouped)

v. Hard drive faulty/error

vi. IEC61850 communications failure

vii. Communications error (for DFRs that are not IEC61850 enabled)

viii. Time synchronisation error

ix. Operating mode selection (the selected mode shall be continuously illuminated)

x. Panel Not Healthy (NB: This indication shall be on the panel and not on the DFR. See section 3.6.1 for more detail.)

3.4.5.3 Remote controls

a) The following remote controls shall be required:

i. Manual trigger

ii. Select/Change operating mode

iii. Settings changes (refer to section 3.7.2)

3.5 DFR Functional Requirements

The functional specification is detailed in this section and states the purchaser’s minimum requirements for the DFR system.

3.5.1 General

The DFR shall be a complete automatic and digital fault recording system capable of data acquisition and recording. Fault records shall be permanent, time-stamped and accurate records, including pre-fault information of transient disturbances in a power system. Communication capability must be available for fault data transmission and setting changes, locally and remotely. Design of this system shall emphasise system availability, reliability, ease of installation, maintenance and convenience of expansion.

The required fault recording system is intended for Transmission system applications such as EHV/HV feeders, transformers, reactors and SVCs (static VAR compensator) at electrical power substations for double busbar as well as breaker-and-a-half configurations.

3.5.2 Analog and Binary Input Channels

a) The DFR shall be capable of recording both analog input signals as well as binary input signals.

b) The use of any combination of analog and binary input channels shall not affect the use of any other channel or degrade the general performance.

c) While the DFR is recording, there shall be filtering implemented such that no false information is recorded on the sampled channel or on any adjacent channel.

d) No other functions of the DFR shall be degraded in any way.

Table 1 below specifies the number of analog (voltage and current) input channels and binary input channels required for the various applications of the DFR within Eskom Transmission substations.

e) It shall be possible to configure and group various analog and binary input channels into the following bay-type combinations or groups for the purpose of triggering and recording of fault records.

f) All of these shall be provided as options. The supplier shall specify how these combinations can be achieved.

Table 1: Bay-type combinations/Groups

	Analog Input Channels (Voltage)	Analog Input Channels (Current)	Binary Input Channels
Double Busbar EHV/HV Feeder	4	4	32
Brkr&1/2 EHV/HV Feeder	4	8	32
Reactor	4	4	32
SVC	8	16	32
Double Busbar Transformer with Auxiliary Transformer	8 + 4 (REF)	12	64
Brkr&1/2 Transformer with Auxiliary Transformer	8 + 4 (REF)	20	64

g) All analog channels inputs shall be independent (i.e. on a per phase basis) such that the star point can be wired externally as shown below:

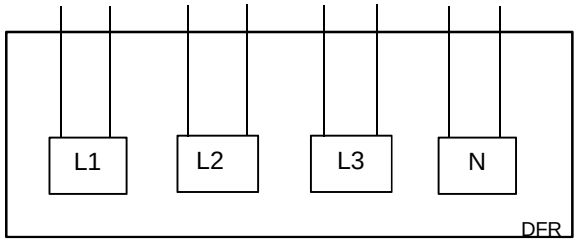


Figure 1: Independent analog input channels

h) For breaker-and-a-half type applications, where multiple CT inputs need to be summated, the native software of the DFR shall allow the user to select the option to perform summation of CT measurements internally.

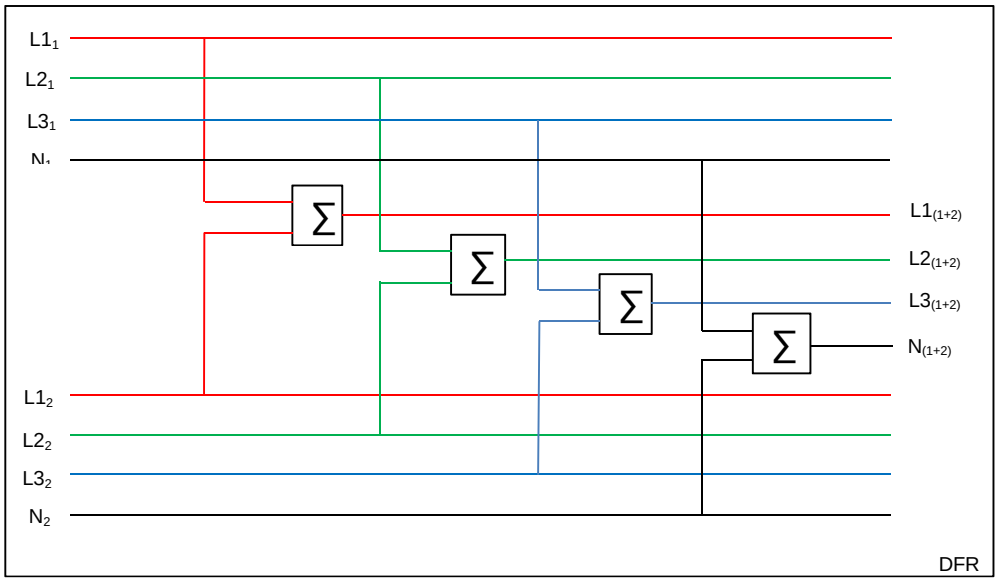


Figure 2: Internal summation of CT measurements

3.5.2.1 Analog Channels

a) All analog input signals shall be digitised with at least 16 bits of resolution for clear waveform reproduction.

b) Input scaling shall be adjusted automatically for both analog current and voltage inputs by the DFR.

3.5.2.2 Binary Channels

a) User defined labelling of binary channels shall be permitted, with labels consisting of a minimum of thirty two (32) alpha-numeric characters.

3.5.3 Sampling Rate

a) At least two simultaneous different sampling rates shall preferably be possible to monitor fast transient and slow phenomena like power swing.

b) Each sampling rate shall be independently settable.

c) Preference shall be given to recorders that can do at least two simultaneous different sampling rates on the same data input cards/units.

d) The sampling rate of analog channels shall be settable from 1 Hz to at least 2.5 kHz (50 samples/cycle).

e) The binary channels shall be sampled at the same rate as the analog channels.

3.5.4 Real-Time Clock and Time Synchronisation

a) The DFR shall have an internal real time clock and built-in calendar with a facility to synchronise the clock.

b) The DFR shall be time synchronized for event time-stamping purposes using Simple Network Time Protocol (SNTP) version 3 or later (i.e. for Options A and C as per section 3.1). The IEEE 1588 Precision Time Protocol version 2 (as per IEEE STD C37.238-2011) may be offered as an option.

c) Provision shall also be available (as an option) for the DFR to be time synchronized using an IRIG-B time code signal from the station time synchronization device or from a centralized data concentrator. This shall be required for legacy substations that are not IEC61850-ready (i.e. Options B and C as per section 3.1).

d) In the absence of a time synchronizing source, the real-time clock shall not drift by more than 2s per day.

e) The stamping accuracy on the DFR shall be 1ms or better.

f) The time shall be within accuracy limits across the total temperature range specification of the DFR.

g) The DFR time shall be maintained for a minimum period of seven days in the event of a loss of auxiliary supply.

h) Where an internal battery is used to meet this requirement, it shall have a minimum lifespan of 10 years and shall be replaceable without a need for soldering.

i) The battery type and replacement procedure shall be clearly documented in the applicable DFR manual.

j) The DFR shall support Coordinated Universal Time (UTC) time offsetting such that the DFR time is set to local South African time.

k) In the event of the time synchronization source being unavailable, correction of the DFR time shall be performed without adversely affecting the operation and/or parameters of the DFR and without resetting any other parameters in the DFR.

3.5.4.1 Date management system

a) Date and time formats shall be configurable.

b) Hardware, software and firmware offered in terms of this enquiry shall be able to accurately process all fault recordings on the DFR irrespective of the date and time on that recording.

c) The DFR, when used in accordance with the manufacturer's documentation, and when used in combination with other products (e.g. hardware, software and firmware) shall properly exchange date data between them.

3.5.5 Data Storage

a) The DFR shall have a solid state hard drive with a non-volatile storage capacity of at least 1GB (exclusively for fault records).

b) The hard drive shall also have a minimum capacity of 400 recordings of 12 seconds at maximum sampling rate.

c) The DFR RAM (random access memory) shall also have a minimum capacity of 10 recordings of 12 seconds at maximum sampling rate.

d) In case of hard drive failure, the RAM shall maintain these recordings.

3.5.5.1 Data Integrity and Storage

a) No data loss is acceptable - data compression should not cause any loss of data.

b) The DFR shall be set to automatically overwrite the oldest file when memory (storage and RAM) is full, following the FIFO (first in, first out) approach.

c) All operating (i.e. settings) and system configuration parameters shall be stored in non-volatile memory so that the DFR shall return to normal operation after a power-up cycle.

d) Recorded data per bay-type combination/group shall be uniquely identified to avoid confusion during downloading.

e) There shall be no loss in recorded fault data caused by any operation of the DFR.

3.5.6 Operating Modes

a) The DFRs shall have at least three different operating modes, viz.

i. Normal mode – all selected triggering (for that specific feeder) shall be active. This mode will be selected when the feeder being monitored is under normal operation.

ii. Maintenance mode – all triggering (for that specific feeder) shall be blocked/de-activated.

iii. Test mode – all selected triggering (for that specific feeder) shall be active. However, fault records should be marked/flagged appropriately as a test record to indicate that the fault record was captured during testing.

b) The operating mode selections shall be independently selectable from within the operating software for each bay-type combination/group being monitored by the DFR (e.g. it should be possible to select Feeder 1 on maintenance mode while Feeder 2 remains in normal mode).

c) A binary input shall be provided per bay-type combination/group on the DFR such that an external input from the bay protection scheme can be used to select ‘maintenance’ operating mode for that specific bay-type combination/group.

d) The DFR shall alarm hourly when the operating mode has been left/remains in the ‘maintenance’ or ‘test’ modes.

3.5.7 Triggering

a) Sensors are triggers for analog channels (e.g. undervoltage level detection sensor).

b) Triggers for analog channels shall have level detection and rate of change detection sensors.

c) Triggers for binary channels shall have edge and change of state detection.

d) It would be preferred if sets of logical combinations between any triggers were settable.

e) It shall be possible to arm or disarm triggers on each channel and for sensor levels to be changed by the operator while the DFR is operational.

f) All triggers shall be locally or remotely programmable and settable.

g) The sensors shall be continually available to monitor the power system.

h) All sensors shall reset automatically after a disturbance or fault.

i) The recorder shall be capable of being triggered by the following user specified triggers:

i. external start (manual trigger)

ii. matrix triggering of groups of channels

iii. binary channel

iv. overvoltage and undervoltage

v. overcurrent

vi. rate of change, voltage or current

vii. frequency triggers (for frequency monitoring)

viii. logical combination of triggers (preferred)

ix. low frequency oscillation sensors (preferred)

j) User defined legends shall be available for each settable trigger.

k) The legends of fault records shall provide an immediate display of the cause of the recording to operating personnel.

l) The trigger levels shall be individually adjustable and all triggers whether analog, binary, or combination will be capable of being manually enabled or disabled through the device operating software.

3.5.7.1 Manual Triggering/External Start

a) The DFR shall be equipped with a push button (preferably on the front panel) for manual triggering.

b) The user shall also be able to manually trigger the DFR by means of a software command using the device operating software.

3.5.7.2 Matrix Triggering

a) Matrix triggering (the activation of recording cards/units on non-affected bay-type combinations/groups according to a set matrix) shall also be available on the DFR.

b) It shall be preferred if multiple DFRs shall be able to communicate with each other for the purpose of matrix triggering.

An Ethernet switch will be provided for interconnectivity between the DFRs.

