SP ENERGY NETWORKS

Load Management Schemes

Introduction

Purpose

- Provide information on the purpose, design and operation of LMSs
- Discussion & feedback to improve design and operation wherever possible

Agenda

- System Requirements
- LMS & ANM
- LMS Design
- Scheme performance
- Operational arrangements
- Lunch
- 121 discussions

What Are Load Management Schemes?

SPT defined term

"A system comprised of geographically distributed measuring devices and site specific customer interfaces to detect, in real-time, unacceptable overloading of transmission assets and disconnect the generation contributing to the overload in accordance with contractual agreements."

Purpose of LMS

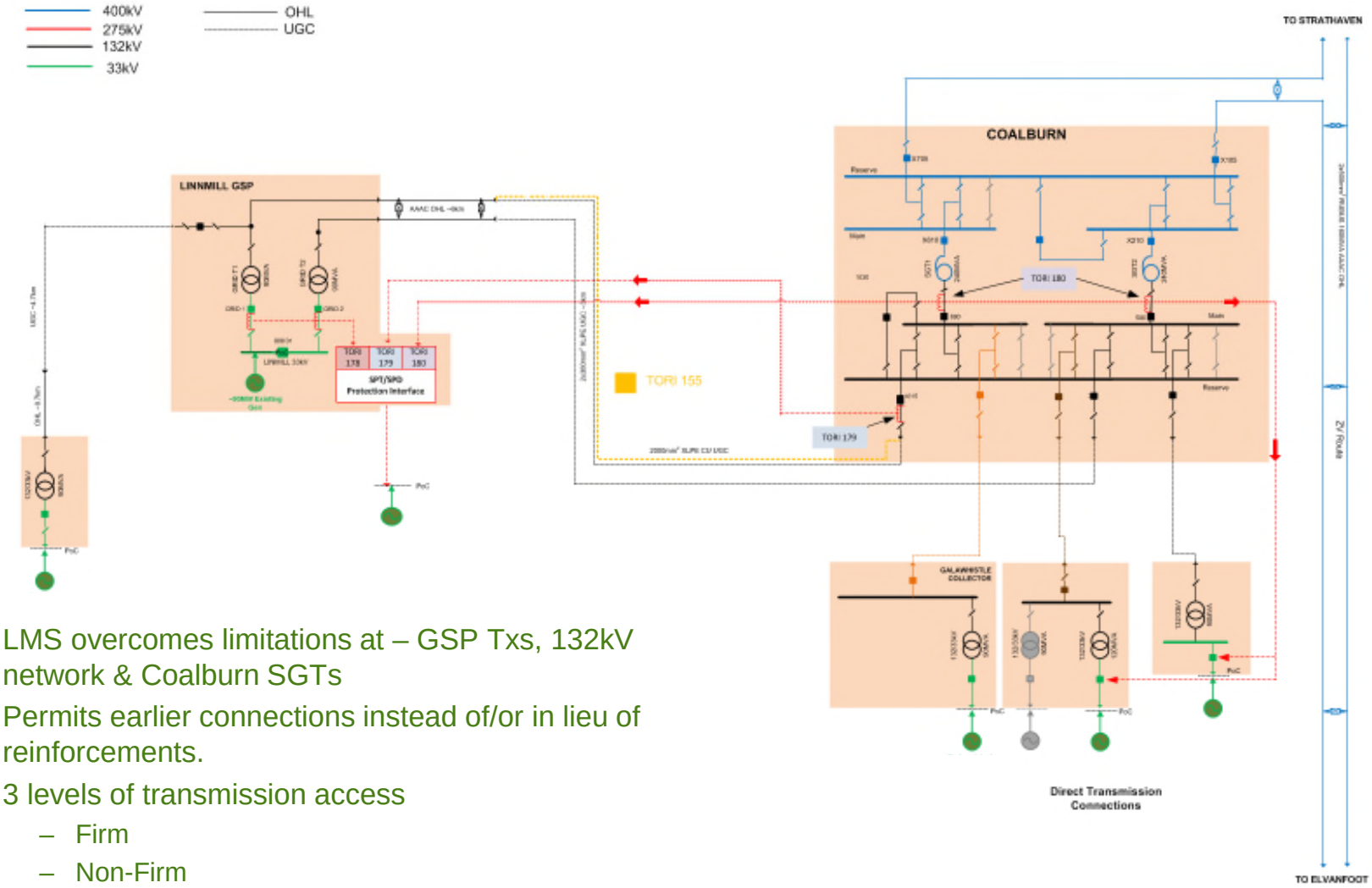
- To permit connections in advance of necessary enabling works usually in areas of the network which are, at times, already operating at or beyond capacity.
- To facilitate enduring non-firm Transmission access.
- AND to protect assets from unacceptable overloads

Neil Miller

August 2017

LMS Background

Why LMS?



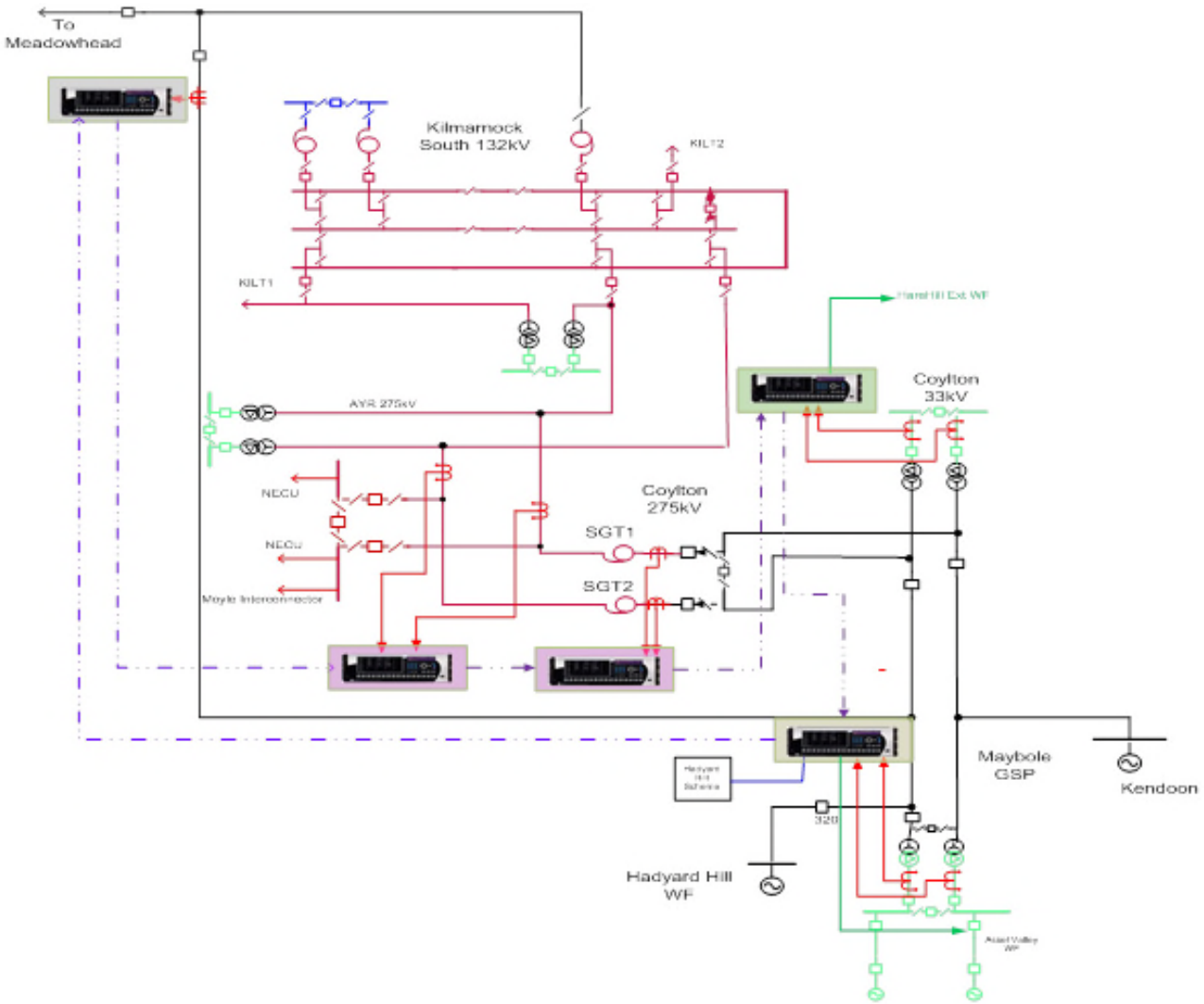
- LMS overcomes limitations at – GSP Txs, 132kV network & Coalburn SGTs
- Permits earlier connections instead of/or in lieu of reinforcements.
- 3 levels of transmission access
  - Firm
  - Non-Firm
  - Restricted Available Access (RAA)

