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SYSTEM MONITORING – FAULT RECORDING

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PURPOSE AND SCOPE

This document describes the functional and performance requirements for Users' equipment directly or indirectly connected to the National Electricity Transmission System. It applies to Users who are required to provide Fault Recording pursuant to the terms of the Bilateral Connection Agreement.

It is noted that such equipment is expected to be of benefit to both the Generator and TSO in helping to analyse system events and diagnose the root cause of transients that could otherwise affect the performance and safe operation of the grid or generator's facility.

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Equipment topologies other than those proposed in this specification are acceptable where such solutions can be demonstrated by the User to meet the overall functional and performance requirements specified herein. In particular, different monitoring and fault recording functions can be integrated into the same hardware, provided that the required data can be recorded and retained in line with the requirements specified for each data type.

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Whilst some requirements are essential to meet minimum legal standards others can be deviated from with mutual consent by all stakeholders and subject to the comments above. ~~This Specification defines National Grid's technical requirements for fault recording. Fault recording equipment is required to provide monitoring of system faults. This~~ Technical Specification (TS) ~~describes~~ defines

the functional and performance requirements for fault recording on National Grid's 400 kV, 275 kV and 132 kV transmission systems.

Common requirements for all System Monitoring are given in NGTS 3.24.68. Fault Recording is one of three functions specified.

This TS is dealing with one of the three system monitoring functions - fault recording which is for the benefit of protection functions. Other system monitoring functions include System Dynamic Monitoring (TS 3.24.70) and Plant Performance Monitoring (function within Substation Control Systems). The requirements are applicable for each individual feeder econnection between the User and the System.nd as specified within the Bay Specifications.

Where the fault recording function is integrated within another item of equipment, then this Specification shall form part of the overall Specification specification for the equipment hosting the fault recording function ie NGTS 3.24.68, System Monitor Common Requirements.

Where integrated Monitor is specified or standalone fault recording facility is supplied, fault recording function or facility shall comply with the requirements as specified in the main part of this TS.

See Appendix A at the end of this TS for fault recording integrated within protection. Where fault recording function is integrated within another item of equipment such as protection relays, then it shall comply with the requirements in Appendix A.

PART 1 – FUNCTIONAL AND PERFORMANCE REQUIREMENTS

1 FUNCTIONAL REQUIREMENTS

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1.1 Fault Recording Provision and Location

Where applicable, Ffault recording function in Integrated Monitoring (IM) or standalone fault recording facilities shall be supplied on every feeder/interconnector/connection end at 400 kV, 275 kV and 132 kV substationsunless otherwise agreed with NGET.

Note: Users are required to provide a fault recording facility at each connection point to the transmission system only. The exact locations shall be agreed in the Bilateral Connection Agreement (BCA). Fault recording is provided by the relevant asset owners.

Where fault recording function is integrated within protection, fault recording location shall be specified as per TS 3.24.07, in line with acceptable integration options provided (See Figure 2 and Appendix A).

~~The following shall apply:~~

- ~~Limited fault recording facilities for non-feeder circuit (e.g. Supergrid Transformer, Bus Section, Bus Coupler, etc.) shall be met by utilising the spare analogue and event channels provided within an adjacent feeder fault recording facility.~~

- ~~Where the number of non-feeder circuits at a substation exceeds the available spare channel capacity provided by the feeder fault recording facility, then a separate common fault recorder shall be supplied to provide the necessary analogue and event channels for the additional non-feeder circuits.~~

- ~~The fault recording equipment shall be provided with and set to the channel allocation and labelling guidance given in Figure 2 of this Specification (channel order may vary).~~

1.2 General

The fault recording system shall, when triggered, record at least the following signals in analogue form:

- Three-phase currents~~.~~
- ~~Residual current.~~
- Three-phase voltages~~.~~
-
- Active power
- Reactive power
- Frequency

In addition, where applicable (i.e. HVDC connections), DC current and voltage is to be recorded.

-

Optionally, ~~T~~the fault recording system ~~shall~~ ~~might~~may also record the following signals (event information) in digital form:

- ~~First and second m~~Main protection equipment outputs.
- Associated intertripping and signalling equipment outputs.
- Switchgear operation before, during and after system fault incidents.

Informative: Specific analogue and event channels ~~required~~ are shown in ~~TGN(E) 156 and~~ Figure 2 as ~~appropriate~~guidance.