3.5.7.3 Binary Triggering

a) Triggering by a binary channel shall be independently selectable per channel.

b) The DFR shall be capable of triggering from all binary input channels, with the trigger arming status being easily changed locally and remotely using the device operating software.

c) Binary triggering of the DFR shall be possible via external contact operation i.e. triggers shall be operator selectable and shall be set for either leading edge, trailing edge; low to high, high to low and both.

3.5.7.4 Overvoltage and Overcurrent Triggering

a) Overvoltage and overcurrent sensors shall have selectable resolution of at least 1% of full scale of analog channels and will be adjustable from zero to full scale.

3.5.7.5 Undervoltage Triggering

a) Undervoltage sensors shall have selectable resolution of at least 1% of full scale of analog channels and will be adjustable from zero to full scale.

3.5.7.6 Rate of Change Triggering (Voltage and Current)

a) An adjustable rate of change sensor for voltage and current shall be required.

b) The trigger shall have selectable resolution of at least 1% per second of full scale of analog channels and will be adjustable from 1% per second to 1000% per second of full scale.

3.5.7.7 Frequency Triggering

a) Frequency triggers shall be adjustable to start the frequency recording, with steps of no larger than 0.01 Hz, with the minimum adjustable trigger 49.89 Hz and the maximum adjustable trigger 50.11 Hz.

b) An adjustable rate of change trigger will also be required, with values adjustable between 1Hz/second to 9Hz/second or equivalent.

3.5.7.8 Logical Combination of Triggers

a) If the capability is provided for triggering on logical combinations of triggers, the logical combinations of triggers from more than one channel including analog and binary channels shall be able to trigger the DFR. For example trigger 3 and trigger 5 both triggered at the same time or trigger 7 triggered can trigger a recording.

3.5.7.9 Low Frequency Oscillation Triggering

a) If the capability is provided for triggering on low frequency due to power swings, oscillation sensors shall sense oscillations on the power system.

3.5.8 Fault Records

a) All analog and binary channels shall be recorded independent of the trigger mode/triggering selection. Only the allocated (used) analog and binary channel shall be recorded.

b) The waveform recording shall contain all analog signals to the DFR and all significant binary signals (protection tripping elements, circuit-breaker status, input and output contact status, etc.).

c) The selection of recorded channels shall be user programmable.

d) The oscillographic waveforms and binary event information shall be displayed within a single window when the data is uploaded to the device's operating and analysis software for post fault analysis purposes.

e) All data must be time stamped with the date, time and source name, as well as the trigger cause.

f) The date and time format shall be user configurable.

g) All fault records shall consist of pre-fault and post-fault information.

h) The pre-fault and post-fault durations shall be independently selectable.

3.5.8.1 Pre-Fault Record Duration

a) The DFR shall be capable of producing a record of the fault including a pre-fault record length adjustable between 250ms to 2500ms, at maximum sampling rate.

b) Step sizes for adjustment should not be larger than 10ms.

c) The pre-fault memory shall be in operation at all times providing continuous system monitoring.

3.5.8.2 Post-Fault Record Duration

a) Upon occurrence of a trigger condition, the DFR shall automatically start to record data until the maximum time authorized for the fault record has been reached or until the trigger condition disappears.

b) The minimum record time shall be settable individually, for each bay-type combination/group and shall record for a minimum time after the first trigger condition appeared, user adjustable from at least 100ms to at least 7500ms.

c) The maximum record time shall be settable individually, for each bay-type combination/group, user adjustable from at least 750ms to 10000ms.

d) Step sizes for adjustment shall not be larger than 10ms.

e) If any trigger is active after the minimum time has elapsed, the recording shall continue.

f) If new triggers become active, the minimum record time shall be applicable from the newest trigger.

g) If the triggers disappear after the minimum record time and before the end of the maximum fault record time, the DFR will stop recording and wait for the next trigger condition.

h) The DFR will re-arm automatically.

3.5.8.3 Identification of Records

a) The DFR shall record on each digitally stored record the date (month, day, year), time (hour, minute, second, millisecond), substation name, bay-type combination/group names, cause of trigger, and scaling and timing axis factors.

b) This means all information needed to analyse a given record shall remain attached to the fault record.

3.5.9 Transmission Modes

a) The DFR shall operate in either of two transmission modes (provision shall be made for both):

i. In manual mode the DFR shall hold its data transmission until polled by a local/remote user or data concentrator manually.

ii. In automatic mode the DFR shall be set up to transmit fault data to a local or remote data concentrator immediately after the DFR records the event (i.e. without manual intervention/polling).

b) Even when the DFR is set in automatic mode, it shall still be possible to download a fault file manually as well as allow engineering access to change settings, etc.

c) If the DFR is set to automatic mode, test records shall not be transmitted.

3.5.10 Frequency Monitoring

Frequency monitoring is done to be able to obtain a global view of the electrical system's behaviour and condition.

a) Not all DFRs will be armed to trigger to record frequency trends, but all DFRs shall have the capability.

b) Frequency monitoring shall allow sampling of the system frequency (nominally 50Hz) at a rate that can be adjusted between a hundred samples per second (100Hz) and one sample per second (1Hz).

c) Frequency monitoring shall allow for this recording to continue for a period adjustable between ten (10) seconds and one thousand (1000) seconds, before and after trigger (with a step size of 1 second).

3.5.11 Alarms

a) The DFR shall monitor and report any hardware, software, communications card/unit or any other internal device failure.

b) Isolated potential free relay outputs shall be provided as alarm outputs.

c) These contacts shall be able to withstand up to 220V DC.

d) The alarms shall be internally activated until the alarm condition returns to normal.

e) All alarm outputs shall be configurable.

f) Provision shall also be made to group alarms as per user requirements i.e. specific internal alarms shall be combined (marshalled) to produce a single external alarm.

g) The root cause of all alarms (grouped or individual) shall remain detectable through both remote interrogation using the device operating software as well as by means of local indications on the front of the DFR.

h) Alarms shall be displayed locally on the DFR as well as alarmed remotely as hardwired binary outputs and/or MMS messages (to be finalised during development phase).

i) DFR alarms shall remain detectable i.e. provision shall be made to set each alarm to be latched or unlatched.

The following are the minimum alarms that shall be provided:

3.5.11.1 Watchdog Alarm

a) The DFR shall be capable of monitoring its own operation automatically by verifying the integrity of all internal circuits and shall raise a hardware failure alarm if it fails the self-check function (e.g. if certain components/parts do not respond correctly to watchdog queries).

3.5.11.2 Memory Low

a) The DFR shall automatically alarm (locally only) when memory is low. It shall be preferred if it has a selectable value above 80 % of the memory used.

3.5.11.3 Loss of External Time Synchronisation

a) The DFR shall automatically alarm when the synchronisation clock signal is either not present or has been determined to be invalid by software / firmware.

3.5.11.4 Component Failure Alarms

a) The DFR shall automatically alarm for any failure of DFR components that are key to the proper/effective functioning of the DFR (such alarms can include data input card/unit failure, CPU card/unit failure, hard drive failure, communications card failure, etc.)

3.5.11.5 IEC61850 communications failure

a) IEC61850 communications failure that affects the GOOSE and MMS signals shall be monitored by each DFR and:

i. Reported locally on the DFR via an indication LED;

ii. Reported locally via the panel unhealthy (PNH) indication;

iii. Reported remotely; and,

iv. Shall not cause an unwanted operation.

b) The DFR shall independently monitor the communications with all other devices.

c) The communications failure to a specific DFR shall not affect the performance of the information exchange between the other DFRs with healthy communications.

3.5.12 Engineering Access

a) Users shall be granted read/write access to the DFR settings and read access to the fault data within the DFR both locally and remotely.

i. Local engineering access to the DFR shall be possible through a dedicated communication port on the front of the device.

ii. Remote engineering access to the DFR shall be possible through a separate communication port at the rear of the device.

b) The DFR shall prevent the possibility of two users accessing the DFR simultaneously. The local user shall be given priority and the remote user shall receive a notification/error message that the device is in use.

3.5.13 System Security

a) DFRs shall support the implementation of 240-55410927 Cyber Security Standard for Operational Technology.

b) The DFR shall be password protected.

c) The password shall be settable via the rear Ethernet port.

d) It shall be possible to set a password with a minimum of 16 characters.

e) The password shall support the use of alpha, numeric and “special” characters.

3.5.14 Log file

a) A detailed, time-stamped audit trail of all events (triggering, error messages, alarm pick-ups and drop-offs, synchronization, etc.) and changes (e.g. setting changes, deletion of fault records, etc.) made to the DFR database shall be maintained and made available for display in the form of a log file.

b) The log file shall also identify the user (based on the user account profile) who made the change.

3.5.15 Maintenance

a) Personnel using common tools and test equipment will perform maintenance and expansion on the fault recording (DFR) systems in their installed position.

b) Easy access shall be provided to the DFR components that will require routine maintenance.

3.5.15.1 Module and Component Replacement

a) All input cards/units or modules shall be field replaceable and interchangeable with other cards/units or modules with the same system function.

b) Sufficient information shall be affixed on each module to enable a user to decide definitely whether or not two similar modules are actually interchangeable.

c) Equipment shall be designed such that defective modules can easily be replaced without moving other equipment units.

3.5.15.2 Firmware upgrades

a) Any firmware upgrades shall be limited to one version upgrade at a time.

b) The supplier shall be held responsible for any cost involved in the upgrade procedure.

c) Every version upgrade shall be accompanied by a comprehensive and detailed report on all the possible changes that have been made to the recorder.

3.5.15.3 Internal batteries

a) All the internal batteries used in any part of the recorder shall, be clearly documented and the user shall be informed by visible means when the batteries are due for replacement. For example, a sticker on the front or easily visible part of the device that has the information of the activation date (start of lifetime) and the date that the batteries are due for replacement. This shall be the responsibility of the supplier.

3.5.15.4 In Service Testing

a) The DFR shall be capable of undergoing routine testing, while in full operation, without disturbing functions of the equipment.

b) These tests shall include, but not be limited to measuring power supply voltages and checking all system statuses vital to the normal operation of the DFR, mass storage availability, recorder parameters, and configuration of the DFR system.

3.5.16 Communication Requirements

a) All details of the communication interfaces, including hardware, software, database and protocol details shall be made available to the purchaser so as to allow the equipment to be interfaced to other equipment.

3.5.16.1 Communication Ports

a) The DFR shall be supplied as standard with a front communications port for local engineering access. The front port shall be copper Ethernet (RJ45).

b) The DFR shall have the capability to handle/allow multiple sessions/applications concurrently.

c) The DFR shall have at least two Ethernet communication ports at the rear of the DFR for simultaneous substation communication and remote engineering access. One of these ports shall be a 100BaseFX (1300nm) fibre-optic Ethernet port with Lucent Connector (LC) (preferred) or Straight Tip (ST) connectors and the other port shall be 100BaseTx copper Ethernet with RJ45 connector

d) The front and rear Ethernet ports shall have independently settable IP addresses.

3.5.16.2 Communication Protocols

a) The rear Ethernet ports on the DFR shall support the following protocols for data file transfer (settings and fault data):

   i. File Transfer Protocol (FTP)

   ii. Secure FTP (FTP over SSL and TLS)

   iii. SANS 61850 MMS File Services (optional, but preferred)

b) The rear Ethernet ports on the DFR shall support the following protocols, in order of preference, for remote engineering access to the DFRs:

   i. IEC61850-8-1 (MMS Server)

   ii. Hypertext Transfer Protocol (HTTP)

iii. A stateless ASCII-based protocol delivered over a Telnet session

c) The protocol used for remote engineering access shall also conform to clause 4.2.2.2 c) in 240-64038621 Remote device communication standard for data retrieval and remote access.

d) The supplier shall provide an overview of the communications architecture with the tender returnables.