(TORI Transmission Owner Reinforcement Instruction)

Example – Coalburn 400kV to Linnmill 132/33kV GSP

(existing scheme – TORIs178, 179 & 180)

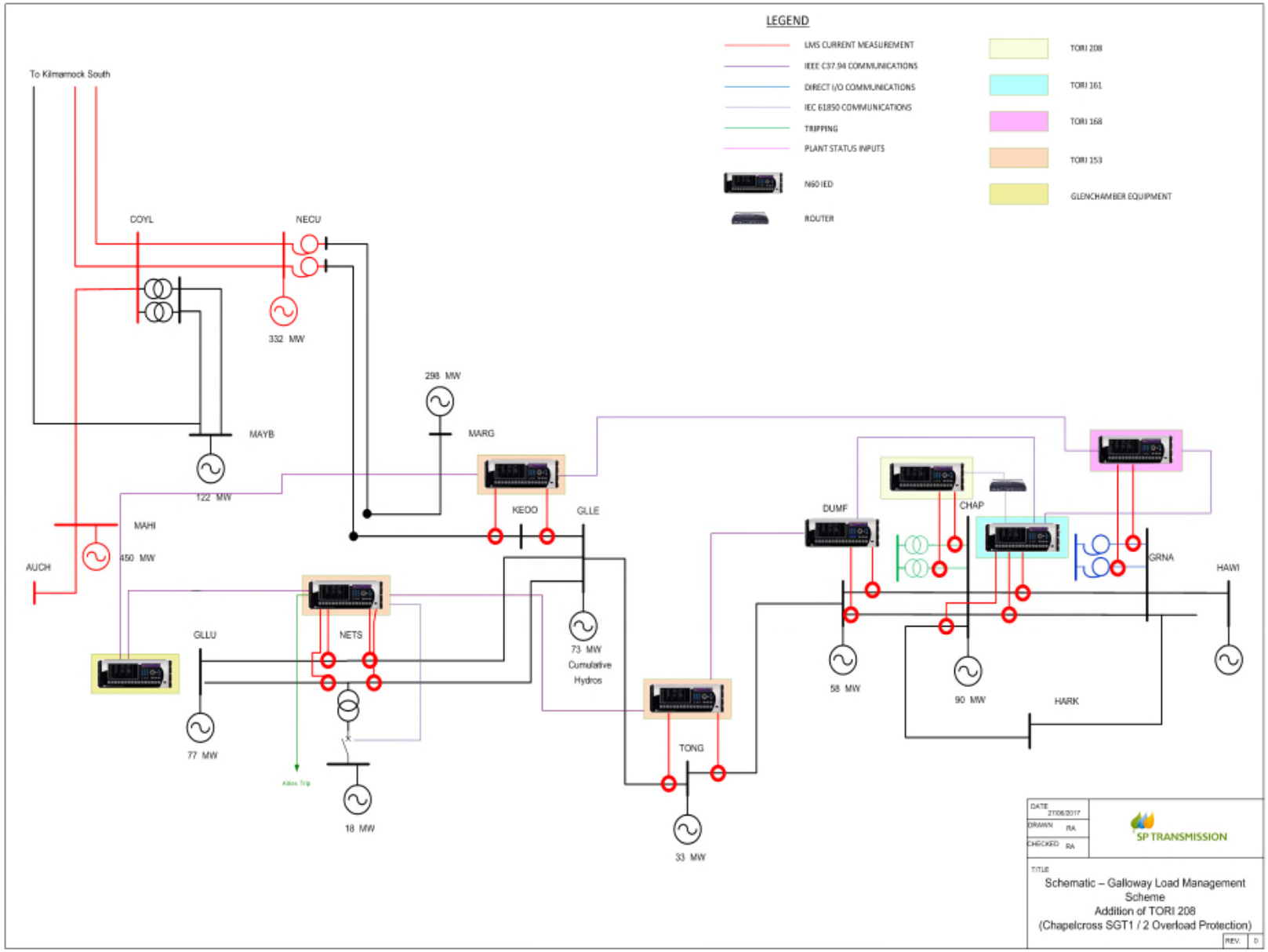
Additional Existing LMS Schemes: Coylton/Maybole/Kilmarnock South 132KV & GSPs



(TORIs 148 & 149)
LMS overcomes limitations at:

- Maybole 132/33kV GSP Txs
- Coylton 132/33kV GSP Txs
- Maybole/Coylton/ Kilmarnock South 132kV Network

Existing LMS Schemes contd.



Dumfries & Galloway LMS (TORI 153)

Chapelcross 132kV LMS (TORI 161)

Gretna SGTx LMS (TORI 168)
Chapelcross GSP LMS (TORI 208)

Additional LMS Schemes

Commissioned:

Eccles 400/132kV SGT1(2) - LMS (TORI 171)

Berwick 132/33kV GSP LMS - (TORI 172)

Future:

- TORI 185 - LMS monitors:
  - Dunlaw Ext to Smeaton 132kV, Galashiels to Eccles 132kV LMS
    (allows gen to connect at Dunlaw Ext 132/33kV and Galashiels GSP)
- Livingston East 132/33kV GSP LMS

- TORI 176/7 – LMS monitors:
  - Coylton – New Cumnock 275kV ccts
  - New Cumnock SGTs (x8) – A,B & C Boards
  - New Cumnock to Blackhill 132kV ccts
  - Glenglass – Blackhill 132kV Circuits
  - Glenglass 132/33kV transformers

  (allows gen to connect at Glenglass, Black Hill, Dun Hill and Galloway s/s)

Conclusions

- LMS schemes to maximise utilisation of existing and future networks providing non-firm and RAA access, and provide earliest possible connection date.

- Approximately 10 individual LMS schemes commissioned to date on SGTs, 275kV circuits, 132kV circuits and 132/33kV transformers.