~~A minimum of 8 analogue channels and 16 event channels per feeder circuit end is shall be required.~~

The fault recorder shall record all the analogue and optionally~~y~~ event data simultaneously with all channels relating to the same time reference.

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The fault record shall be stored in a non-volatile memory storage medium, for subsequent retrieval by means of a Personal Computer (PC).

The equipment shall be capable of retaining its selected parameterisation and settings when its auxiliary energising supply is removed and subsequently reinstated up to a year later.

Informative: It would be preferable not to have batteries as the provider of this memory retention. to have the

Informative: Ffault recording devices need to be powered via a UPS or other supply that would not be disrupted in the event of a de-energisation of the User's connection.

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Recorders shall be designed such that each primary circuit's records are easy to individually access, display on a PC screen, analyse and print.

1.3 Analogue Channels

The sampling frequency of analogue channels for fault recording purposes shall be at least 2 1 kHz and preferably 6 kHz or greater.

The analogue information measurements of the analogue channels shall shouldshall have an accuracy amplitude resolution of at least 1 in 6500040004 million. of 0.1% or better.

Informative: This could, for example, be achieved byThe amplitude resolution shall be as a minimum in line with the performance of a 16 12 bit analogue-to-digital converter.

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The RMS current measurement range shall should be user selectable offering at leasttypically selections for 10, 20, 40, 50 In. The range to be used shall be agreed with NGET but should at least offer ranges up to 30 In.

1.4 Event Channels (Optional)

The sampling frequency for the event channels shall preferably be the same as the analogue channels. However, where the sampling frequency is different, it shall not be less than 1kHz.

The event channels shall be capable of accepting either Normally Open (NO) or Normally Closed (NC) contacts.

1.5 Memory

The fault recordinger systemfunction shall have a non-volatile storage capacity of at least 100 consecutive fault triggered records per circuit.

When full, the oldest fault record in memory shall be overwritten by an incoming fault.

Informative: The fault recorder equipment itself may only have a capacity of, say, 30 records, provided the recording system automatically passes its records to a non-volatile storage system which will retain at least 100 fault records per circuit and can be interrogated as required by this TSSpecification.

Informative: The fault records shall consist of, as a minimum requirement, 100 ms of pre-trigger recording and 400 ms of post-trigger recording for both analogue and logic signals at a sampling frequency of 6 kHz for 8 analogue and 16 event channels.

1.61.5 Clock System

The fault recorder shall be provided with an internal clock to time tag each fault record.

The clock shall be provided with facilities for external time synchronisation at periodic intervals to a substation clock.

1.71.6 Triggering

1.7.11.6.1 Tripping Triggering - General

Means shall be provided to trigger the fault recorder manually, locally and remotely through the remote interrogation softwareas appropriate.

Only one fault record shall be generated for a persistent trigger condition.

Once the fault recorder has been triggered, it shall should not be primed to trigger a further recording until at least 80% of the recording time has elapsed.

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Where required, means shall be provided to select or de-select triggering from any analogue or event channel.

The inhibit facility shall provide clear indication that triggering has been inhibited.

Where applicable, the inhibit facility and shall preferably automatically re-enable the triggering after a selectable period of time as agreed with National Gride.g. 2 hours, 2 days etc.

1.7.21.6.2 Triggering from Analogue Channels

Analogue trigger and amplitude settings shall be in steps of not greater than 5% of the nominal maximum amplitude over the full scale range.

The quantities of the triggering voltage or current shall be proportional to the RMS value of the inputs and shall be agreed with NGET (refer to PST010 (RES)).

Each analogue channel shall be provided with the following independentsuitable selectable triggering facilities, as agreed with NGET:

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- Voltage and Current Threshold Triggering:

  Informative: Fault recorder triggering when the voltage falls or rises to a pre-set threshold or when the current rises to a pre-set threshold.

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- Voltage and Current Variation Triggering:

  Informative: Fault recorder triggering when the voltage falls or the current rises by a pre-set percentage of nominal maximum amplitude of recording in 1 cycle.

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Steps shall be taken to ensure that spurious triggering will not occur on voltage inputs when the primary voltage is already at or near zero.

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- Current Negative Phase Sequence Triggering.