3.6 Scheme Supervision and Monitoring Functions

3.6.1 Panel Not Healthy Indication

The PNH is an alarm condition that indicates that the scheme is in an abnormal state.

a) The following conditions shall activate the PNH alarm:

i. Any device hardware failure (e.g. DFR device, Ethernet Switch, DC-DC convertor);

ii. Any MCB in an abnormal state;

iii. Loss of DC supply (including secure supply circuit failure);

iv. IEC61850 communications failure;

v. When any bay-type combination/group is selected to maintenance or test mode (see section 3.5.6); and

vi. Lamp check – lamp check push button to check the lamp health.

b) The Panel Not Healthy (PNH) indication shall be provided external to any DFR.

c) The PNH lamp shall be positioned on the top left hand side of the panel. The PNH lamp shall be red and supplied by 230 VAC.

3.6.2 DC Supply Monitoring

a) Each DC supply rail shall be monitored and reported (local and remote).

b) Each monitoring device shall be energised upon application of the DC supply it is monitoring, with its associated DC fail normally closed alarm contacts being maintained in an open condition.

c) In the event of a DC supply failure, or the switching to the ‘Off’ position of the relevant DC MCB, the DC fail monitoring device shall be de energised, resulting in the closing of the alarm contacts.

d) The DC supply fail monitoring device shall be connected to the last loop of the supply being monitored.

e) Each supply rail controlled by an MCB shall be monitored.

3.6.3 AC Supply Monitoring

The 230 VAC supply shall be supplied from the station AC board.

a) The 230 VAC supply monitoring shall be done and reported via the DFR.

b) An AC fail relay, ACF(Scheme), shall monitor the status of the 230V AC ‘panel not healthy’ indication supply.

c) This relay will be energised upon application of the AC supply it is monitoring, with its associated AC fail normally closed alarm contacts being maintained in an open circuit condition.

d) In the event of an AC supply failure, the AC fail relay shall be de-energised, resulting in the closing of the alarm contacts.

e) The AC supply fail monitoring relay shall be connected to the last loop of the supply being monitored.

f) The AC supply fail monitoring alarm contact shall be remotely reported.

3.7 Device Operating and Analysis Software Requirements

3.7.1 Software Package

a) The DFR shall be provided with software whereby fault recordings, settings and configuration data may be accessed by a PC.

b) The software suite should not be separated into more than two components. At most, the supplier should offer two separate software suites for use with the DFR i.e. one suite for setting, configuration and management of the DFR and the other for analysis/evaluation of fault records. However, the preferred option is to have a single software suite that integrates all these functions.

c) Eskom shall be issued with a corporate software licence. The licence shall be valid for the lifetime of the DFR, so that licence renewal is not necessary.

d) Any charges associated with the provision of software shall be factored in to the DFR sales price.

e) Eskom shall have the right to freely copy and distribute the software for use within Eskom and by consultants contracted for Eskom projects.

f) The supplier shall provide software support for the full lifetime of the hardware. This shall include bug fixes and software upgrades at no additional cost to Eskom.

g) The supplier shall inform Eskom of any software update that becomes available for DFRs used by Eskom, specifically where the update relates to a problem or deficiency which may affect its reliable operation.

h) Any changes to the software by the supplier shall be indicated by giving the altered software a new version number.

i) The supplier shall provide the Eskom technical representative with reasons for the change, shall provide details of the change, and shall declare all associated effects (e.g. impact on performance, communications, and interoperability with previous versions of DFRs).

j) Eskom shall not be obliged to undertake the evaluation of new software versions for each new version released by the supplier. This decision shall be taken by Eskom's appointed technical representative.

k) All software shall be compatible with Microsoft Windows 7, 32-bit and 64-bit operating systems.

l) The software shall keep up-to-date with future Microsoft Windows OS releases.

m) Use of the software shall not require the user to have administrator rights on the PC.

n) The software shall have a user-friendly Graphical User Interface (GUI) that has a well-organized and uncluttered appearance.

o) The software GUI shall be designed so that all headings, options and information are readable.

p) All error messages shall be given in detail/sufficiently descriptive such that the source of the error can be determined.

3.7.1.2 Role-Based Accounts

a) The DFR operating software shall have the functionality to set up password-protected accounts for users with different levels of authority.

b) The DFR shall support role-based access in at least three levels:

   i. Basic User - Read-only access to view and/or download settings and fault files

   ii. Advanced User - Read access and functionality to create and administrate different role based accounts for basic and administrative users. This user must also be able to reset passwords.

iii. Administrative User - Full read and write access (view/download settings and fault files, change settings, manage accounts, etc.).

c) Levels (b) and (c) shall be password protected.

d) Passwords shall be settable via the rear Ethernet port.

e) It shall be possible to set passwords with a minimum of 16 characters.

f) Passwords shall support the use of alpha, numeric and “special” characters.

3.7.2 Software Functions

a) It is preferred that it shall be possible to open at least two separate analysis windows so that analysis and comparison of fault records (e.g. from both ends of a feeder) can be done concurrently.

b) Appropriate software tools (mathematical and measurement) for the analysis and evaluation of fault records shall be provided.

c) The DFR operating and analysis software shall have the capability to:

i. configure and set the DFR in offline and online modes (i.e. while the DFR is in continuous operation);

ii. hide or “grey out” settings associated with functions that are set as disabled;

iii. validate the configuration and settings by comparing a saved file on a PC, and the active file on a DFR (for legacy substations);

iv. compare configuration, settings, Configured IED Description (CID) between a saved file on a PC, and the active file on a DFR;

v. export an IEC61850 IED Capability Description (ICD) and CID file;

vi. import IEC61850 Substation Configuration Description (SCD) files from third-party configuration software;

vii. import setting and configuration files (for legacy substations), event records (log file) and oscillographic and frequency recordings from the DFR;

viii. when installed on the engineering server, have the capability to poll all the DFRs to upload and store, to a user selectable folder, all new fault record;.

ix. when installed on any server or PC, have the capability to act as a data concentrator to which DFRs will automatically send all new fault records;

x. when acting as a data concentrator, have the capability to export all fault records received in COMTRADE format to a user selectable folder;

xi. provide a full status report of all monitored functions in the DFR (detail in this regard shall be finalised during the development phase).

3.7.2.1 Display of Incident Information

a) Incident information shall be displayed with properly highlighted headings to enable quick identification of the desired source of information.

b) Information shall be displayed in a clear, readable and uncluttered manner, without unnecessary characters, and with sufficient space in between.

c) It shall be preferred if fault location and protection operation can be displayed in a Geographical Format as well as in Table Format.

d) In terms of Geographical Format, the newest incident is shown by default, but it should be possible for multiple faults to be displayed on the Geographical Format, based on a time (start and end times) filter. Information displayed in the Geographical Format will have to be suitably summarized and abbreviated, but a double click on the information box should call up the Table Format display, where more detailed information will be available.

e) In terms of the Table Format, the newest incident is shown by default, but it should be possible to view results of any past incident, and also to set up tables that contain results of multiple past incidents based on search filters.

3.7.2.2 Display of Oscillographics

a) Oscillographics shall be displayed with options of RMS and instantaneous value displays.

b) Oscillographics shall be displayed with selections of colours for each channel individually, as well as the line types and line thickness.

c) Oscillographics shall be displayed with selection of which channels are to be displayed and in what sequence.

d) Oscillographics shall be displayed with the ability to display two channels on the same axis. It shall be possible to drag and drop or to copy and paste a channel from its own axis onto another axis.

e) Oscillographics shall be displayed with the ability to scale the magnitude-axis as well as the time-axis.

f) Oscillographics shall be displayed with the ability to select only certain channels for a configuration operation, while other channels are left unchanged.

g) Oscillographics shall be displayed with the ability to move the time origin of one (or a selection of multiple) axis with respect to the remaining axes.

h) Oscillographics shall be displayed with the ability to import channels from other records or incidents, whether they are at the same time, date, recorder substation or not.

3.7.3 Fault location

a) The DFR software shall have the functionality to determine the distance to fault by means of travelling waves (preferred) or impedance based fault location (single-ended and double-ended).

b) The fault locator shall calculate from the analog information, the location of the fault in km.

c) The distance to fault in km shall be displayed with the fault record in the fault record display.

d) The distance to fault location shall not be adversely affected for series compensated line applications.

3.7.3.1 Traveling wave fault locator (preferred)

a) The traveling wave locator shall be able to use the transients generated by either the fault or the line circuit breaker to locate phase-to-ground and phase-phase faults.

b) It shall locate phase-to-phase and phase-to-ground faults irrespective of the value of the fault resistance.

c) The traveling wave fault locator shall be applied to lines of any length, including sections of overhead lines, parallel circuits and series capacitors.

d) The traveling wave locator shall use the current transformer transients to determine the distance to fault.

3.7.3.2 Impedance based fault locator

a) The software shall have the ability to use double-ended fault recordings to calculate fault location. This shall compensate for common mode variables such as ground resistance, line inductance and capacitance between phases and phase to ground that varies with season and weather.

b) If fault recordings from both ends are not available, single-ended fault location shall also be possible.

3.7.3.3 Algorithms

a) An algorithm should be available for use on series compensated lines.

b) An algorithm using the data from both ends of a line is to be included to minimise common mode errors and seasonal changes in line parameters.

c) The use of multiple algorithms to cater for individual algorithm shortcomings is to be provided as an option (adaptive calculation).

d) Fault type identification and possible causes to be included as in: “high resistance fault: veldt fire, rocky area or high tower foot resistance.” or “lightning, insulator failure, conductor failure or tree”.

e) It shall handle multi-segmented line parameters (more than two).

f) It shall be independent of source impedance (be adaptive to system changes).

g) It shall recognise inter system faults (e.g. between 400 kV and 132 kV lines).

h) It shall consider transposed lines.

i) It shall consider mutual inductance on dual circuit line structures (lines in and out of service).

j) Provision should be made for feedback of actual fault position in order to calculate future faults more accurately (neural network analysis).

3.7.4 Data Exchange

3.7.4.1 Setting file data exchange

a) The DFR settings application software shall provide an import/export facility that will allow settings data to be exchanged with a third-party settings management software database.

b) In particular, the supplier shall demonstrate the bidirectional exchange of DFR settings between the DFR software and a Microsoft Excel spreadsheet.

c) The file format shall be open source and made available to other software developers.

d) Acceptable formats for the data exchange are:

   i. *.xml file format with published style sheets;

   ii. ASCII text file;

   iii. Microsoft Excel file format; and

   iv. Comma Separated Variable (CSV) file format.

e) Any application-specific changes to the configuration shall be made via the DFR settings, and shall be implementable via the Excel settings export capability.

f) All settings and configuration files shall be uploaded to the DFR locally via the front port of the DFR as well as remotely via the rear Ethernet ports.

3.7.4.2 Fault recording data exchange

a) It shall be possible to export and import fault data from or to the DFR software in the COMTRADE formats as per IEEE STD C37.111 (both ASCII and binary files) as well as in the .xml file format.

b) It shall be able to import any type of COMTRADE format and convert it to a standard internal format with correct interpretation of all scaling factors.

c) The software shall also be able to set up templates for the arrangement of channels to be exported in the COMTRADE format.

d) All fault records shall be downloaded from the DFR locally via the front port of the DFR as well as the remotely via the rear Ethernet ports.

3.8 Scheme composition

The scheme solution shall comprise of DFR(s) and any auxiliary equipment required to fulfil all functions as specified in this document, including (but not limited to) the Ethernet switch (and fibre patch panels), MCBs, pushbuttons and indications. The DFR(s), MCBs (except for Isolating Switches and VT MCBs), indications and pushbuttons shall be located at the front of the panel. All the equipment shall have the capability to be mounted in a flush mount 19 inch rack system.