- Further LMS schemes planned (mainly New Cumnock area)

LMS and ANM

LMS & ANM

Purpose - Reminder

- To permit connection in advance of necessary enabling works
- To enable enduring non-firm connections
- To protect network assets from unacceptable overloads

ENA ANM Good Practice Guide Definition

- *"Using flexible network customers autonomously and in real-time to increase the utilisation of network assets without breaching operational limits, thereby reducing the need for reinforcement, speeding up connections and reducing costs."*

LMS & ANM

ENA ANM Good Practice Guide

- *"ANM should only be used on radial elements of the network, where its impact on network operation can be easily understood"*
- *"On more complicated meshed transmission networks, the effect of ANM actions are thought to be too complex and unpredictable to implement safely"*

SPT Applications - Reminder

- Meshed, radial and mixed network areas
- Complex, multiple 'LIFO' queue orders
- Large number of constrained circuits
- Constraints are significant
- Some GSPs at or beyond non-firm capacity: e.g. 180MVA net export with 2x90MVA circuits

LMS & ANM

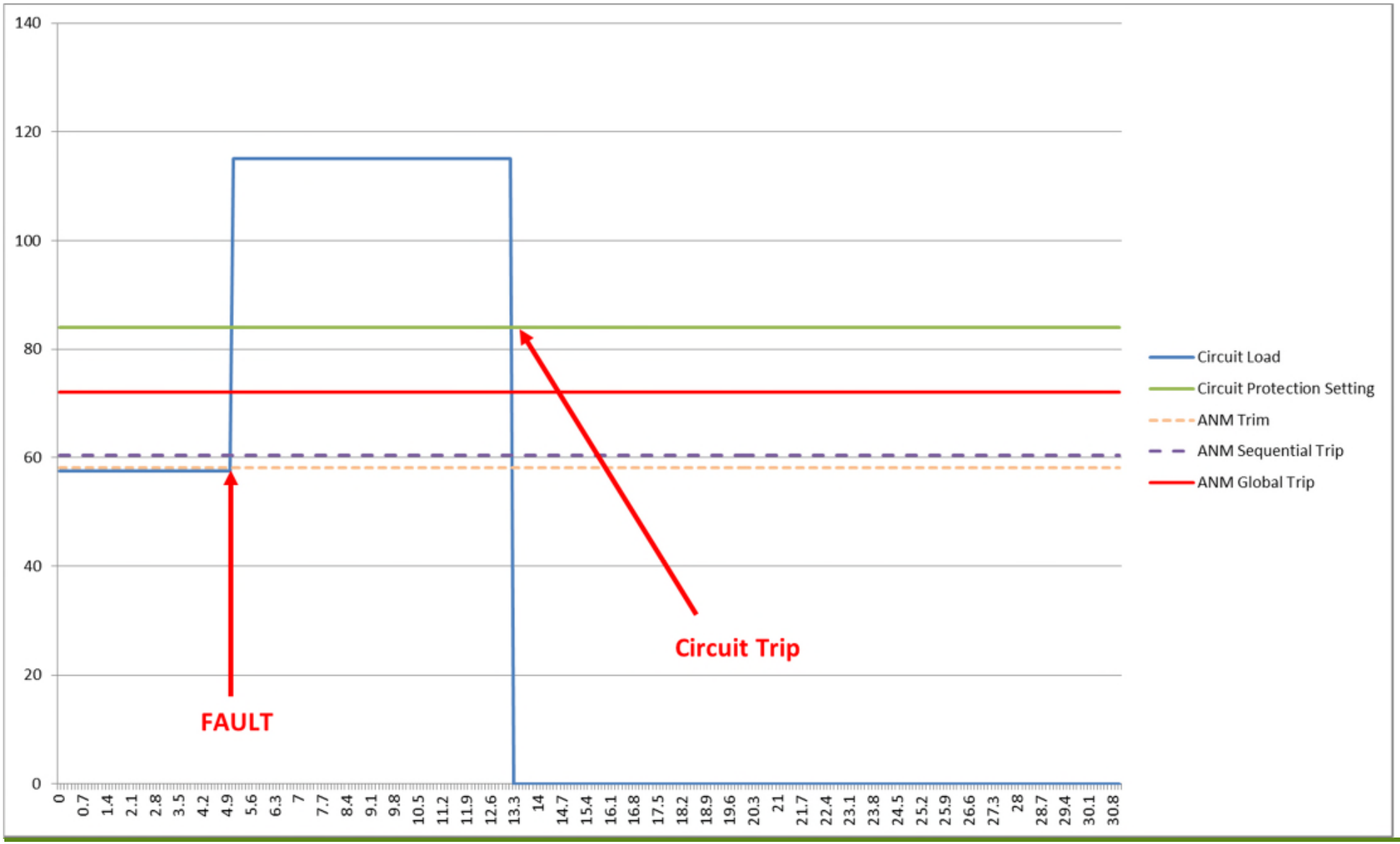
LMS Schemes

- Less sophisticated control actions
- May result in more trips than ANM

- Uses protection hardware for speed and dependability: protect the assets
- Uses protection-class comms
- Multiple LIFO stacks
- Multiple, geographically distant circuit measurements

LMS & ANM

Current Generation ANM Status – Protecting the Assets



LMS & ANM – Future Plans

SPT Proposals

- ANM hardware, architecture and comms to satisfy LMS requirements
- Develop supply chain to facilitate solution for interconnected transmission
- Interface with EBS to co-ordinate with balancing actions
- Challenge the ENA guide

Requirements

- Substation grade hardware & comms
- Real-time contingency analysis
- Wide Area control with PMU and R-GOOSE

When and How

- Dovetail with SPD innovation initiative
- Potential KTR application

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24th August 2017

LOAD MANAGEMENT SCHEME DESIGN AND OPERATION

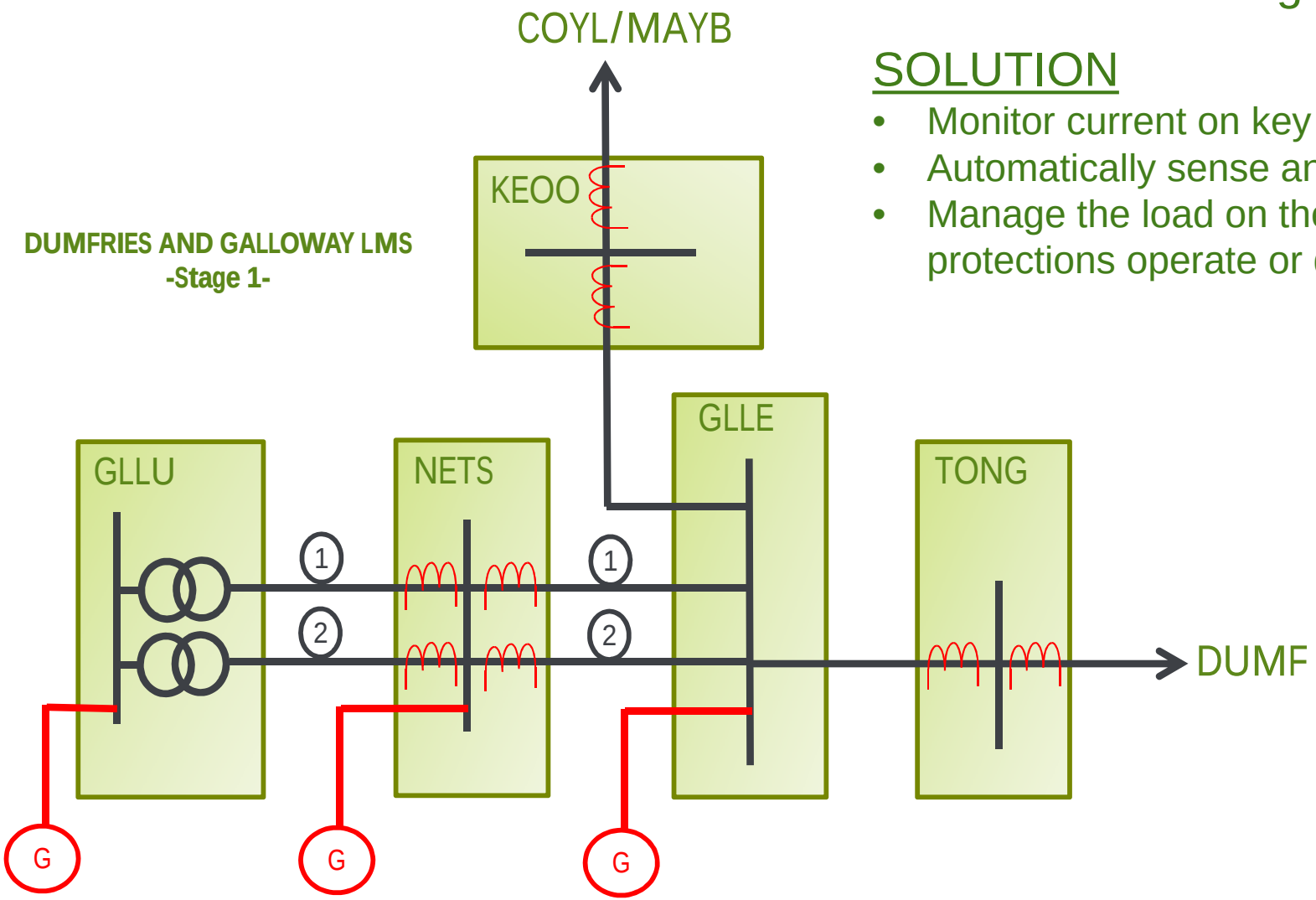
Graeme Duncan, Senior Engineer, SPT
Allan Wales, Lead Engineer, SPD