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Either over-threshold triggering or positive variation triggering is acceptable.

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A or any other mechanism specified in the Bilateral contractConnection Agreement.

For example, fault recorder triggering when the system frequency fallils or rises to a pre-set threshold or the Rate of Change of Frequency (ROCOF) rises to a pre-set threshold.

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1.8 Distance to Fault Estimation

The fault recorder shall be provided with Distance to Fault (DTF) estimation facilities.

Where a single item of equipment serves both feeder circuits on a double circuit overhead line, the DTF estimation shall take into account the effects of mutual coupling between the two circuits.

Where the fault record is available from the remote end in Common Format for Transient Data Exchange (COMTRADE) or native format, the analysis package shall take into account the fault current infeed from the two ends and provide a compensated DTF estimation.

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1.9 Interfaces

The fault recording equipment shall be connected to other equipment as described in the appropriate Bay Specification (e.g. Mesh Corner Bay Specification TS 3.24.06; Feeder Bay Specification TS 3.24.07, etc.) as appropriate, Figure 1 or Figure 2 of this TS (depending on the application) and as declared below.

1.10 Interrogation Facilities

Once a directory of fault records has been retrieved from the fault recorder, the operator shall be able to choose one or a selection of several fault records in a batch, to be up-loaded to the PC.

The user shall be able to easily identify, distinguish and select fault recorder records from those of quality of supply or dynamic records where the fault recorder function is integrated within an Integrated Monitor.

The interrogation software package shall be capable of displaying the retrieved records. Brief information such as fault reference number, site, circuit, date, time etc. about each record shall be displayed on a menu system.

The display interface shall be user friendly, displaying user defined parameters with automatic and manual scaling facilities, enabling manipulation of data for display and printing.

1.11.7 Fault Record Analysis Facilities

National Grid licensed software shall be supplied which is capable of displaying and analysing the fault record.

The fault record analogue channels and event channels for a particular circuit together shall be capable of being displayed on a single screen, e.g. for a feeder, 8 analogue channels and 16 events.

Each analogue channel and each group of events shall be capable of being displayed individually or together with other selected channels.

A minimum of 4 and preferably 8 imported channels from other fault records (taken from different substations and circuits) shall be capable of being added to a window displaying an existing fault record, e.g. the ability to compare channels from both ends of a feeder by overlaying channels in a single window.

Each analogue channel shall be capable of being amplified individually and with other selected channels.

All data selected for display shall be clearly identified by its source, e.g. the identity of the substation, circuit, individual analogue and event channels labels.

The fault reference number, the trigger date, time and cause of trigger, amplitude scale and DTF results shall all be capable of being displayed.

Multiple cursors shall be provided. The instantaneous and RMS primary current and voltage values and instance of time, pertaining to cursor position shall be selectable for display and be selectable for relative measurements.

The display's time base shall be capable of being expanded or contracted.

Each fault record shall be capable of being printed in black and white or colour, printer permitting.

The printed record shall contain the identity of the substation and circuit, the fault reference number, the trigger date, time and cause, identification of individual analogue and event channels, amplitude scale and time increment markers.

Data import and export facilities shall be provided to COMTRADE format in accordance with IEC 60255-24 (BS EN 60255-24) ,), allowing comparison and analysis on a common platform and in particular import into a fault record analysis software package implementing this standard.

The analysis package shall include the following mathematical analysis features, calculated and displayed versus time, relative to the cursor position:

a) % phase sequence components (positive, negative and zero).

b) Harmonics (up to the 11th).

c) Distance to Fault estimation.

d) Frequency of selected input channel.

e) Power system phase angle.

f) Real and reactive power.

g) X/R ratio and time constant.

The software shall have an expert system which is able to produce automatic reports on:

a) Pre-fault and fault current amplitude measured as symmetrical RMS and a value of peak fault current.

b) The type of fault and phases involved, e.g. Red to Earth fault, Red to Yellow phase to phase fault.

c) Fault current duration (ms).

d) Times (ms) from fault current inception to the change of state of all marking events;

e) Preferably a conclusion as to whether the fault record is a record of an internal fault to the circuit, a through fault, a circuit de-energisation, circuit charging, circuit synchronisation, or something else.

f) Preferably a conclusion as to whether the fault record reveals any unusually long or short event responses or fault current duration and a report of what the unusual response is (Out of specification operations).