A 230V AC single socket shall be provided on the DFR panel and shall be supplied from the station 230V AC distribution supply.

3.8.1 DFR(s)

a) The scheme shall either have:

i. (multiples of) a ‘one-box’ type DFR solution where all the processing and control cards/units as well as analog and binary data input cards/units are integrated within a single device; or

ii. a modular type DFR solution where the entire DFR scheme has one common set of processing and control cards/units and where analog and binary data input cards/units can be added as separate modules to expand the number of bay-type combinations/groups that can be monitored.

b) The DFRs shall comply with 240-64685228 Generic Specification for Protective Intelligent Electronic Devices (IEDs).

3.8.2 Auxiliary Components

a) The auxiliary components shall comply with 240-62773019 Specification for low voltage electrical auxiliary components.

3.8.2.1 230V AC Supply MCB - MCB (AC) (10 Amp)

The 230V AC MCB provides for the protection and isolation of the 230V AC voltage (ON or OFF) to the Panel Not Healthy (PNH) indication. This indication (red) is located on the panel.

2 pole MCB (selection between OFF and ON)

OFF - Isolate the 230 VAC supply to the panel not healthy indication circuit; and,

ON - Apply the 230 VAC supply to the panel not healthy indication circuit.

3.8.2.2 Main 1 DC Isolating MCB – DCI (M1) (10 Amp)

This MCB provides for the protection and isolation of the main 1 DC voltage (ON or OFF) to the DFR scheme.

2 pole MCB (selection between OFF and ON)

OFF - Isolate the DC supply to the DFR scheme circuits; and,

ON - Apply the DC supply to the DFR scheme circuits.

3.8.2.3 Main 2 DC Isolating MCB – DCI (M2) (10 Amp)

This MCB provides for the protection and isolation of the main 2 DC voltage (ON or OFF) to the DFR scheme.

2 pole MCB (selection between OFF and ON)

OFF - Isolate the DC supply to the DFR scheme circuits; and,

ON - Apply the DC supply to the DFR scheme circuits.

3.8.2.4 DFR DC Isolating MCB – DCI (DFRn) (6 Amp)

This MCB provides for the protection and isolation of the DC voltage (ON or OFF) to each DFR. This MCB provides for the ability to isolate DC supply to any one DFR without affecting the availability of any one of the other DFRs or functions located within the same supply.

2 pole MCB (selection between OFF and ON)

OFF - Isolate the relevant DC supply to the DFR; and,

ON - Apply the relevant DC supply to the DFR.

3.8.2.5 DFR 24 VDC Isolating Switch – ISW (24VDC_DFRn) (6 Amp)

This shall only be required for legacy substations with hardwired binary inputs.

This isolating switch provides for the isolation of the 24 VDC wetting supply voltage (ON or OFF) to the binary circuits of the DFR. This isolating switch provides for the ability to isolate DC supply to any one DFR's binary circuits without affecting the binary circuits of any one of the other DFRs located within the same supply.

2 pole Isolating Switch (selection between OFF and ON)

OFF - Isolate the relevant 24V DC supply to the binary circuits of the DFR; and,

ON - Apply the relevant 24V DC supply to the binary circuits of the DFR.

3.8.2.6 VT Main - MCB (VT_DFRn) (2 Amp)

This MCB provides for the protection and isolation of the VT supply (ON or OFF) to each DFR. Three single phase MCBs are required: Line 1, Line 2 and Line 3.

2 pole MCB (selection between OFF and ON)

OFF - Isolate the VT supply to the DFR; and,

ON - Apply the VT supply to the DFR.

3.8.2.7 VT Synch - MCB (Sync_DFRn) (2 Amp)

This MCB provides for the protection and isolation of the Synchronising VT supply (ON or OFF) to each DFR.

2 pole MCB (selection between OFF and ON)

OFF - Isolate the connected busbar VT supply to the DFR; and,

ON - Apply the connected busbar VT supply to the DFR.

3.8.2.8 Ethernet Switch DC Isolating MCB - DCI (ETHSW) (6 Amp)

This MCB provides for the protection and isolation of the DC voltage (ON or OFF) to the Ethernet

Switch (ETHSW). The DC for the Ethernet switch is connected after the DFR system DC supply MCBs (DCI(M#)) and within the secure supply circuit and is therefore also dependent on the position of DCI(M1) and DCI(M2).

2 pole MCB (selection between OFF and ON)

OFF - Isolate the DC supply to the Ethernet switch; and,

ON - Apply the DC supply to the Ethernet switch.

3.8.2.9 DC-DC Convertor

This shall only be required for legacy substations with hardwired binary inputs.

The binary inputs to the DFR will be connected to dry contacts in the bay protection scheme. A wetting supply shall therefore be required to detect/pick up the operation of any of these contacts. A 110-220 VDC to 24 VDC DC-to-DC convertor shall be provided to supply binary inputs to the DFR.

3.8.3 Ethernet switches and communications architecture

The Ethernet switch and fibre patch panels shall not form part of this enquiry but will be free-issued to the successful tenderer of this enquiry.

a) The supplier shall make provision in the scheme/panel design for one 1Ux19 inch slot for the installation of a single Ethernet switch as well as two 1Ux19 inch slots for the installation of two fibre patch panels.

b) The supplier shall also make provision for the required cabling for the Ethernet switch.

c) The fibre optic cables between the DFR(s) and the Ethernet switch as well as the fibre optic cables between the fibre patch panels and the Ethernet switch shall form part of this enquiry.

d) All the DFRs within a specific scheme shall connect to the Ethernet switch in a star topology. The connections between the Ethernet switch and DFRs shall be multi-mode fibre.

e) The DFR's fibre connection requirements shall comply with 240-64685228 Generic Specification for protective Intelligent Electronic Devices (IEDs).

3.8.4 Equipment compliance

a) The solution(s) shall be manufactured using only equipment that is compliant with this standard and the relevant specified standards.

3.8.5 Serial, hardware and firmware version numbers

a) Each functional unit of each scheme (e.g. rack, sub-rack and auxiliary components) shall contain a unique, indelible and easily identifiable serial number and where applicable, the hardware and firmware version number.

b) A list of all items (with associated serial numbers, hardware version numbers and firmware version numbers) shall be provided with each production scheme.

c) The successful tenderer shall maintain a comprehensive record of all transactions involving serialised items.

3.9 Physical panel construction

3.9.1 Safety and regulatory requirements

No approval given or implied by Eskom shall relieve the supplier of any statutory obligations regarding safety.

3.9.2 Scheme housing and mounting

The required scheme shall comprise of (multiple) 'one-box' type DFR devices or a modular type DFR system housed in a single (or multiple) panel(s). The panel design shall be swing frame panels.

The swing frame schemes shall consist of a front panel module and a terminal back plate coupled by wiring tails. It shall be possible to mount the module(s) in an 800mm x 600mm x 2400mm (WxDxH) swing frame panel specified to 240-60725641 Specification for Standard (19 Inch) Equipment Cabinets. The depth of the front panel module shall be a maximum of 350 mm. Tails shall be made long enough to allow free movement of the swing frame (door). Easy access shall be provided to the back of all DFRs. No plug-in system (except for the connector terminal rails provided on DFRs and auxiliary components) will be allowed.

3.9.3 Panel design

Where the module fills a complete panel (more than half) then the full panel is considered a scheme, whereas if the module fills less than half of a panel it shall be considered for modular design. A module should be easily transportable and shall be designed to be easily removed.

Where the module is constructed in a box-form, the rear of the module shall be open to ease access to the internal components and to improve heat dissipation.

Rack mountable DFRs shall be firmly attached to the chassis of the front panel module, independently of the 19 inch rack securing bolts. The DFR shall be positioned at an acceptable working height, but not lower than 500mm off ground level.

The A.C and main D.C. isolation MCBs (except for those for isolation of the 24 VDC wetting supply and VT and Synchronisation supply) shall be located at the front of the panel/module. The MCBs shall be fitted in the following order: MCB(AC), DCI(M1), DCI(M2), DCI(ETHSW), DCI(DFR1), DCI(DFR2), etc. The 24 VDC Isolating Switches (ISW(24VDC_DFRn)) and MCBs for VT (MCB(VT_DFRn) & Synchronisation (MCB(Sync_DFRn)) supply for each DFR shall be located on the terminal plates at the rear of the panel.

The supplier shall make provision in the scheme/panel design for one 1Ux19 inch slot for the installation of a single Ethernet switch as well as two 1Ux19 inch slots for the installation of two fibre patch panels. The supplier shall also make provision for the required cabling for the Ethernet switch.

The design of a scheme shall be such that, when fitted in a swing frame panel to 240-60725641 Specification for Standard (19 Inch) Equipment Cabinets with all doors closed and covers in place and with all internal equipment correctly mounted and fully operational, the temperature rise at any free air point shall not exceed 10°C. Forced cooling shall not be used.

The front of the panels shall be compatible with a flush mount 19 inch rack system in accordance with IEC 60297-1. Nineteen inch (19") rack mounting hole arrangements shall be as per the IEC 60297-1. Only closed holes shall be permitted. The minimum thickness of the panel shall be as follow; face plate 3mm and side sheets 2mm.

The classification of enclosures shall be in accordance with SANS 60529. The minimum degree of protection provided shall be IP 41 for the front panel, and IP 1X for the rear of the module and back plate.

The channel base frame of each panel enclosure shall be drilled and fitted with holding down bolts to suit pockets to be provided by Eskom. The bolts shall be delivered with the panels. The gland plated shall be pre-drilled to make provision for the maximum possible cable entry with additional spare holes.

Suitable means of lifting shall be provided for.

3.9.4 Panel finishing

After fabrication is complete the metal surfaces shall be finished in accordance with Eskom Standard OPS 2366/11- 3 Corrosion Protection Specification. The paint colour of the interior and exterior of the housing shall be to SANS 1091 colour code G29: Medium Grey. The base channels, base back plate and checker plate support angle shall be gloss black. The interior side plates and terminal back plate shall be smooth powder coated to SANS 1091 colour white.

3.9.5 Component mounting and fixing

Lock washers shall be used with all screwed fittings except where the use of self-locking nuts or fasteners, make their use unnecessary. Permanent fixings such as rivets shall only be used for fixed mechanical parts, and not for electrical or electronic components. Self-tapping screws shall not have sharp points and shall not be used for fixing items such as cover plates which may have to be removed and replaced.

Components shall be located, secured and disposed with respect to each other and the structural members so that they, together with all connecting wires, can be inspected, removed and replaced without damage to, or undue disturbance of, other parts of the equipment or wiring.

Components shall be mounted inside the scheme or module. Where mounted on the back plate, it is preferred that a dedicated rail be provided for this purpose. Components shall not be mounted on the back plate or on the side of the panel which shall be reserved for terminal blocks only.

3.9.6 Terminals

Terminals for connection to external circuits shall be to approval. Not more than two conductors shall be connected to any side of a terminal. Terminals shall be suitable for use with crimped or compression type terminations. Refer to document 240-70413291 (Terminal block specification).

A combination of terminals as given in clauses 3.3.2, 3.3.3 and 3.3.4 in document 240-70413291 Specification for Electrical Terminal Blocks shall be used. Further details in this regard shall be specified during the product development phase.

Terminals to which external cabling is to be connected (boundary terminals) shall be permanently and indelibly marked in an approved manner. Each terminal shall be clearly and unambiguously identifiable by suitable marking which is on or adjacent to it.

3.9.7 Terminal strips

The terminal strips shall be legibly numbered: X1, X2, etc. To improve visibility, the label shall be placed on the right side of each terminal strip for the swing frame panels The terminal strips shall be positioned horizontally top to bottom on the back plate of the swing frame panels: X1, X2, etc.