CONTENTS

LMS PRINCIPLES

Transmission network approaching capacity in areas with generation potential

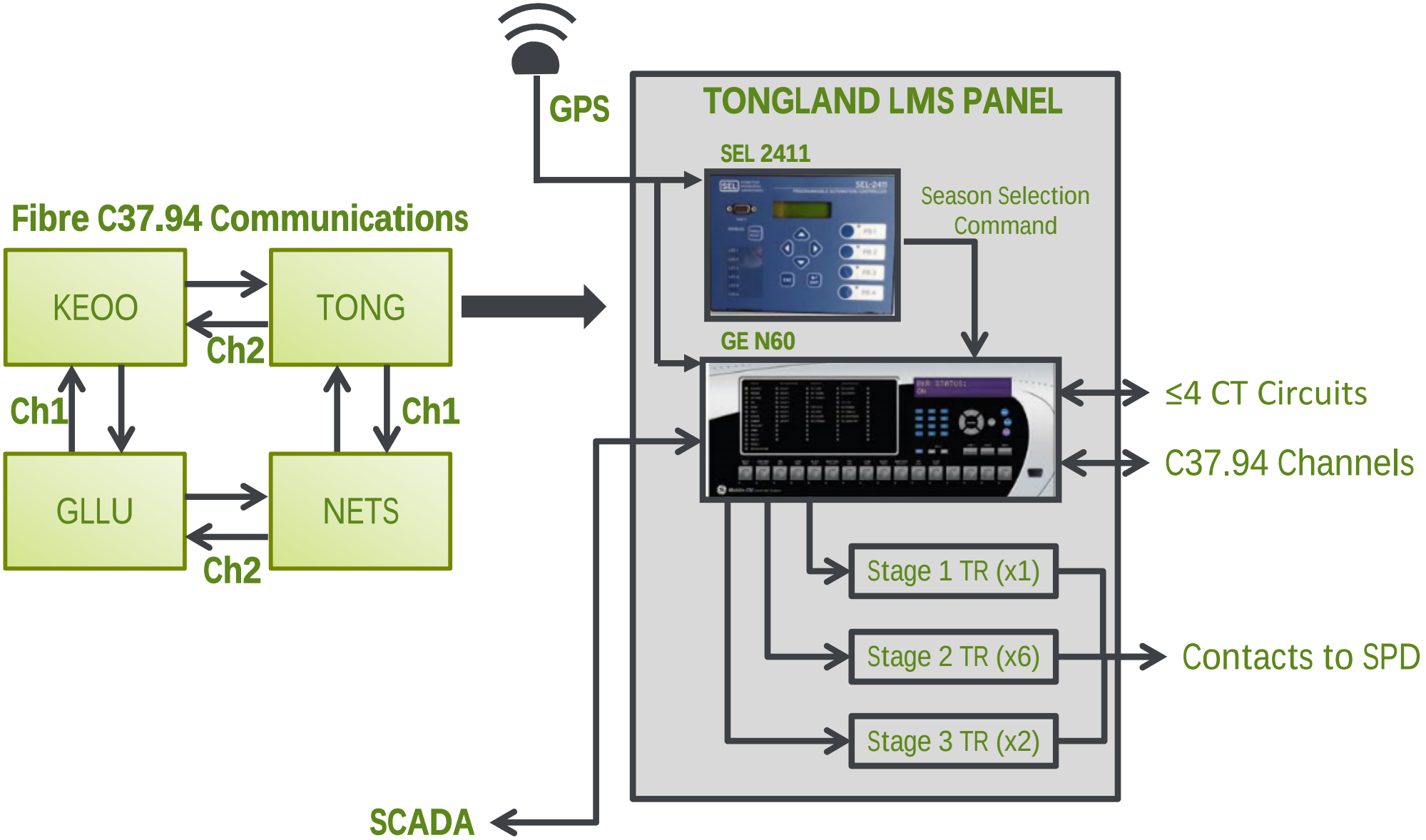
DUMFRIES AND GALLOWAY LMS
-Stage 1-



SOLUTION

- Monitor current on key circuits on the network
- Automatically sense any overload condition
- Manage the load on the network before system protections operate or damage occurs