Where applicable, the fault recorder expert system results shall be suited for exporting into the Substation Information Management Units (IMUs) where applicableNational Grid Fault and Defect System (FADS).

1.12 Initiations

1.12.1 Event Channels (Single point status input)

The allocation of initiation contacts to the event channels shall be in accordance with Figure 2 of this TS as appropriate.

1.12.2 Clock Synchronisation

An initiating input from the substation clock for clock synchronisation shall be provided.

1.12.3 Outputs (Single point status outputs) - Alarms and Indications

Equipment failure shall be enunciated through the substation alarm and event logging system.

Unless otherwise specified, eEquipment alarms shall be provided for the following:

a) Fault Recorder healthy/faulty.

b) Fault Recorder out of service.

c) Fault Recorder operated.

1.13 Inputs

1.13.1 Current Transformers

The allocation of current channels shall be in accordance with Figure 2 of this TS as appropriate.

1.13.2 Voltage Transformers

1.8 The allocation of voltage channels shall be in accordance with Figure 2 of this TS as appropriate. Settings

1.8.1 Trigger settings for analogue and digital quantities shall be agreed between the User and NGET (refer to PST010 (RES)). It is essential to coordinate these settings to ensure that for any event data from all Users is available. Settings are to be agreed with NGET for each application.

1.8.2 The settings shall ensure that the Fault Recorder does not trigger under normal credible running and loading arrangements.

1.8.3 Optionally, the Fault Recorder will trigger from a digital event for a fault condition (i.e. trip relay operation). Any relevant plant change of state indication will be captured as a digital input, but the Fault Recorder will not be triggered by this change of state.

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2 PERFORMANCE REQUIREMENTS

2.1 General

The fault recorder and its ~~remote~~ interrogation equipment shall perform correctly in accordance with the requirements detailed in this TS~~pecification~~, for the range of power system conditions and variations specified in TS 1 ~~and Cl 101,~~ (RES) ~~general hardware requirements in TS 3.24.04~~ and the range of environmental conditions specified in ~~TS 2.24 and~~ TS 3.24.15 (RES).

~~The time resolution of analogue and event channels (where provided) shall not be greater than 1~~ 2 ~~ms.~~

~~The time coincidence between channels, event to event, analogue to analogue and event to analogue shall be less than 12µs or less1 ms.~~

2.2 Analogue Inputs

~~The fault recording equipment should be able to reproduce a symmetrical 60 kA fault (equates to a fully offset 30 kA fault).~~

For CT inputs, where required, full d.c.DC offset shall be accurately reproduced when the X/R ratio of the system fault in-feed is a minimum of 16 and the~~a~~ design maximum symmetrical RMS fault current component is offset by an additional factor of 0.6.

Informative: The system X/R ratio determines the time constant of the d.c. component's decay.

~~*Informative: The point on wave determines the degree of offset. Although many faults may be fully offset (offset by 1), it will be rare that a fault will be both fully offset and at full design fault current as the fault level falls away with distance to fault and many substations do not have full design fault level. Hence an offset factor of 0.6 has been chosen as a combined practical maximum factor.*~~

~~*Informative: A 400 kV maximum 63 kA symmetrical earth fault would mean that the primary maximum measurement range (FSD) would need to be 63 000 x 1.6 = 100 kA RMS (100 000/2000 = 50A secondary for a 2000/1 CT). A 275 kV maximum 40 kA symmetrical earth fault would mean that the primary maximum measurement range (FSD) would need to be 40 000 x 1.6 = 60 kA RMS (60 000/1200 = 50A secondary).*~~

~~*Informative: For a secondary RMS measurement range of 50 In, the pk-pk measuring range is 50 A x 1.414 x 2 = 141 A pk-pk for a 1 amp nominal CT input.*~~

Unless otherwise ~~specified~~agreed, t~~T~~he voltage channels ~~shall~~~~should~~should accurately reproduce 150% of nominal.

~~*Informative: All National Grid CVT secondary voltage outputs are nominally 63.5 V. 150% of Vn is 95 V.*~~

Unless otherwise ~~specified~~agreed, A~~a~~nalogue channels, including any interposing transformers or shunts, ~~shall~~ should have a composite error of ~~less than~~ 1.0% or less.