The design shall cater for the termination for all used cores within a common cable on one terminal strip only. Terminal strip functionality shall be divided according to the following table:

Terminal Strip number	Functionality (in recommended order)
X1	Power and control terminals: • DC supply per DFR; • Binary outputs (e.g. alarms) • Time synchronization • Etc.
X2	CT and VT input terminals MCB(VT_DFRn) MCB(Sync_DFRn)
X3	Binary input terminals ISW(24VDC_DFRn)
X14	Main Power Supplies: • DC supply • AC supply DC-DC convertor

3.9.8 Wiring trunking

Wiring trunking shall be horizontal. Each trunking shall be fitted with a cover of insulating material. These covers shall be designed so that they can be fixed in position, and removed without the use of tools. Trunking shall be adequately dimensioned to accommodate the maximum number of cables especially where the cables enter the trough.

For the swing frame panels, a horizontal plastic trunking strip shall be provided above and below each terminal strip to accommodate wiring. Where space permits, the wiring for the top and bottom or left and right of each terminal strip shall be accommodated in separate trunking strips of minimum dimensions 60mm (h) x 25mm (w). This means that double rows of trunking will be provided between all terminal strips.

Where there is insufficient space on the terminal back plate or terminal rear side to accommodate double rows of trunking, a single trunking strip of minimum dimensions of 60mm (h) x 40mm (w) may be provided between terminal strips.

Trunking shall be of the ‘fine’ tooth type (tooth width 6.1 mm as opposed to 12.0 mm).

In order to facilitate easy access to all terminals and wires, a minimum gap of 30mm shall be provided between trunking and the top and bottom of the terminal blocks. To further improve accessibility, the terminal attachment rail may be mounted on posts or an angle iron such that the rail is raised from the back plate by 70mm. The number of terminal strips required will depend on the terminal requirements per individual scheme.

Proprietary brands of PVC or equivalent material trunking shall be used, but regardless of the type of construction, the design and sizing of the trunking with cover shall be subject to Eskom approval before manufacture commences.

3.9.9 Wiring supports

Vertical lacing supports of non-magnetic material shall be provided for securing cable tails. Joints or splices in any wiring are not acceptable. Any support for wiring must be of a non-conductive material. Vertical lacing supports of non-magnetic material shall be provided for securing cable tails. Wiring and cabling shall be adequately supported and clamped. Where wiring is routed from the inside of a panel to a panel door, its’ wiring shall be routed through a protective wiring sock. Grommets or bushes shall be used where wires or cables pass through metalwork. Wiring and cabling shall be routed such that its insulation is not subject to injurious temperatures or stresses.

In the case of horizontal terminal rows the panel wiring shall be connected to the lower side of the terminals and the cables shall be connected to the upper side.

3.9.10 Wiring terminations

The selection of specific terminal block types for application in a scheme shall take cognisance of the typical wire size to be applied at the scheme interface.

The terminals of all DFRs and other panel components shall be readily accessible when the panel is fully wired. Any difficulties experienced, either with layouts or terminal accessibility shall be referred to Eskom prior to the commencement of the wiring.

Not more than two conductors shall be connected to any side of a terminal and where two conductors are connected to a terminal, care shall be taken to ensure that lugs and ferrules are fitted to the conductors so as to allow the wires to approach the terminal as near parallel as possible.

The stripping of insulation shall be carried out so that no damage to conductors occurs. Any nicked wiring will be rejected. The stripping tools used shall be of the type which permits the length of strip to be pre-set.

All wires and cables less than 6 mm² in the panel shall be terminated with pre-insulated crimped connectors of approved types. Other types of lug which are to Eskom's approval may be considered.

Schemes shall include at least two spares of each terminal block type used.

The scheme back plate shall include horizontal terminal strips for the swing frame panels.

For the swing frame panels with horizontal terminal strips, internal scheme wiring to terminal strips on the terminal back plate shall be connected to the lower side of the terminals and the cables shall be connected to the upper side.

Wiring terminations shall be of such a length and executed in such a manner that the conductors are not subject to injurious tensile stresses or flexing which might cause fatigue failure, whether as a result of vibration or otherwise.

All terminations shall be made with the tool recommended by the manufacturer of the lugs. Crimping tools shall be of the type which will not release the termination during normal operation until the crimp has been correctly formed. A double die crimping tool shall be used in order to affect both the lug and insulation support crimp simultaneously.

All wires and cables larger than 6 mm² shall be terminated with an approved lug. The lug shall be crimped with a hydraulically actuated hexagonal die tool as recommended by the manufacturer of the lug.

There shall be no bare wire exposed between a lug and the insulation of the wire to which it is crimped.

All tools used shall be regularly inspected and tested with approved gauges, and maintained or repaired as necessary. Tools shall be inspected and tested initially at weekly intervals, but this period may be extended in the light of experience. A log of inspections shall be maintained for Eskom's inspection.

The lugs selected shall be the correct barrel size for the size of wire or cable with which they are to be used, and the dimensions of the tongue shall match the stud, screw or aperture of the terminal to which they will be connected.

A sample of each type of lug, wire, tool and finished connection if not previously approved shall be submitted to Eskom for approval before wiring is commenced.

The size, current and voltage rating shall match the wire and cable used.

3.9.11 Wiring identification

Wiring leads connected to the boundary terminals shall be permanently marked with an approved type of marking device, with black letters impressed on a white background or black letters on a yellow background provided that the colour selected is consistent throughout the panel and/or suite of panels and is to Eskom's approval.

Interlocking slip-on types of ferrules or one piece ferrules may be used and shall match the size of wire onto which they will be fitted.

For heavy conductors and very light telephone type wiring where the preferred type of marking ferrule is not available, other methods will be subject to Eskom's prior approval.

All wiring shall be identified using numbers, at each end, following the alphanumeric wire identification conventions stated in the generic equipment standard for wiring, wire marking and cable numbering, Unique Identifier 240-64636794.

3.9.12 Wiring sizing and practices

The wiring sizing and practices shall be as per the wiring standard 240-64636794.

The overload rating of the scheme/module wiring shall be higher than the protected MCB rating.

3.9.13 Earthing

All earthing shall be done in accordance with the Standard for Earthing of Protection Equipment, Unique Identifier 240-64100247.

3.9.14 Labelling

All labelling shall be done in accordance with the Standard for Panel Labelling, Unique Identifier 240-62629353.

3.9.15 Packaging for transport

The schemes/panels/modules shall be securely packed before transporting by road to site or store, as specified per batch order. If the supplier is required to deliver and off-load, he must ensure that he uses transport with proper off-loading facilities.

The supplier shall pack the schemes/panels/modules in a manner that is designed to prevent damage or deterioration during transit to the final destination.

The supplier shall pack the schemes/panels/modules taking account of rough handling, exposure to extreme temperatures, salt, precipitation during transit, open storage, the final destination and the absence of heavy handling facilities at certain points in transit or on arrival.

Acceptance of the schemes/panels/modules or any other equipment by the Eskom representative at the time of delivery is also subject to inspection by the Eskom representative for loss and damage. Unless instructed otherwise by the Eskom representative, the supplier shall promptly replaces loss of and repairs damage to the schemes/panels/modules arising from the inspection.

4. Tests

The applicable type and routine tests required by Eskom shall constitute the type and routine tests acceptable on all devices, DFRs and the complete fault recorder scheme/module. The successful tenderer(s) are responsible for the implementation of the required tests and the production of the necessary report documentation. The successful tenderer(s) shall compile a detailed test plan, and shall be agreed between the supplier and the Eskom representative prior to the commencement of any of the required tests. It shall be noted that an Eskom representative shall witness all of the tests.

4.1 Prototype Tests

The purchaser's engineers will carry out type and functional tests once the prototype scheme is completed.

4.1.1 Environmental Testing

Type tests shall be carried out by the successful tenderers (possibly with the involvement of a third party test organisation) and shall be witnessed by Eskom's representative. These tests may be destructive in nature and as such, any product or device, which has undergone any of these tests, shall not be used in any production scheme.

Unless specified to the contrary, type testing shall consist of performing the required tests on at least one sample of the design. Tests shall be performed on equipment which has not been the subject of previous type testing or, at Eskom's discretion on equipment which has been the subject of any modification which could affect the performance of the equipment.

Normal performance tests shall be performed before any type tests for comparison to determine damage.

Subject to Eskom's approval, evidence of equivalent tests performed on substantially similar equipment may be accepted provided that the test results are available in the form of a fully detailed certified test report.

When relevant, a check shall be made before the commencement of type testing, to ascertain that the equipment as supplied, inspected and adjusted from the production line, is correctly set up. Any differences found between the equipment as supplied and as required by its standard shall be recorded. The measurements taken to establish this shall also be recorded.

If during testing any further adjustments are required, such adjustment shall only be made with Eskom's approval and repetition of some of the previous tests may be required.

The supplier shall submit a detailed schedule of the proposed tests for approval before the commencement of the tests. This schedule shall be complete and include the following information:

- Date and place of test;
    - Details of the equipment to be tested, such as standard, type and serial numbers, contract reference and all relevant drawings and documentation;
    - A list of all test equipment which may be used, and performance standards of each test equipment listed, clearly showing that the stability, resolution, accuracy range, capacity, etc. ratings of the chosen equipment are more than adequate for the test performance requirement. When such information is not known, for instance when test equipment has to be specially manufactured, it shall be demonstrated that such equipment performs in the way intended so that its use is acceptable to those witnessing the tests;
- Details of usage and test equipment and the test methods, together with the connection diagrams and other related data;
- Description of measurements and observations to be made together with their intended number, frequency, sequence and time duration for each test; and,
- Documentation to be used for the recording of all results of testing and also the format of the certifying test documents.

If during the tests any failure occurs, any adjustments are made, or the equipment design is changed, Eskom shall be informed and may require the previous tests to be carried out again.

Where equipment is designed to be connected to other equipment at remote sites where different environmental conditions such as temperature and supply voltage can prevail, tests may be required to demonstrate that these differences do not adversely affect the compatibility of the equipment.

4.1.1.1 Insulation resistance (across isolating barrier) test

When a barrier is used to provide isolation from external circuits, its insulation resistance shall be measured. If the barrier is required to withstand high voltage stresses, then it shall be stressed at the specified voltage to demonstrate its withstand capability and a further insulation resistance test shall be made to ascertain that it has not been significantly degraded as a result of the stress being applied. The tests shall be performed in accordance with IEC 60255-5. Test details are given below.

The insulation of all circuits which include contacts of switches, DFRs or contactors for isolation functions shall be tested for insulation resistance. This shall be not less than 20 MΩ when measured at DC 500 V.

For circuits intended for connection to AC 100 V or DC 100 V and above, 2 kV RMS shall be applied for 1 min and this shall be followed by a further insulation resistance test.

For circuits intended to provide isolation against large differences in earth potential as in class IV electrical environment, the barrier shall, after the initial resistance measurement, be stressed to the design voltage and this shall be followed by a further insulation resistance test.

NOTES:

a) Resistance measured at a potential of DC 500 V applied across the isolating barrier.

- R = R1 > 20 MΩ

b) For switches, DFRs and contactors 500 V is to be applied between

- The opposite ends of each circuit with contacts in open position.
- Both ends of each circuit to earth with contacts in closed position.

c) Circuits intended for connection to 100 V (AC or DC) and above to be stressed to AC 2 kV for 1 min after initial resistance measurements. Stress to be applied between:

- The individual circuits of this type
- Each circuit of this type and all other circuits including earth. These other circuits can be strapped together electrically for the purpose of this test.

d) Final insulation resistance shall be such that

- R = R2 > 20 MΩ; or,
- R2/R1 > 0,7.

e) Barriers to provide protection against large rises in earth potentials to be stressed across barrier at design voltage for 1 min after initial isolation resistance measurement. Final insulation resistance test as above.