SCHEME ARCHITECTURE

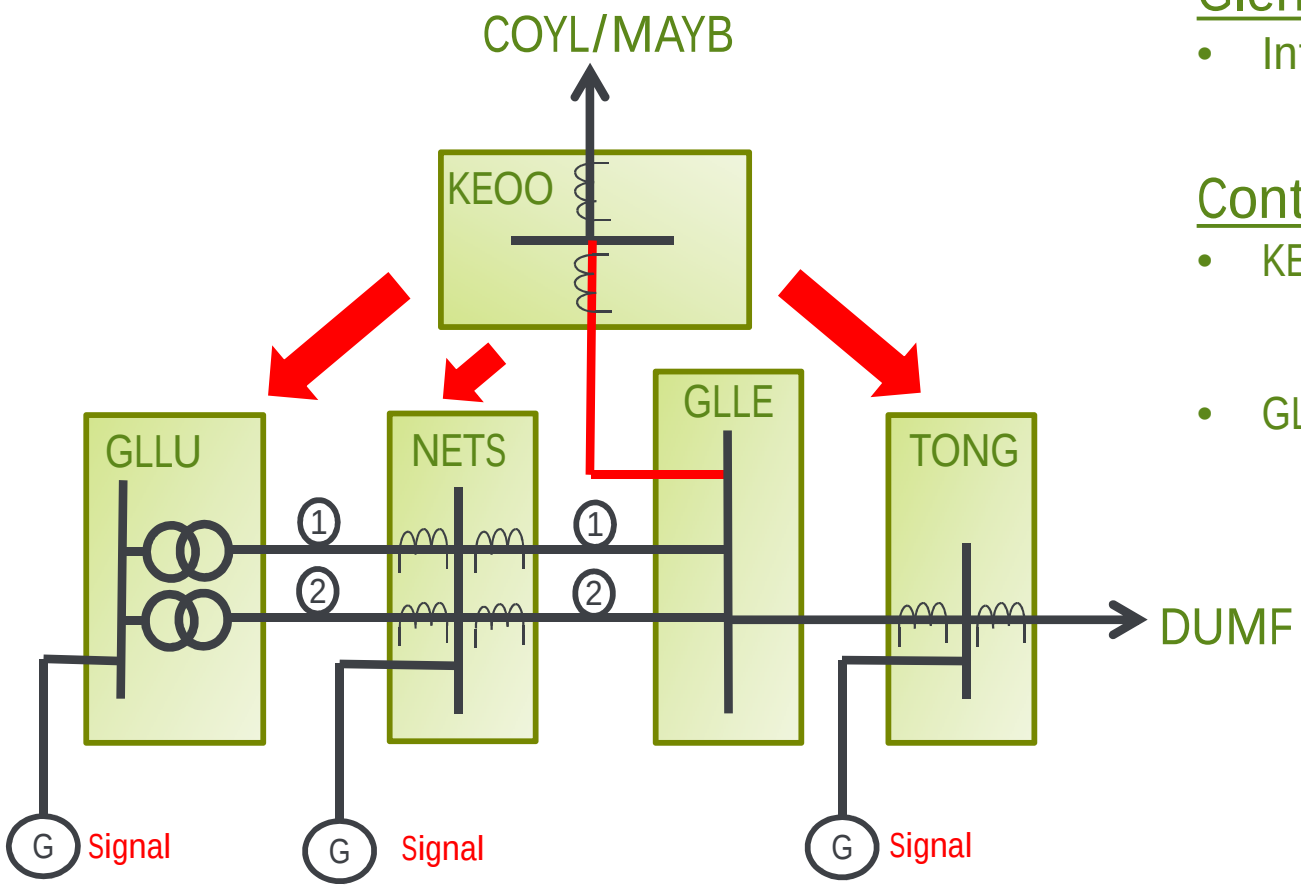


OPERATIONAL STAGES

- STAGE 1: Reduce Generation Signal
  - 95% of transformer or overhead line pre-fault rating
  - 1 contact available per windfarm for signalling purposes
- STAGE 2: Delayed Trip
  - 100% of transformer or overhead line pre-fault rating
  - Tripping contacts for up to 6 windfarms with 500ms separation
  - 2 contacts available per windfarm
- STAGE 3: Instantaneous Trip
  - 120% of transformer or overhead line post-fault rating
  - Tripping contacts for up to 6 windfarms with instantaneous operation
  - 2 contacts available per windfarm
- Season dependant ratings
  - Summer: May, June, July and August
  - Autumn/Spring: March, April, September, October and November
  - Winter: January, February and December
- Ratings graded with existing protections
  - LMS must operate before existing protections
- Tailored tripping arrangements

LMS IN ACTION

Stage 1 Overload (>1.2s) : KEOO GLLE CCT



Kendoon

- Stage 1 Trip Relay Operation & Intertrip Send
  - Signal sent to Windfarms via SPD

Glenluce, Newton Stewart & Tongland

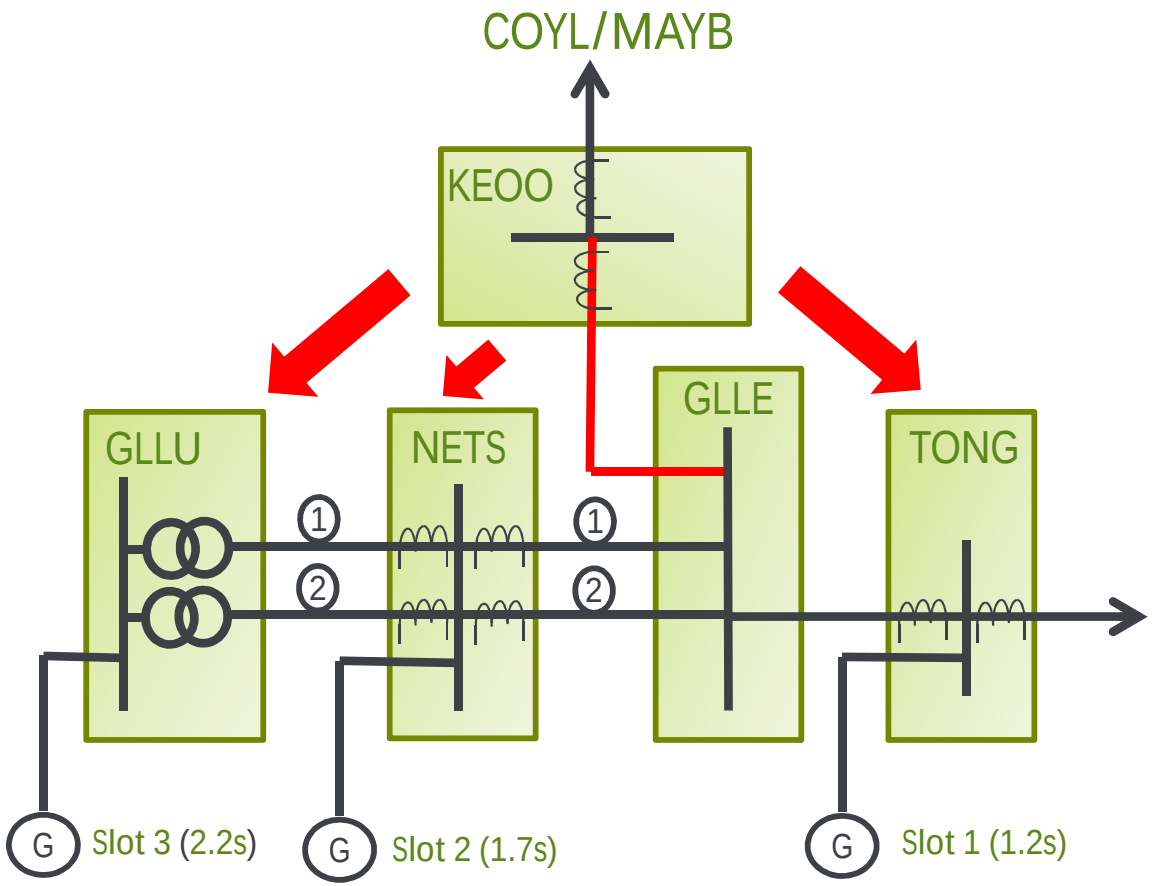
- Intertrip Receive & Stage 1 Trip Relay Operation
  - Signal sent to Windfarms via SPD

Control Room

- KEOO Signals
  - Stage 1 Op: GLLE CCT
  - Stage 1: Reduce Generation Signal
- GLLU/TONG/NETS Signals
  - KEEO: Stage 1 Received
  - Stage 1: Reduce Generation Signal

LMS IN ACTION

Stage 2 Overload (>1.2s) : KEOO GLLE CCT



Kendoon

- Stage 2 Trip Relay Operation & Intertrip Send
  - Sequential trip of WF's via SPD