Unless otherwise agreed, T~~t~~he bandwidth (-3 dB) of the analogue channels ~~shall~~ should cover, as a minimum requirement, a frequency range of 20 Hz to ~~500~~ 400 Hz.

The response time of an analogue trigger shall not be greater than 40 ms.

2.3 Event Channels (Optional)

Unless otherwise agreed and where provided the event channels should be capable of the following:

- The response time of an event trigger shall be sufficiently short to trigger for event durations of 2 ms and above.
- Triggering shall not take place, however, for events lasting less than 0.5 ms or as a result of electrical noise.
- The event channels shall not trigger the fault recorder when the voltage of the input signal is less than 50% of nominal input voltage rating.
- The response time for storing the data relating to change of state of event signals shall not exceed 0.5 ms for every acceptable sampling rate.
- A minimum pulse width of 1 ms with an accuracy of 0.5 ms shall be capable of being captured. This requirement shall be met when multiple changes of state occur on any channel or group of channels.

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~~2.4 DTF Estimation~~

~~The DTF estimation result shall be within 3% of the actual distance to fault for any phase fault or earth fault with zero fault resistance.~~

~~3 TEST REQUIEMENTS~~

~~3.1 Power System Conditions and Environment~~

~~The fault recording equipment shall be demonstrated to operate correctly for the power system conditions and environment as the range of system fault infeeds, X/R ratios, balanced and unbalanced load currents, offsets, voltage levels, shunt capacitance currents, harmonic currents, oscillatory currents, resonance conditions and travelling wave effects that are defined in TS 1 and Cl 101.~~

~~3.2 Accuracy~~

~~The accuracy of the fault recorder shall be such that, when set appropriately, and over the range of conditions referred to, the equipment shall perform correctly and in accordance with this TS.~~

~~The accuracy shall not be affected by more than ±10% (±2% for auxiliary power supply variations) for the conditions specified in TS 1, Cl 101, TS 2.24 and TS 3.24.15.~~

~~TYPE REGISTRATION~~

~~The fault recording function or equipment shall be type registered in accordance with National Grid Transmission Procedure – TP 183.~~

43 FORMS AND RECORDS

N/A

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

~~5~~4 DEFINITIONS AND ABBREVIATIONS

Integrated Monitor (IM)	Equipment which contains Fault Recording, Dynamic System Monitoring (slow scan) and Quality of Supply Monitoring functions within a single system.
Distance to Fault (DTF)	Estimation of the distance from the relay to the primary system fault.
COMTRADE	Common Format for Transient Data Exchange
CT	Current Transformer
DC	Direct Current
IED	Intelligent Electronic Device
LAN	Local Area Network
RMS	Root Mean Square
VT	Voltage Transformer
WAN	Wide Area Network

65 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	November 2005	New Appendix (Appendix A) has been added	Pelqim Spahiu Asset Policy	Peter Roberts Asset Strategy Manager
12	January February 2018	Updated references & definitions; Minor changes for original Section 1-2 and Appendix A; Added new Section 4 for General Type Registration Requirements.First issue	Dechao Kong Thomas Charton Asset Policy	Daniel Penny Asset Policy Manager

7 IMPLEMENTATION

7.1 Audience Awareness

Audience	Purpose Compliance (C) / Awareness (A)	Notification Method Memo / letter / fax / email / team brief / other (specify)
ETO, Capital Delivery, SO, Alliances.	C	Email

7.2 Training Requirements

Training Needs N/A / Informal / Workshop / Formal Course	Training Target Date	Implementation Manager
N/A	N/A	N/A

~~7.3 Compliance~~

~~N/A~~

~~7.4~~5.1 **Procedure Review Date**

5 years from publication date.

PART 3 - GUIDANCE NOTES AND APPENDICES

~~8~~6 **REFERENCES**

TS 1 (RES) Ratings and General Requirements for Plant, Equipment, Apparatus for the National Grid System.

~~TS 2.24 Substation Information, Control, Protection and Metering.~~

~~TS 3.24.1 Substation Information, Control, Protection Local Area Network.~~

~~TS 3.24.04 Hardware and Common Functions.~~

~~TS 3.24.06 Mesh Corner Bay Functions.~~

~~TS 3.24.07 Feeder Bay Functions.~~

TS 3.24.15 (RES) Environmental and Test Requirements for Electronic Equipment.