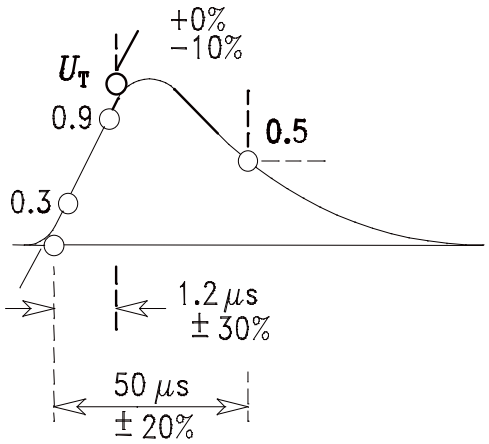
4.1.1.2 Electrical impulse test 1, 2/50 μs

This test is to demonstrate that the equipment has been correctly designed to withstand, without damage, the electrical stresses to which it might be subjected in practice.

The test to be applied is based upon IEC 60255-5. The impulse wave form is an aperiodic transient voltage without appreciable oscillations having a 1,2 μs rise time and an exponential decay to half amplitude in 50 μs.

When a large number of identical interface circuits are used, this test may be restricted to a representative sample, the proportion being to Eskom's approval.

A suggested circuit for the production and application of the test waveform is given in IEC 60255-5.



NOTES:

a) Source energy 1/2 joule for 1,0 kV to 5,0 kV.

b) Source energy 1/8 joule for 0,5 kV.

c) Source energy 1/12 joule for 0,25 kV.

d) Source impedance 500 Ω.

No less than 3 positive and 3 negative pulses each applied at intervals of not less than 5 s.

Application Method	Test voltage 'V' (kV)		
	Class II	Class III	Class IV
a)	-	1,0	5,0
b)	-	1,0	5,0
c)	0,25	0,5	1,0
d)	1,0	1,0	1,0

NOTES

Method of application - Test voltage 'V' shall be applied between:

a) Each terminal and the safety earth (common mode).

Note: Where practicable all terminals may be connected together.

b) Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

c) Signal terminals of the same circuit (series mode).

d) Power supply terminals of battery powered equipment (external supply) (series mode).

Note: A terminal is defined as any connection to or from the equipment including those to power supplies.

4.1.2 Functional Testing

The purchaser's engineers will carry out functional tests to verify the scheme wiring, DFR configurations and overall scheme functionality. These tests shall be performed on the deemed prototype scheme, devices and shall include, but not be limited to, the following:

- Secondary injection tests to prove correct functional operation and to check the functional accuracy and calibration of the units; and,
- Type testing of scheme and devices.

Any specific test which shall prove, to the purchaser's satisfaction, the required performance aspects of the fault recorder scheme and devices which may be impacted by minor equipment modifications, refinements or development work.

The supplier(s) shall develop and verify the required test routine prior completion of the proto-type testing. The test routine shall be for the test equipment being utilised by Eskom.

4.1.2.1 Initial visual inspection

The initial visual inspection shall be performed to ensure that the equipment is of sound construction and, so far as can be ascertained, meets the requirements of this standard, schedule A of the enquiry document and the offered equipment within the tender submission documentation.

4.1.2.2 Initial performance test

The initial performance test shall be carried out on the completed proto-type scheme and prior any type testing and shall consist of a comprehensive series of measurements of the characteristics of the equipment to demonstrate that its performance is in accordance with its functional requirements, including the detailed requirements of schedule A of the enquiry document and with this standard. This test shall normally be performed at an ambient temperature of 20 °C ± 5 °C while supplied at 120% of the normal DC voltage.

4.1.2.3 Final performance test

The final performance test shall be carried out after completion of type testing and shall consist of a comprehensive series of measurements and observations of the characteristics and performance of the equipment to demonstrate that no unacceptable deterioration has occurred as a result of previous tests. The test shall normally be performed at an ambient temperature of 20 °C ± 5 °C. The equipment shall be tested while supplied at normal supply voltages and subsequently with worst case combinations of supply voltages (80% and 120% nominal DC voltage).

4.1.2.4 Final visual inspection

The final visual inspection shall be performed to check whether any damage exists or deterioration has occurred as a result of any of the previous tests or activities. Eskom will determine the action which is necessary as a result of any findings of the inspection, which shall be made known as soon as possible.

4.2 Testing Of Production Schemes

4.2.1 Routine Testing

The successful tenderers shall, in conjunction with the purchaser, compile the required routine tests. These tests constitute the minimum routine tests acceptable on all devices, DFRs and the complete fault recorder scheme. The successful tenderers are responsible for the production of the routine test report. The successful tenderers shall compile a detailed functional test report template for approval by Eskom's representative. These tests shall be done on each production unit and produced during QA inspection. The required tests can be modified by the Eskom representative, if deemed necessary; to ensure that only the required site tests are outstanding prior delivery to site.

Routine testing shall comprise a series of tests to confirm that individual production equipment has been correctly manufactured and set up. The quality assurance shall be subject to Eskom's approval and Eskom reserves the right to witness any or all of the tests. An inspection of manufacturing processes such as plating, encapsulation, welding, etc., and separate checks and proof of adequate quality control may be required.

The details of routine testing shall be agreed between the supplier and Eskom prior to the commencement of manufacture of the equipment concerned. If the production equipment differs in any respect from the equipment upon which the type testing was performed, Eskom shall be informed and may require a repetition of those tests which might have been made invalid by the changes in the design of the equipment.

The successful tenderers shall, in conjunction with the purchaser, compile a test certificate, indicating clearly the successful completion of all the required routine factory tests. As part of the QA requirements, a copy of the completed certificate shall accompany each production unit.

4.2.1.1 Visual inspection

The visual inspection shall be performed to ensure that equipment complies with the requirements of this standard and the approved bill of material (equipment type and versions), and the equipment is properly installed.

Eskom will determine the action necessary as a result of any adverse finding of the inspection, which shall be made known as soon as possible.

4.2.1.2 Performance test

This test shall be performed to check that the equipment is capable of performing all its specified functions and is still within calibration. The calculated site specific settings shall be applied and tested (with test routine).

4.2.2 Site testing

Where site testing related to interfacing is required, it shall be performed unless otherwise approved, with the equipment correctly installed in its final location.

4.2.2.1 Visual inspection

Inspections will be performed by Eskom to establish that the equipment has been delivered to site and installed correctly and without damage. Such inspections shall be called for by the installation contractor before another contractor is allowed access to the equipment. This practice shall be enforced whenever two or more contractors require access to equipment to carry out their contract work.

4.2.2.2 Performance test

The performance test shall be done with the equipment fully installed and supplied from the specified sources and correctly interfaced with all its associated plant and equipment. It shall be established that all associated plant and equipment has undergone separate tests before conducting the final system tests.

The following sequence is required as it ensures the availability of specific functions at appropriate times:

- Deliver, erect and install scheme at substation;
- Cable contractor installs and terminates all cabling as per application drawings. For refurbishment projects the cable termination's must be coordinated with outage of existing scheme;
- Verify all scheme and external cable wiring as per application drawings and energise external power supplies to scheme;
- Verify and commission all interfaces to the primary equipment and to other scheme/modules, this includes GOOSE data verification (if applicable).
- Complete commissioning tests for fault recording equipment, apply and verify all subsequent setting changes. Protection personnel that are trained on the applicable equipment items must conduct these tests;
- Verify and commission all interfaces between the various disciplines. These tests will be conducted jointly by protection, telecommunications, measurements and control personnel that are trained on the applicable equipment;
- Verify and commission with higher level devices. Personnel that are trained on the SCADA equipment must conduct these tests. All measurement quantities, plant status, scheme/module selections, alarms and controls shall be tested to all clients;
- End-end verification of binary and analogue quantities; and,
- On energising of the relevant DFR scheme equipment, final commissioning and on-load checks must be conducted by the various responsible personnel.

4.2.3 Test Template

The supplier(s) shall develop and verify the required test template(s) prior to completion of the proto-type testing. The test routine shall be for the test equipment being utilised by Eskom.

The test routine shall be designed for use by the commissioning and maintenance staff with minimal experience.

The tenderer shall ensure that regular and suitable training and transfer of knowledge is available for the usage of this test template, on the functioning of each of the DFR functions and on how such functions need to be tested to yield the desired response.

The test template shall operate and be made available for test equipment hardware and software platforms commonly used within Eskom Transmission.

The test template shall make provision for a full 'commissioning' test (where all enabled functions are tested thoroughly) as well as a scaled down 'routine maintenance' test, where the user can manually select which functions he would like to test.

The DFR settings shall be imported automatically from the settings database and/or settings template into the test template without any user interaction. Note that the settings shall not be downloaded from the DFR and then be dumped into the test template. Also no manual typing in of settings or any other form of manual interference is permissible while the settings are imported into the test template.

The test template shall be interactive and prompt the user with specific and complete instructions (e.g. 'Connect binary input 1 to DFR panel terminal X3.1') whenever any action needs to be taken by the user, any wiring changes need to be made to the test set up. The test template shall be non-intrusive, no settings changes or disabling/enabling of functions shall be permitted. The test execution shall be paused for any such user interaction, and the user must acknowledge having completed such instruction (e.g. click on 'OK' or 'Continue') before the test template shall continue execution.

If a function is disabled (not-used) in the DFR via settings, the test template shall automatically disable all the tests associated with such a function.

When printing a test report, only the enabled test modules shall be printed.

All IEC61850-enabled DFRs shall be tested by the use of IEC 61850 GOOSE messages. The test template shall make use of a 'TEST' GOOSE to 'trigger' for a specific test, i.e. the feedback from the DFR to stop injection. The purpose of testing is that for each DFR function the settings associated with this function needs to be 'checked' with a test starting from 10% below and moving towards 10% above the setting, i.e. to confirm that the settings have been entered and downloaded correctly to the DFR.

The test report shall provide a summary of the number of test modules, number of test modules tested, number of passed tests, number of failed tests, and number of tests with errors (e.g. no connection to test set / manual assessment).

5. Tender Requirements

5.1 Tender Completion Requirements

The tenderers are to take cognisance of the following:

- An incomplete tender submission will be deemed as non-compliant.
- An alternative offer shall only be considered if the main offer is compliant.
- Technical schedule A: The Purchaser's Requirements.
- Technical schedule B: Guarantees and Technical Particulars (to be completed by tenderers).
- The tenderers shall not change the content of this document.
- The tenderers shall clearly, for each clause that requires a statement of compliance in the A/B schedules, respond by either stating "Comply" or "Do not Comply" and state deviation details.
- If a clause in the A/B schedule requires a statement of compliance and additional information, the tenderers shall state clearly "Comply" and shall provide detail information or state "Do not Comply" and shall provide detail information.
- If a clause in the A/B schedule requires information only, the tenderers shall provide the necessary information.
- All additional options shall be detailed.

5.2 Tender Evaluation Criteria

The tender evaluation will take the form of a:

- Desktop review of submitted documentation (A/B schedules); and,
- Hands-on demonstration of the offered products by the vendors. The hands-on demonstration will include, but not be limited to:
  - All DFRs offered are successfully demonstrated to meet Eskom's minimum IEC 61850 function and interoperability requirements (as per the Eskom standard); and,
  - The DFR interface software user friendly and operates on Eskom-standard laptop computers (Windows XP, Windows 7 and Windows 8), and all IEDs are demonstrated to be accessible via such a computers/software to upload, download and compare settings and configuration files and to retrieve fault records (COMTRADE export capability).