Glenluce, Newton Stewart & Tongland

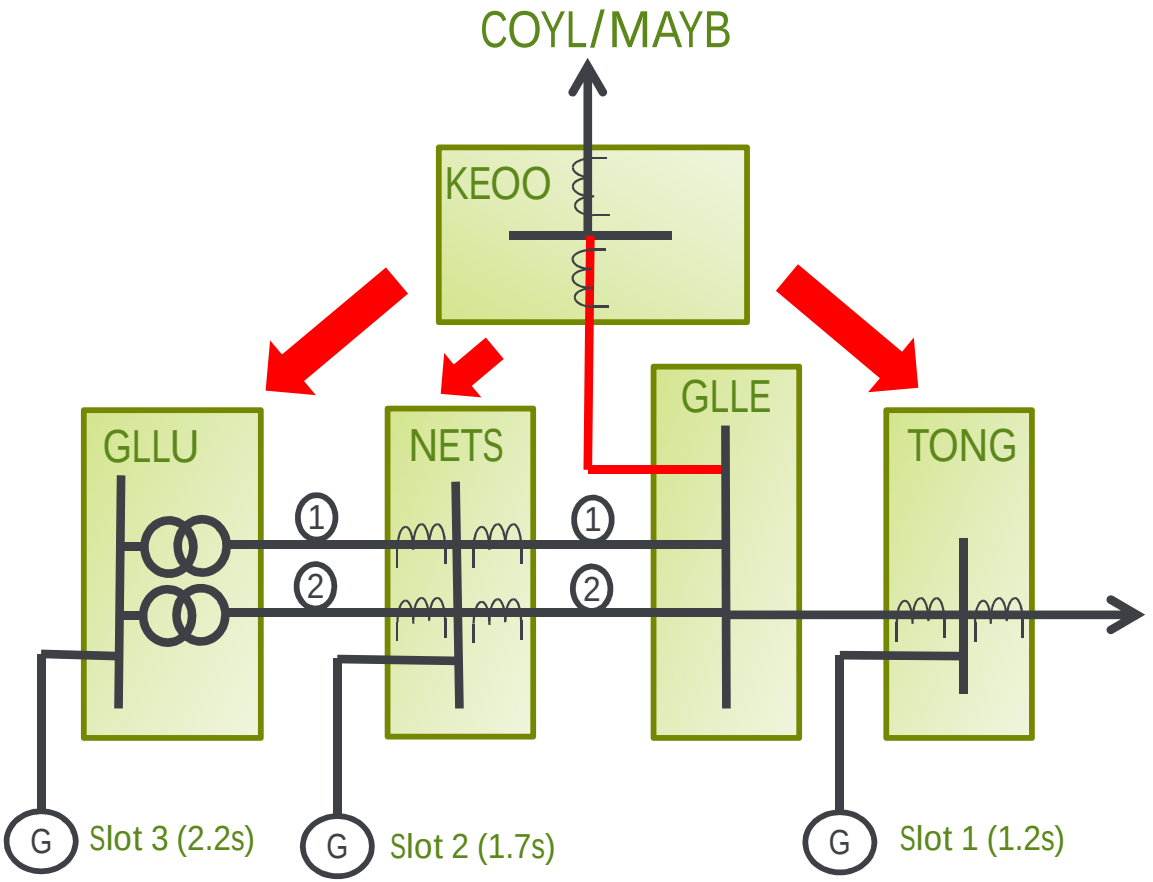
- Intertrip receive & Stage 2 Trip Relay Operation
  - Sequential trip of WF's via SPD

Control Room

- Plant Status Change
- KEOO Signals
  - Stage 2 Op: GLLE CCT
  - Stage 2: Sequential Trip
- GLLU/TONG/NETS Signals
  - KEEO: Stage 2 Received
  - Stage 2: Sequential Trip

LMS IN ACTION

Stage 3 Overload (>1.2s) : KEOO GLLE CCT



Kendoon

- Stage 3 Trip Relay Operation & Intertrip send
  - Instantaneous trip of WF's via SPD

Glenluce, Newton Stewart & Tongland

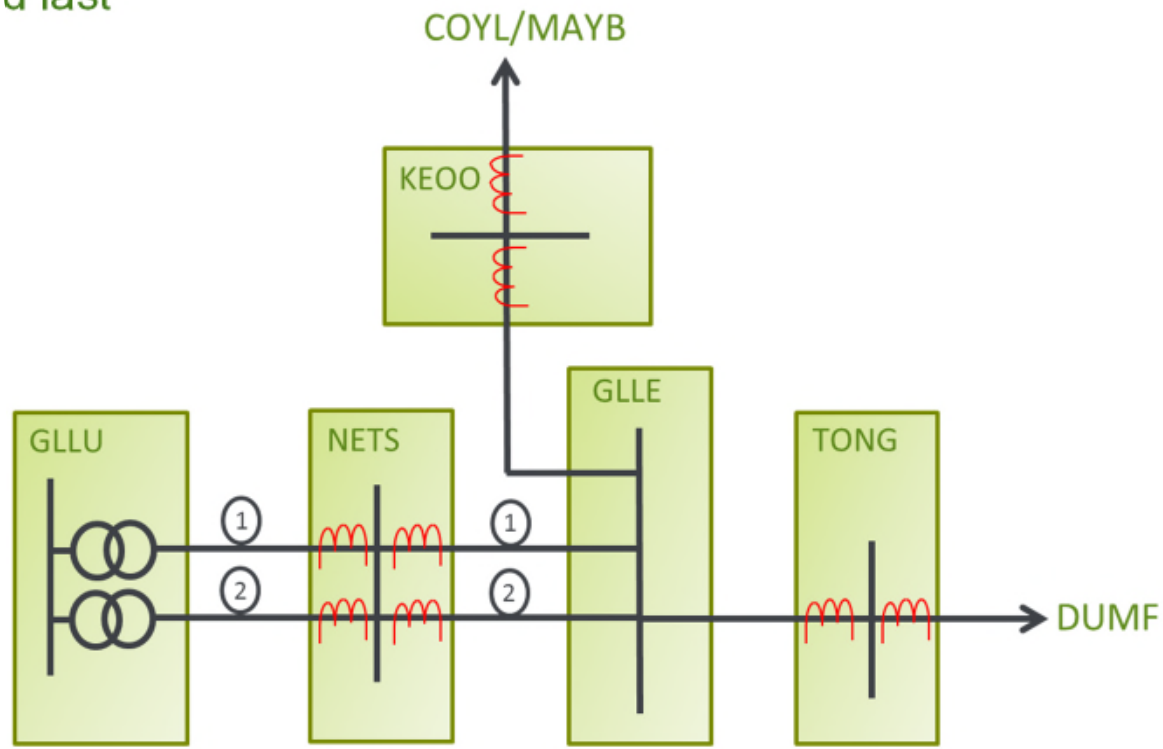
- Intertrip receive & Stage 3 Trip Relay Operation
  - Instantaneous trip of WF's via SPD

Control Room

- Plant Status Change
- KEOO Signals
  - Stage 3 Op: GLLE CCT
  - Stage 3: Instantaneous Trip
- GLLU/TONG/NETS Signals
  - KEEO: Stage 3 Received
  - Stage 3: Instantaneous Trip

TAILORED ARRANGEMENTS

- Selective Tripping
  - Overloads on circuits may only be applicable to connections at specific sites
- Loss of Grid Connection
  - Tripping may occur on sites with loss of Transmission level network connection
- Interface with Existing Schemes
  - New LMS are graded with existing load management schemes with existing windfarms disconnected last



SCHEME EXPANSION

- Adding Additional Windfarms on Existing Schemes
  - New windfarms will be connected in a slot position to trip according to queue position
  - Tripping of new windfarm connections via LMS will be tested before energisation, generally at final stages of construction phase.
  - Short outage on LMS scheme to prove correct operation for a simulated stage 1, stage 2 and stage 3 operation before energisation

SPD TO WINDFARM INTERFACE

- Hardwired Signal from SPT LMS Scheme applied to SPD IED for transmission to Windfarm over communications channel
- At the Windfarm, the signals are converted back to clean contacts which the Windfarm control system can pick up
- The signals follow the LMS scheme, so if the ramp down is followed by a trip, the SPD statutory Circuit Breaker will trip
- At present, the trip will occur regardless of the WF output. Investigation is being carried out into whether the connection can be maintained if the generation is zero
- This will involve more equipment and probably some cost. Decisions will also have to be made on the action during communications failure

ANY QUESTIONS?