~~TP183 Type Registered Equipment Procedural Requirements.~~

IEC/BS EN 60255-24 Common Format for Transient Data Exchange (COMTRADE) for Power Systems.

PST010 (RES) Backup Protection Grading across National Grid/Distribution Network Operator Interfaces and other Third Parties

~~TGN(E) 156 Application of System Monitoring Equipment~~

~~CI 101 Technical and Operational Characteristics of the National Grid Transmission System~~

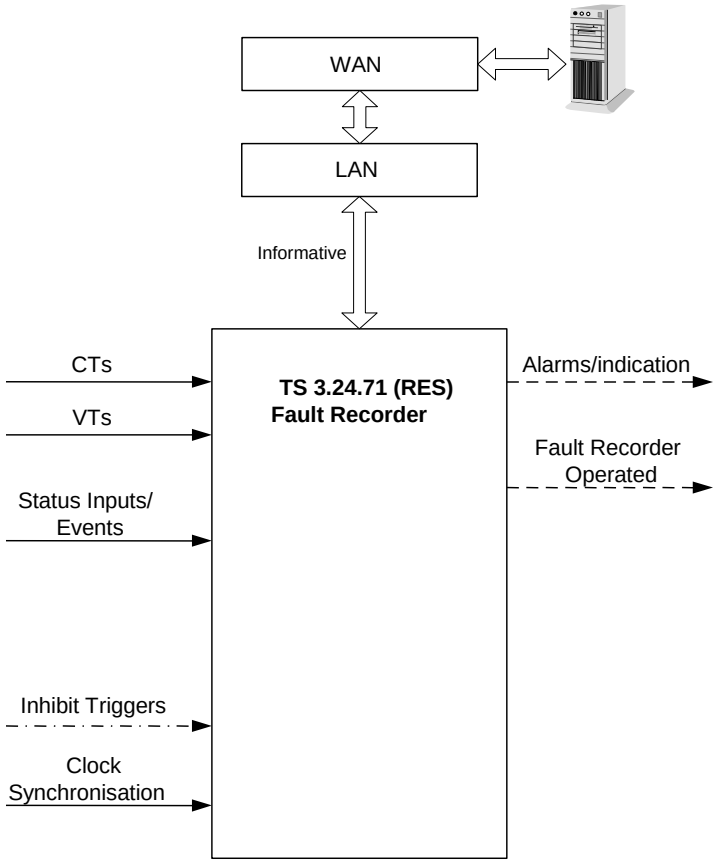

Figure 1: Typical Fault Recording Application within an Integrated Monitor (Analogue and Events (Optional) Input to System Monitoring Devices)