5.3 Product Development Process

The project shall comprise two phases; an engineering/development phase and a production phase. The purchaser will sign a development contracts for the engineering/development phase with the successful vendors. The engineering/development phase ends with the awarding of production contracts for the required scheme solutions and spare items. Vendors who have been awarded development contracts shall be accountable for producing deliverables according to the project schedule.

The product development phase is the detailed engineering phase in which:

- Proto-type scheme design diagrams, based on Eskom's design standards and formats, is finalised;
- Proto-type scheme is developed and built;
  - The prototype scheme is tested for compliance against this standard document;
- Type testing requirements verified and done (if so required);
- DFR configurations finalised and verified;
- DFR Eskom default settings and settings templates are finalised;
- IEC61850 configuration finalised and verified;
- Scheme permutations and complete list of scheme spares including pricing finalised;
- Specialised training; and,
- The technical and SHEQ documentation is finalised and approved by the purchaser.

All relevant information regarding the configuration/marshalling of the DFRs shall be supplied to the purchaser one month after contract award. The purchaser reserves the right to call for further information at any time during the development of the prototype scheme.

The purchaser will be an active participant during this phase. The purchaser has the option to either purchase the proto-type scheme or the first production unit.

5.3.1 Proto-Type Scheme Design Diagrams

During the initial part of the engineering development phase, only drawings shall be produced and no panel manufacturing shall take place. The tenderers shall provide in-depth details of their equipment's interfaces with applicable substation equipment, for the purpose of producing the prototype drawings. The drawings shall be produced on the purchaser's CAD system, using standard drawing symbols and standard layouts. Thereafter, preliminary drawings will be supplied bearing the label "PROTOTYPE". Only drawings so sourced, and bearing the prototype label will be regarded as valid. The purchaser shall assume overall responsibility for the production of scheme drawings.

The prototype design freeze follows the approval, by the responsible Eskom representative, of the prototype drawings as per the development program. The approval of the drawings shall take place before the scheduled design freeze date.

The purchaser shall be an active participant during the product development phase. During this phase, the scheme design shall be completed, the documentation and drawings shall be finalised and approved, all type testing and functional testing shall be completed to the purchaser's approval, the specialised training requirements shall be fulfilled and the first production unit (prototype scheme – including primary plant simulator) shall be completed. The prototype scheme shall consist of the following main devices:

- DFR(s);
- Ethernet switch (free-issued).

The successful tenderers shall, within one month of contract award, supply the purchaser with a set of comprehensive equipment documentation, setting guidelines and the operating/analysis software. Each device shall be equipped with the hardware and firmware version that will be supplied during the production phase. The operating and analysis software version shall be the version that will be required to communicate with the production phase devices.

5.3.2 Proto-Type Scheme Development and Built

The first production scheme, as determined by the purchaser, shall constitute the prototype. The purchaser will determine the exact composition of the prototype.

Eskom technical staff will interact directly with the contracted vendors in the development of detailed designs, prototypes and associated tests. This is different to the tender stage where all correspondence with vendors is channelled via the purchaser's representative. Any correspondence relating to contract pricing will still be communicated with the vendor by the purchaser's representative.

The Eskom technical team will:

- Act as moderators between vendors, endeavouring to ensure that competing products are equally flexible and user friendly, thereby reducing the possibility of strong user preferences for one product over the other during the production phase of the contracts;
- Ensure that standard gaps identified during the product development stage are addressed. They will document such decisions for incorporation into a future revision of the standard;
- Compile a buyer's guide drawing for codification of items on SAP;
- Develop the buyer's guide drawing into a scheme ordering schedule;
- Convert the vendor's scheme Master drawings into the standard Eskom format, with application detail as applicable;
- Develop DFR-specific settings philosophies;
- Sign off all project deliverables including scheme manuals and procedures; and,
- Conduct and sign off all scheme prototype tests.

5.3.3 Design Freeze for the Production Phase

Once the product development phase is completed, a design freeze shall come into effect. No further changes shall be permitted to the scheme, the scheme components or the scheme drawings. Any changes subsequent to the design freeze, during the production phase, shall be formally submitted to the Eskom representative for approval (sign off). All changes shall be formally tracked.

5.3.4 Production Phase

During the production phase, the schemes are ordered, manufactured, tested, QA inspected, delivered, offloaded and erected in position at site.

The successful tenderers shall, in conjunction with the purchaser, compile a test plan with QA inspection holding points.

5.3.5 Production Scheme Delivery

The production schemes shall be delivered to site with:

- As build scheme diagrams;
- QA inspection report;
- All DFRs shall have the purchaser's (Eskom) default settings applied. The settings, as set by the supplier prior to shipment of the scheme, shall also be provided to the purchaser;
- All DFRs shall be fitted with the final DFR configuration;
- All DFRs shall have a CID file available for SCD configuration;
- All DFRs shall be configured with the IEC61850 SCD (where applicable);
- DFR project file that includes the Eskom default settings, configuration/marshalling and IEC61850 engineering (station final SCD file imported to the DFR and GOOSE receive signals configured),
- Configured free-issue Ethernet switch(s); and,
- Production unit routine test report.

5.4 Price Schedule Categories

The main scheme components (typically imported DFRs or custom components) shall be included as separate price schedule items in a product standard. Vendors shall tender spares prices against these items for inclusion in the overall evaluated price of the offer.

During the product development phase, the detail of these items (main and spare) shall be finalised for codification on SAP and will be available for order via the contract.

5.5 Engineering Fees and Provision of Prototypes

For products for which the vendors will be paid engineering fees and/or prototypes purchased, this will be done under a signed development contract. The vendor engineering fees shall include:

- Engineering services for the development of Eskom-specific intellectual property: master drawings, DFR configuration settings, documentation. These shall be quoted for as a number of hours per type of resource (Chief Engineer, Engineer, etc.) and stated hourly rates.
- Costs for advanced/expert engineering software for Eskom product custodians as recommended by the vendor for the development or management of the products.

Eskom will review the submissions from the vendors and shall propose a reasonable capped amount for vendor engineering fees to be used in the upcoming tender. This decision will take cognisance of historical development costs paid for similar commodities. Vendors may tender engineering fees at any amount up to the capped value. Should a vendor require additional engineering fees, these shall be re-couped by them via a component in the product pricing.

The following vendor expenses (where applicable) will be absorbed into the product pricing:

- Costs relating to the development of product production facilities.
- A corporate licence for DFR interface software meeting Eskom's minimum requirements.

Prototype schemes shall be purchased by Eskom at the tendered price of a production scheme (plus applicable optional items). The vendor will undertake any re-engineering of the prototype as may be required (at his cost) such that it has identical wiring and functionality of a production unit.

5.6 Warrantees, Spares and Support

5.6.1 Warrantees

The supplier shall provide a minimum of a 10 year warrantee on the DFRs provided in the scheme. The warranty shall include the repair of all failures due to latent defects (i.e. excluding failure due to mishandling or misuse of the equipment by Eskom or Eskom appointed representatives). Any charges associated with the repair/replacements and shipping of the defective equipment from the local supplier's office to and from the works of the overseas principal shall be for the supplier's expense.

The supplier of DFRs for fault recorder schemes shall undertake, in writing, to support each product for a minimum period of 15 years from the date of contract signature. Product support shall include services to repair or replace any damaged or failed DFR that falls outside the terms of the above-mentioned warrantee. Eskom shall be liable for all costs associated with these services. Replacement DFRs shall preferably be of the same type, model number and firmware as the failed DFR, but alternative products of substantially similar physical dimensions and terminal layouts offering the same or increased functionality shall be accepted in fulfilment of this requirement.

The supplier shall notify Eskom of the planned discontinuation of any DFR used in a current or previous national contract.

5.6.2 Spares

The supplier shall supply a comprehensive list of spares that shall, at minimum, include one of the DFRs used, as well as MCB's, switches, lamps, empty sub-racks and any consumable items. The supplier shall also include on the list of spares any other recommended spares necessary for the proper maintenance of the DFR scheme. The spares items shall be priced individually and the list shall include a description of the item, a reference number, the pricing details and the guaranteed delivery time. All spares shall be delivered in approved cases suitable for storing such parts over a period of 10 years without damage or deterioration.

Spare devices shall be available from the tenderers for a period of at least 10 years subsequent to the expiry of the contract. Spares shall be carried at the tenderers's local works according to the following amount of schemes in service:

Table 2: Spares requirements

Number of schemes in service	Available immediately (within 24 hours of order)	Additionally available on demand within 72 hours
1 to 20 schemes	1 spare of each device	A maximum of 2 spares of each device
21 schemes and more	2 spares of each device	A maximum of 3 spares of each device

The successful tenderers shall maintain an up-to-date register of at least three contact persons who may be contacted regarding spares. This information shall be communicated to the purchaser when any of the details contained therein are altered.

The purchaser shall annually audit the spares holding as per the requirements of this standard.

5.6.3 Repairs

The tenderers shall provide a schedule detailing the guaranteed turnaround time for the repair of faulty equipment. The turnaround time shall include any international transport and customs clearance times as applicable. If the turnaround times differ for different equipment, the schedule shall include these details. The tenderers shall also state the extent to which repairs can be effected at the tenderers' s local works, including the capability and equipment that the tenderers possesses in order to effect such repairs. The tenderers shall, for all repair work, inform the purchaser of the exact nature of the failure, how such failure was remedied and how these failures, and other similar failures, can be prevented. The solutions to the identified failures/deficiencies shall also be implemented to all the in-service and spare devices and shall be for the cost of the tenderers. The implementation will be governed by the availability of the devices due to power network constraints.

The tenderer shall ensure that there are local repair facilities available for first-line fault finding.

5.6.4 Support

The purchaser requires a maximum transfer of technology from the supplier's principals to enhance the local support capabilities. The tenderers shall indicate in his offer how he intends committing to this requirement.

The transfer of technology shall include, but not be limited to:

- Operating and analysis software;
- DFR functions (detailed description and explanations); and,
- Compilation of standard DFR (Eskom) templates that also include the IEC61850 engineering.

The vendor shall have at least more than one local skill with specialist knowledge. The specialist knowledge shall include but not be limited to the overall life cycle of the solutions, including:

- Ordering options;
- Configurations and settings; and,
- Commissioning and maintenance.

5.7 In-Service Experience Requirements

The tenderers shall provide details of their device's operating record and installation details with their offers. The tenderers shall also provide details on all offered IEDs, the firmware upgrades made in the past 3 years. The Purchaser will use DFR devices that satisfy the following conditions:

- Available 'off-the-shelf';
- Have a proven track record in terms of an acceptable in-service record on networks 132kV and less in utilities world-wide. The tenderers shall provide proof of track record by documentation and reference to buyers and/or utilities world-wide;
- Have a minimum in-service experience of 50 equipment-years, at time of tender closure, with at least 25 devices/DFRs having an in-service record of more than 6 months. This shall apply to the same or similar production unit version of device/DFR that the Purchaser would employ;
- The offered DFRs shall not be scheduled for discontinuation or major changes within the first 4 years of the production phase;
- The vendor shall notify Eskom well in advance regarding any discontinuation, major hardware and firmware changes of the offered DFRs;
- Successfully pass all functional testing; and,
- Successfully pass all specified environmental type tests.

Cumulative years of service are only based on an in-service period of identical hardware and firmware versions.

6. Documentation

6.1 Scheme Manual Requirements

The required documentation shall include a full description of the scheme including the detailed information/manuals on all scheme components and devices. Also required are the complete drawings for each of the scheme permutations. The scheme manual shall include the product configuration and a hard copy of the scheme drawings. All documentation called for shall be finalised and approved before the engineering/development phase ends and awarding of production contract phase.

The documentation shall be clear, concise and to the point. The supplier shall compile all documentation and a complete documentation set (printed and bounded and in electronic format *.doc(x)) shall be submitted to the purchaser on conclusion of the engineering/development phase.