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System Monitoring – Load Management Schemes

Finlay Macleod
Operational Support
August 2017

System Monitoring – Load Management Schemes

- Load Management Schemes can comprise many IEDs across several substations
- For security reasons, these IEDs are not remotely accessible
- This creates practical challenges of Protection Engineers visiting site to download relays following LMS operations
- Therefore operations are analysed using fault recorder and SCADA data
- SPEN System Monitoring operate a network of ~500 fault recorders on the Transmission System – some of these cover circuits involved with LMS
- Fault Recorders and SCADA outstations are GPS time synchronised so precise timing of events is known

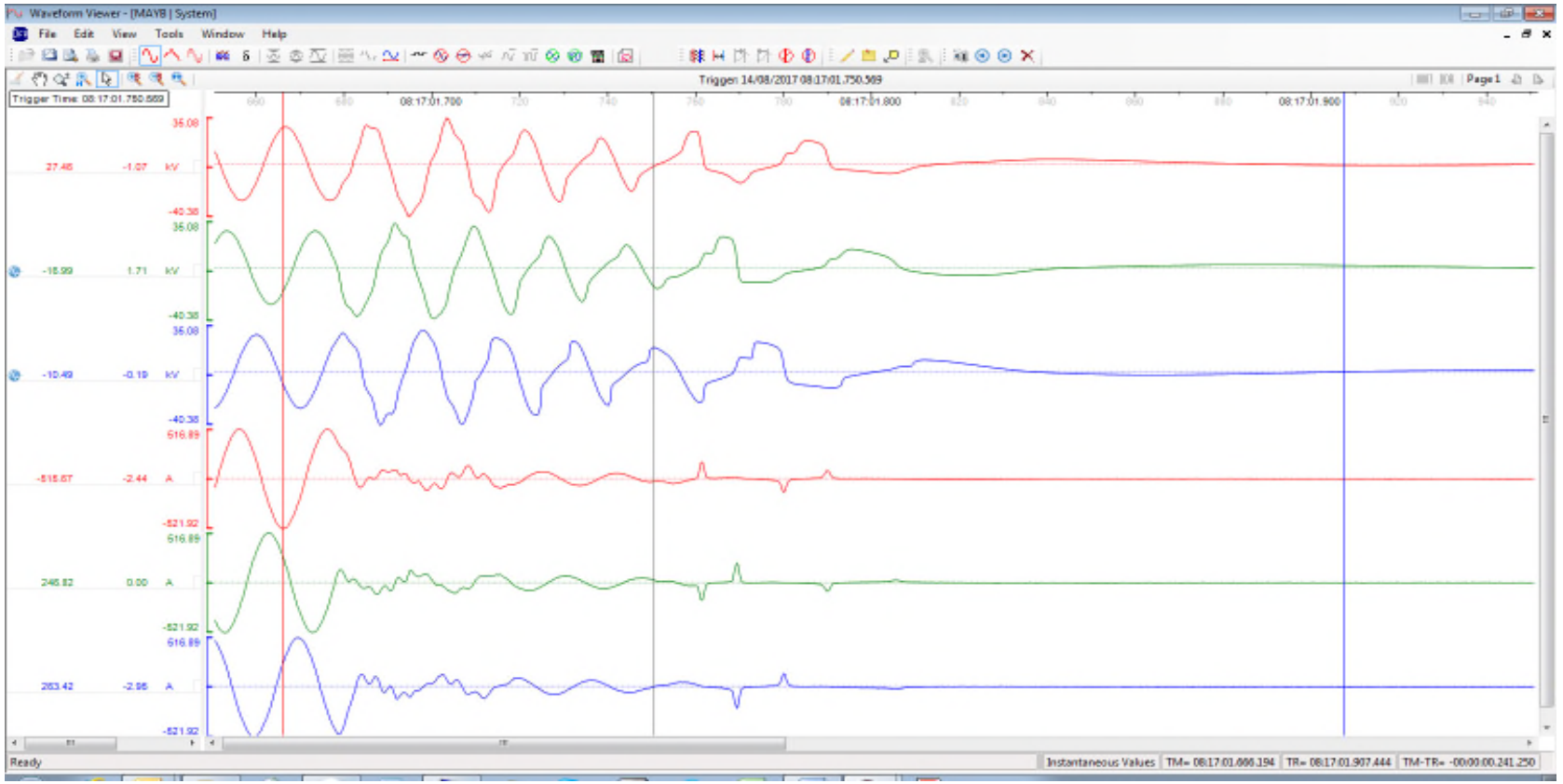
Operation of an LMS scheme raises ‘Stage Signals’ as explained earlier

When these signals are received, data is recovered from Fault Recorders associated with the LMS

We have reviewed 42 LMS operations in 2017 so far – all have operated correctly

Fault Recorders are completely independent of the LMS IEDs so any incorrect operation would be detected

Example high resolution Digital Fault Record (DFR) from wind farm trip caused by LMS operation

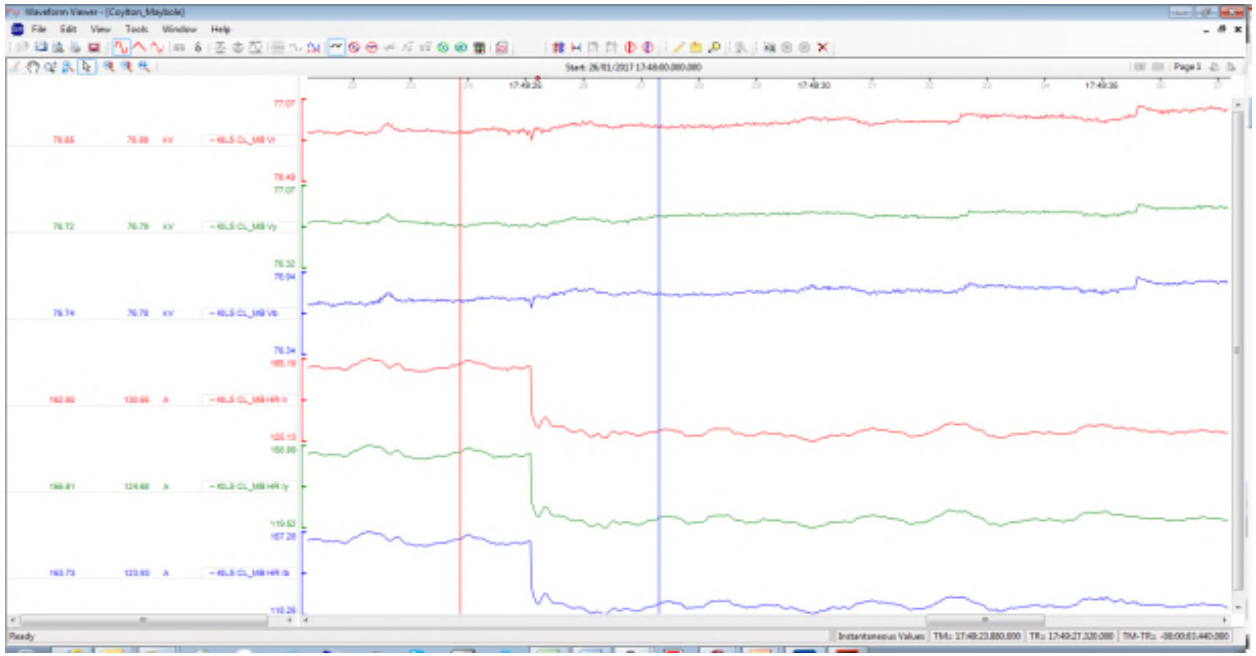


However, not practical to set Fault Recorders to trigger on overcurrent levels which change with the seasons

Therefore the Fault Recorder's extended functionality is utilised, in particular "continuous slow scan" feature (CSS)

Lower resolution recording than DFR (1 rms value per cycle)

Ideal for LMS monitoring



CSS is typically retained on the Fault Recorder for 2 weeks before being overwritten

Therefore it is important that any data / investigation requests are received within this timescale!