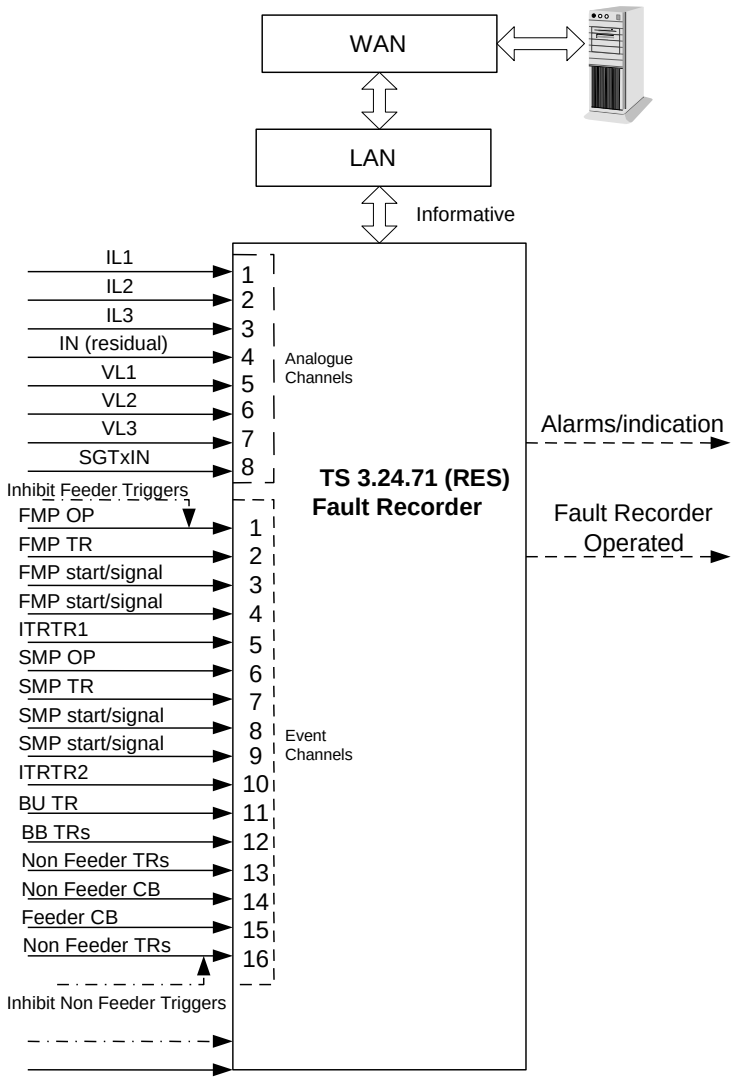

Figure 2: Example of a typical application showing Fault Recorder Generic Connections and Labels for TSO Feeders
FMP – First Main Protection, SMP – Second Main Protection – For HVDC additional DC quantities are to be measured.

APPENDIX A - FAULT RECORDING & FAULT LOCATION FUNCTIONS INTEGRATED WITHIN MAIN & BACKUP PROTECTIONS

Informative: Where Integrated Monitorsing (IM) facilities are required at specific sites, and the fault recording and fault location functions are primarily catered for within the IM integrated package at those sites as specified in the main part of TS 3.24.71.

Where IMs are not specifically required, the fault recording and fault location functions can still

be achieved by being part of an IM or as a dedicated standalone fault recorder but may also be supplied as an integral part of other equipment located within the bay e.g. Main and backup protection.

Informative: This Appendix specifies exceptions to TS 3.24.71 main part where lower levels of requirement are acceptable for integration within equipment other than IM and standalone fault recording facilities.

Informative: PS(T) 010 states the application requirements for fault recording. The following describes how the policy is achieved with the fault recording function integrated within main and backup protection.

A1 FAULT RECORDING PROVISION AND LOCATION

A1.1 For Feeder Bays

Where no Integrated Monitor is specified or standalone fault recording facility supplied, a fault recording function shall be provided, set and enabled as an integral part of each of the first main, second main and backup protections.

At least one fault location function (DTF) shall be provided on a feeder bay.

Informative: This may be integrated in any equipment, provided the DTF result can be remotely interrogated.

A1.2 All Bays other than Feeders

Where no Integrated Monitor is specified or standalone fault recording facility supplied, a fault recording function shall be provided, set and enabled as an integral part of at least one of the first main, second main (where applicable) or backup protections. Where it is available in more than one device, it shall be set and enabled in those devices as well.

A1.3 All Bays

Where the Integrated Monitor facility has been requested at a particular site, then the high performance fault recording function in each IM bay shall be utilised as specified in the main part of TS 3.24.71.

Where, additionally, a fault recording or fault location function is integrated within a main or backup protection then it shall be set and enabled as well.

A2 FUNCTIONAL REQUIREMENTS

A2.1 Analogue Channels

The sampling frequency of analogue channels shall be at least 1 kHz.

The analogue information shall have an amplitude resolution of at least 1 in 4000.

Informative: For example, resolution can be achieved by a 12 bit analogue-to-digital converter or better.

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The RMS current measurement range shall be preferably 50 In. However, this will be dictated by the protection's maximum measuring capability Unless otherwise agreed, the RMS current measure range shall and should not be less than 30 In and shall be 50 In where applicable.

Informative: The fault recording equipment should be able to reproduce a symmetrical 60 kA fault (equates to a fully offset 30 kA fault).

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A2.2 Event Channels

The sampling frequency for the event channels shall be at least 1 kHz.

A2.3 Memory

The equipment shall have a non-volatile storage capacity of at least 32 consecutive fault triggered fault records and DTF results per circuit.

Informative: The fault recorder equipment itself may only have capacity for 10 records, provided the recording system automatically passes its records to a non-volatile storage system which will retain preferably 100 fault records per circuit and can be remotely interrogate, e.g. an Information Management Unit (IMU).

The fault recorder shall consist of capacity to store at least 10 records with each record length of 1.5 s.