The scheme manual shall have as a minimum the following chapters:

Chapter 1 General Description

1.1 Basic description of the scheme and devices

1.2 Intended area of application

1.3 Brief description of the digital fault recorder functions

1.4 Contract/agreement data

1.5 Device configuration (logic diagrams)

1.6 Drawing set (scheme)

Chapter 2 Mechanical Construction

2.1 Mechanical drawings

2.2 Construction details

Chapter 3 Controls, Indications and Test Facilities

3.1 List of controls and indications

3.2 Detailed description of functions

3.3 General operational data

3.4 Test facilities

Chapter 4 Digital Fault Recorder Functionality

4.1 Detailed description of DFR functions

4.2 Triggers

4.3 Scheme philosophy

4.4 Scheme logic

4.5 Application guidance

4.6 Burdens

4.7 Protocols

Chapter 12 Software and firmware

12.1 Hardware, firmware and software version control procedure

12.2 History of updates (Include ordering codes)

12.3 Upgrade procedure

12.4 Communication software

12.5 DFR to Data Communications Equipment protocol

Chapter 13 Peripheral Equipment

13.1 DFR to PC requirements (port, cable, etc.)

13.2 DFR to Data Communications Equipment requirements (port, cable, etc.)

13.3 PC requirements

6.2 Settings Guide

The settings guide shall include a comprehensive set of blank and example setting details to cover all user settable functions in the scheme and devices shall be provided. A list of the settings, as set by the supplier prior to shipment of the scheme, shall also be provided to the purchaser. The supplier shall provide the recommended setting limits to ensure that the required DFR performance is obtained. A list of settings (including the Eskom default settings) and settings guidelines shall be provided for all functional elements and shall indicate any setting limitation and any possible conflict with any other setting.

The settings guide (printed and bounded and in electronic format *.doc(x)) shall be finalised and submitted to the purchaser for approval before the engineering/development phase ends and awarding of production contract phase.

The supplier shall provide for each setting, the relevant criteria that determine how a setting should be set as well as the formulae required to calculate the setting.

6.3 Scheme Selection and Application Guide

The scheme selection and application guide shall include a complete description of the different scheme permutations and selection thereof for specific applications. The application section of the guide shall include a full description and the physical interfacing of the scheme with components external to the scheme (e.g. DC board, CTs, VTs, JB, substation automation, etc.).

The scheme selection and guide (printed and bounded and in electronic format *.doc(x)) shall be finalised, approved and submitted to the purchaser before the engineering/development phase ends and awarding of production contract phase.

6.4 Scheme Drawings

The scheme drawings shall be as per the drawing standard 6DR- #100. The supplier shall be accountable for the compilation of drawing for all scheme/module permutations.

6.5 Documentation Handover Requirements

The supplier shall be accountable, on completion of engineering/development phase to handover the

following documentation to the Eskom's responsible engineer. The documentation format shall be printed and bounded and in electronic format *.doc(x), vendor specific documentation shall be in Acrobat format.

- Scheme manual (section 6.1);
- Settings guide (section 6.2);

- Scheme selection and application guide (section 6.3);
- Scheme drawings in Microstation format (section 6.4);
- Factory acceptance testing report;
- Type test report;
- Scheme and spares lists for codification;
- Final PS5 price schedules; and,
- Equipment/DFR manuals.

7. Training

The tenderer shall include proposals for the training of Eskom personnel. The following item shall be quoted:

The local specialised training of selected Purchaser engineers (not more than 6) by an expert(s) from the tenderer's principal works. The price shall be quoted on a per week basis. Details of the specialised training will be negotiated during the development phase of the contract. The required training shall include, but not be limited to, an in-depth working knowledge of all devices and products (hardware, firmware and software functionality), the DFR operating and analysis software, setting and application, commissioning, maintenance and first-line fault finding.

The Grid staff training at the tenderer's local works. The price shall be quoted on a per week basis. Details of the training will be negotiated during the development phase of the contract. The required training shall include, but not be limited to, a working knowledge of all devices and products (hardware, firmware and software functionality), the DFR operating and analysis software, setting and application, commissioning, maintenance and first-line fault finding.

8. Authorization

This document has been seen and accepted by:

Name and surname	Designation
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9. Revisions

Date	Rev	Compiler	Remarks
Oct 2015	1	E.D.Thekkekottaram	New document. Specification for Transmission Digital Fault Recorder Schemes.

10. Development team

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

- Edward Hutcheons
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11. Acknowledgements

- Bongani Qwabe
- Thys Bower

Annex A – Price Schedule Items

(Normative)

The main scheme components (typically imported DFRs or custom components) shall be included as separate price schedule items in a product specification. Vendors shall tender spares prices against these items for inclusion in the overall evaluated price of the offer. During the product development phase, the detail of these items (main and spare) shall be finalised for codification on SAP and will be available for order via the contract.

The scheme/module permutations are detailed in this standard document. Listed are typical price schedule items, and the items shall be independently priced:

Item	Description
1.1	Scheme Engineering
1.1.1	Design
1.1.2	Development
1.1.3	Factory Acceptance Testing (refer to section 4.1.2)
1.1.4	Scheme Type Testing (refer to section 4.1.1)
1.2	Scheme Documentation
1.2.1	Settings guide (refer to section 6.2)
1.2.2	Scheme selection and application guide (refer to section 6.3)
1.2.3	Scheme manual (refer to section 6.1)
1.2.4	Test tools – test routine/template
1.3	Scheme/module permutations (independently priced) – Option A (as per section 3.1)
1.3.1	6DR-#100 (application for 1 x double busbar EHV/HV feeder – refer to Table 1 in section 3.5.2)
1.3.2	6DR-#100 (application for 1 x breaker-and-a-half EHV/HV feeder – refer to Table 1 in section 3.5.2)
1.3.3	6DR-#100 (application for 1 x double busbar transformer with auxiliary transformer – refer to Table 1 in section 3.5.2)
1.3.4	6DR-#100 (application for 1 x breaker-and-a-half transformer with auxiliary transformer – refer to Table 1 in section 3.5.2)
1.3.5	6DR-#100 (application for 1 x reactor – refer to Table 1 in section 3.5.2)
1.3.6	6DR-#100 (application for 1 x SVC – refer to Table 1 in section 3.5.2)
1.4	Scheme/module permutations (independently priced) – Option B (as per section 3.1)
1.4.1	6DR-#100 (application for 1 x double busbar EHV/HV feeder – refer to Table 1 in section 3.5.2)
1.4.2	6DR-#100 (application for 1 x breaker-and-a-half EHV/HV feeder – refer to Table 1 in section 3.5.2)
1.4.3	6DR-#100 (application for 1 x double busbar transformer with auxiliary transformer – refer to Table 1 in section 3.5.2)
1.4.4	6DR-#100 (application for 1 x breaker-and-a-half transformer with auxiliary transformer – refer to Table 1 in section 3.5.2)
1.4.5	6DR-#100 (application for 1 x reactor – refer to Table 1 in section 3.5.2)

Item	Description
1.4.6	6DR-#100 (application for 1 x SVC – refer to Table 1 in section 3.5.2)
1.4.7	Cost to upgrade from hardwired interfacing to IEC61850 interfacing on the DFR as per Option B in section 3.1 (include all costs involved e.g. hardware, firmware upgrade costs, etc.).
1.5	Scheme/module permutations (independently priced) – Option C (as per section 3.1)
1.5.1	6DR-#100 (application for 1 x double busbar EHV/HV feeder – refer to Table 1 in section 3.5.2)
1.5.2	6DR-#100 (application for 1 x breaker-and-a-half EHV/HV feeder – refer to Table 1 in section 3.5.2)
1.5.3	6DR-#100 (application for 1 x double busbar transformer with auxiliary transformer – refer to Table 1 in section 3.5.2)
1.5.4	6DR-#100 (application for 1 x breaker-and-a-half transformer with auxiliary transformer – refer to Table 1 in section 3.5.2)
1.5.5	6DR-#100 (application for 1 x reactor – refer to Table 1 in section 3.5.2)
1.5.6	6DR-#100 (application for 1 x SVC – refer to Table 1 in section 3.5.2)
1.6	Training
1.6.1	Specialised training per day (± 10 people)
1.6.2	Product training for grid staff per day (± 8 people)
1.7	Spares – list and independently priced

1) Design

Item 1 includes the following for the prototype and all other permutations:

- Panel Architecture,
- Scheme drawings,
- IEDs configuration,
- IEC 61850 bay engineering
- Process interface units engineering

This item further requires that the tenderer take the information which is given in the standard specification document for a specific portion of the scheme and implement it in hardware form, using specific protection products which are available to him.

The actual hardware of the prototypes shall be excluded from this price.

2) Development

Item 2 includes the following:

- Structural design for the prototype and all other permutations,
- Construction and building of the prototype scheme.

3) Test Tools

Eskom would like to be able to make use of already developed automated test software produced by relay test set manufacturers. Eskom has invested large sums of money in the Omicron and Megger range of test sets, it would therefore necessary for automated test procedures to be developed and implemented via these test sets. These test procedures shall be written in such a manner that would assist in the training of the field and testing personnel. The test templates shall be owned and managed by Eskom during production phase.

These templates and routines shall be verified during the product development phase. The test routine shall include the verification of all settable settings and input/outputs (binary and IEC 61850).

Annex B – Performance Questions

(Normative)

Tenderers are required to submit in writing, with their offer, answers to the following questions. Any technical documentation which might assist the answers must be provided. The answers to the questions will be taken into account in evaluating the offers. The performance questions, as applicable, shall be answered for each protection device offered. Actual performance to be stated and not general information on a product range, but specific to the offered product.

1) Is the offered DFR solution of a 'one-box' type or 'modular' type (see section 3.8.1)?

2) If 'one-box' type, what is the maximum number of bay-type combinations/groups (as per Table 1 in section 3.5.2) that can be monitored by a single DFR device? Give combinations of different bay-type combinations/groups.

3) If a 'modular' type DFR system is proposed, what is the maximum number of bay-type combinations/groups (as per Table 1 in section 3.5.2) that can be monitored by a complete scheme?

4) Is the offered DFR system expandable (i.e. can additional modules be added to the device/scheme to increase the number of bays being monitored)?

5) What is the maximum sampling rate available?

6) If multiple sampling rates are possible, are these fixed or adjustable (i.e. are these user selectable from within the device operating software)?

7) Can two different sampling rates be selected to operate simultaneously on each analog data input card/unit (see section 3.5.3)?

8) With reference to section 3.1, state whether Options A and B and/or Option C is offered for this enquiry.

9) If a DFR with hardwired binary input interfacing only is offered (i.e. for legacy substations as per Option B of section 3.1), how easy/complicated will it be to upgrade this DFR to be IEC61850 enabled such that GOOSE and MMS messages can be exchanged between the DFR and the IEC61850 station bus? Will this upgrade include just a card swop and firmware update or will it be more intrusive?

10) Is this DFR capable of handling/processing IEC61850 sampled measured values? If not, is this being considered/developed and how long will such development take (i.e. when do you expect to have a fully IEC61850 enabled device (in terms of both analog and digital signals) ready)?

11) What is the size of a fault file (in bytes) for a recording with 4 voltages, 4 currents and 32 binary inputs at a maximum sampling rate of 12 kHz?

12) List the different operating systems that the DFR operating and analysis software is compatible with.

13) Will any maintenance be required on the DFR? If so, give details of the required maintenance.

Annex C – Drawing Set

(Normative)

The following drawing set accompanies this specification:

Scheme Name: 6DR - #100

Drawing Reference: 0.52/30403

Number of Sheets: 11

This generic drawing is based on the existing digital fault recorder scheme used by Eskom with hardwired interfacing of both analog and binary inputs.