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Load Management Scheme Seminar

24th August 2017

Operational Control Centre Kirkintilloch

Overview

- OCC Kirkintilloch
- Operating load management schemes
- Managing events – planned and unplanned
- Questions

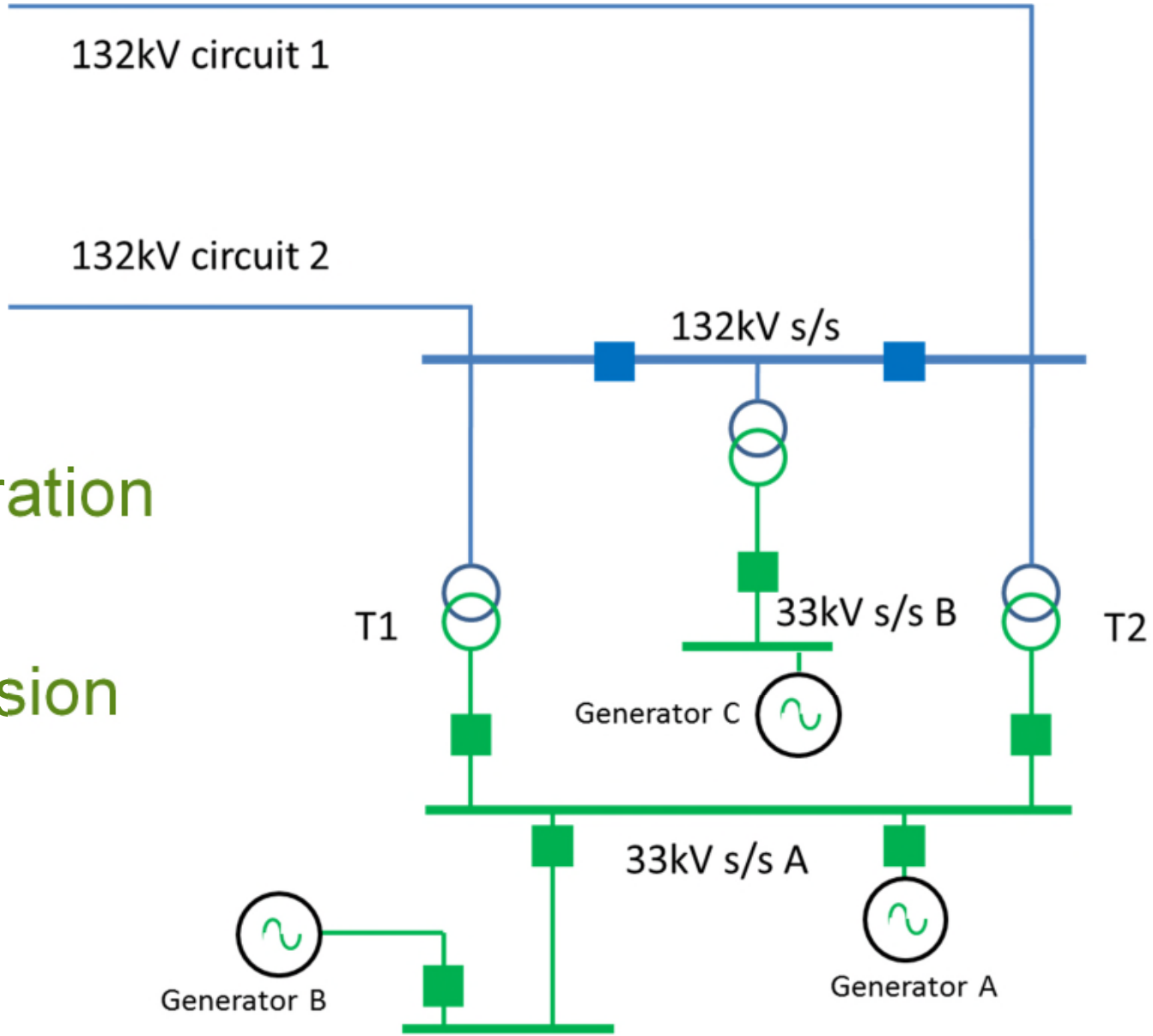
Operational Control Centre at Kirkintilloch

2 Control Functions

- Transmission Control (33kV and above)
- Distribution Control (33kV and below)

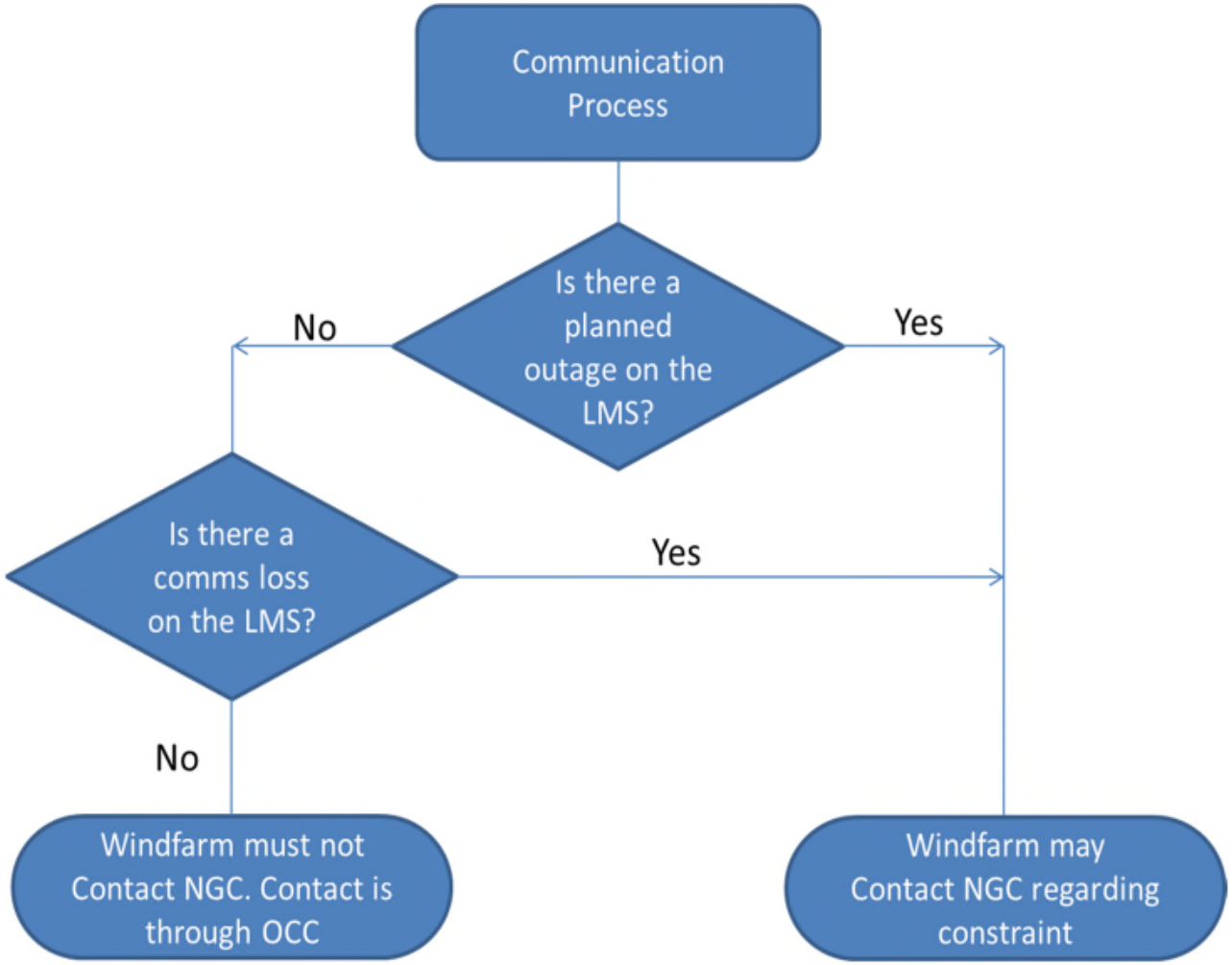
Both functions situated at Kirkintilloch

- 4 schemes in operation
- Protects Transmission assets



Communication

- Planned?
- Unplanned?



Questions and discussion