Informative: As a minimum requirement, 100 ms of pre-trigger recording and 400 ms of post-trigger recording for both analogue and logic signals at a sampling frequency of 1 kHz for 8 analogue and 16 event channels are expected.

A2.4 Triggering

Event channel triggering shall be performed to Figure 3 of this Appendix A.

Internal tripping commands which (includeing intertrip send/ and receive signals and together with send/ and receive blocking/acceleration signals, a wheres applicable,) shall trigger the fault recording function.

Generally, other internal events shall mark the fault record only. The event list of distance protection should shall also record Z1, Z2 & Z3 started and operated signals.

Informative: No cross triggering between IED's and bays is required.

The cross-triggering shall be performed where independent fault recoding functions are set and enabled as an integral part of each of the first main, second main protections for the bays as specified in the contact.

A2.5 Interfaces

The equipment shall be connected to other equipment as described in the appropriate Bay Specification (e.g. Mesh Corner Bay Specification, TS 3.24.6, Feeder Bay Specification TS 3.24.7etc.) as appropriate, Figure 1, Figure 2 and Figure 3 of this TS (depending on applications).

A2.6 Interrogation Facilities

Access shall be required to the fault records and DTF result, locally at the equipment and remotely through the IMU where available.

The equipment shall enable the automatic retrieval to the IMU of fault records and DTF results.

A3 PERFORMANCE REQUIREMENTS

A3.1 Analogue and Event Channels

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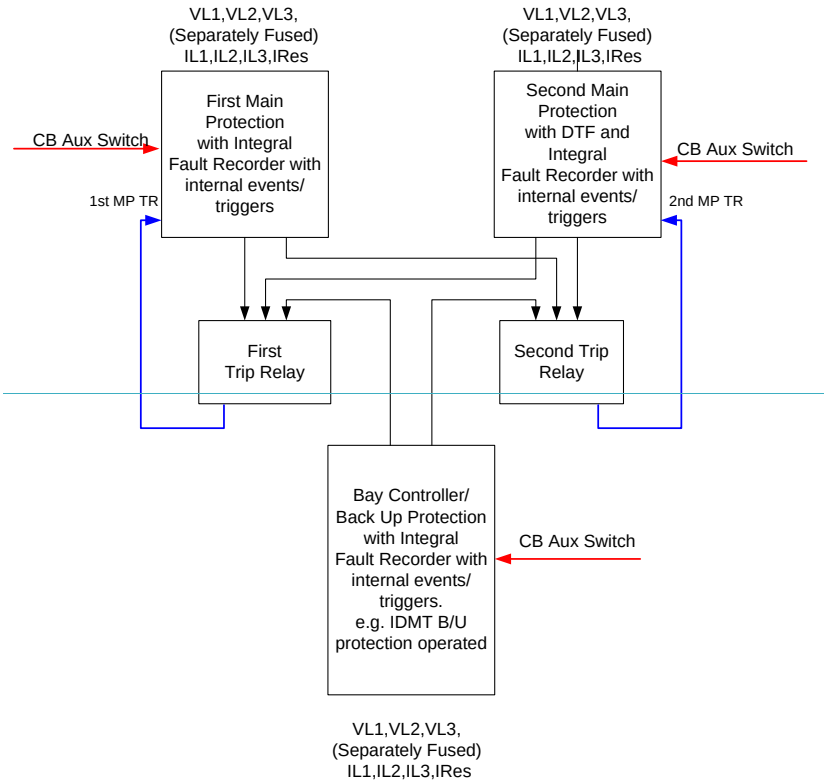
The time resolution of analogue and event channels shall not be greater than 2 ms.

The time coincidence between channels, event to event, analogue to analogue and event to analogue shall be less than 2 ms.

The bandwidth (-3 dB) of the analogue channels shall cover, as a minimum requirement, a frequency range of 20 Hz - 400 Hz.



~~Note:~~

~~1) All tripping event channels shall be set to trigger~~
~~2) Event channels require ability to be inhibited~~
~~3) Colour indicates additional wiring requirements of Fault Recording~~
~~4) Bay Controller shall trigger for under voltage and over current (phase and neutral)~~
~~5) All IEDs to report to IMU~~

~~Figure 3: Integrated Fault Recorders – Triggering (Feeder Configuration Shown)~~