CM089 – Electricity System Restoration Standard
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STCP 04-6 Issue 003 Offshore Datalink Functional Specification for Telecontrol Communication Interface

STC Procedure Document Authorisation

Company	Name of Party Representative	Signature	Date
National Grid Electricity System Operator Ltd			
National Grid Electricity Transmission plc			
SP Transmission plc			
Scottish Hydro Electric Transmission plc			
Offshore Transmission Owners			

STC Procedure Change Control History

Issue 001	19/10/2009	New Procedure for Offshore Transmission Regime
Issue 002	25/11/2013	Issue 002 incorporating PM070
Issue 003	01/04/2019	Issue 003 incorporating National Grid Legal Separation Changes
Issue 004	07/09/2023	Issue 4 incorporating changes to facilitate the Electricity System Restoration Standard

Introduction

This document describes the functional requirements for a Telecontrol Communication Interface (TCI) to enable the National Electricity System Operator (NETSO) to safely control, monitor and supervise Offshore Transmission Owner (OFTO) Network Assets (Plant and Equipment).

If the NETSO directly operates the OFTO Network Assets through the TCI, these additional requirements are marked in italics and underlined, otherwise these requirements are not applicable.

It is anticipated that these Network Assets will be mainly at OFTO Offshore locations but could include some OFTO Onshore Assets, at grid connection points.

To achieve this function, control and data acquisition systems will be required to interface to the OFTO control equipment, which will allow operation and supervision from a Remote Control Point located at the Electricity Network Control Centre (ENCC).

Abbreviations

ENCC	Electricity Network Control Centre
IEMS MAIN	One of the NETSO SCADA Master stations
IEMS DBU	Disaster Backup Unit: One of the NETSO SCADA Master stations
NETSO	National Electricity Transmission System Operator
GI74	General Indications 1974 (NGESO SCADA communication protocol)
IEC101	Abbreviation for IEC60870-5-101, International Electrotechnical Commission standard for SCADA used by NGESO
IEMS	Integrated Energy Management System – This is the NETSO SCADA Master System consisting on the Master stations MAIN and DBU. (Disaster Backup Unit)
OFTO	Offshore Transmission Owner
SCADA	Supervisory Control and Data Acquisition
TCI	Telecontrol Communications Interface

Architecture

The TCI shall be provided by the OFTO at an Onshore location determined by the NETSO.

The TCI shall enable connection to at least 2 independent SCADA stations (Main and Backup system at the NETSO control centre) via independent ports. Each port shall be equipped with a direct and alternate channel. Hence the TCI shall support 4 communication channels organised as two independent ports with two communication channels (Main and Alternate) on each port. These ports and channels shall support GI74 or IEC101 Communication Protocol, as agreed with the NETSO and described in Appendix A (GI74) and Appendix B (IEC101).

The NETSO shall provide and manage the communication infrastructure and the telecommunication services up to the TCI.

The following functions shall be supported through the TCI and are described in this document: –

Plant and Equipment Alarms
Alarm Grouping
Digital Plant Indications
Analogue Indications
Transformer Tap Positions
Maintenance Indications
Plant and Equipment Controls
Circuit Breaker Synchronising

Additional Functional Requirements and Configuration and Test Requirements of the OFTO control systems are described in Appendix D.

Technical Requirements

1 Telecontrol Communication Interface

The Offshore Transmission Owner (OFTO) system shall provide a Telecontrol Communication Interface (TCI) to the Remote Control Point, using GI74 or IEC101 protocol as agreed with the NETSO.

For the avoidance of doubt, there is no obligation to change existing GI74 installations to IEC101 protocol. However, there is nothing to prevent this change where an OFTO chooses to so. It is expected that all new installations will use IEC101 protocol.

The message exchange and control action sequences of GI74 protocol is specified in Appendix A. IEC101 configuration requirements are described in Appendix B and C. The TCI shall consist of two independent ports for communication with the Remote Control Point.

For the avoidance of doubt, this specification only applies to communications between the OFTO TCI and NGESO. It specifically excludes inter-control centre communications between Transmission Owners and NGESO.

Each port shall provide main and alternate communication channels.

1.1 Channel Switching

To provide backup and physical diversity the communications between the slave and master stations there is a requirement for the communications to be able to be directed to one of two physical channels out of each of the master stations (iEMS Main and DBU).

The slave station is required to have 2 physical channels to the iEMS Main and 2 physical channels to the DBU.

The master station decides which channel is healthy and directs traffic to this channel. A channel is considered to be healthy provided a valid response is received from the slave station within the timeout period.

If communications fail at the IEC101 link level the master station will attempt a reset of the link before changing to the back-up channel and on changing channels the master station will perform a station initialisation. Likewise, for GI74 the master station will attempt to switch to the other route in case of a communications failure.

At the slave station both connections may be considered as identical and the slave station shall transmit responses on the channel from which the interrogation was received. A response should not be sent on the backup channel if the active channel fails before the response can be made.

For GI74 TCIs the health of each channel is checked using hardware handshaking (see Appendix A).

For IEC101 TCIs a request Link Status shall be sent by the master station (approx every 10 to 30s) to the non active communication channels. This is to confirm that the non active communication channels are healthy. The link layer of the non active communication channels shall respond appropriately to the Request Link Status received. If the Request Link Status is not received on a non active communication channel within a configurable period (default 120s), then the appropriate channel fail alarm for this channel shall be set.

1.2 Multiple Port Working

In order to allow the iEMS Main and the DBU to independently scan the slave station two ports, each consisting of two independent point-to-point communications channels, as mentioned above, are required from each slave station. There is no coordination between the

communications channels and therefore frames may be transmitted simultaneously on all channels.

Channel switching shall be supported as above.

Both IEMS Main and iEMS DBU communications are required to be supported simultaneously (on different ports) and may transmit different information (from within the same range of data).

2 TCI Control and Control Arbitration

The NETSO has "control" responsibility and shall either operate the OFTO Network Assets directly or instruct others to operate the OFTO Network Assets. However, for consistency "Control" is used for the location operating the plant and "Point" the location from which this action may be initiated.

In this document the Remote Control Point is the Electricity Network Control Centre (ENCC) which is to be configured as the master station.

This document does not cover the OFTO control point requirements.

At the TCI, comprehensive information relating to the plant status shall be presented; this shall consist of indications of plant and equipment states, alarms necessary to safely control and supervise plant and equipment and indications of primary circuit and supervisory analogue values.

When the Remote Control Point is not the active point of control, the TCI shall still provide the above information.

When the Remote Control Point is the active point of control, then controls received at the TCI shall be executed.

Under normal conditions the Remote Control Point shall be the normal or default control point.

The Remote Control Point shall be able to take control if it is not currently in control.

The Remote Control Point shall take control of the OFTO Network Assets by sending a specific control to the TCI. This action shall result in control of the OFTO Network Assets (except those switched into maintenance) being transferred to the Remote Control Point.

An indication shall be provided at the TCI to indicate the control point currently in control of the OFTO Network Assets.

At any one time only one control point shall have control of each OFTO Network Asset (Plant and Equipment) and this control status shall be reported to the TCI.

2.1 Control Authority

Plant controls at the slave station shall only be allowed on one port at any one time. The selection of which port is allowed to control is termed Control Authority.

On the slave station, a User Application process to block plant controls on ports which are not allowed control is required.

A command from the master station shall select which port at the slave station is to have Control Authority.

All plant controls from the port which does not have Control Authority shall be blocked with the exception of the command to select Control Authority.

Control Authority shall default to the port connected to the iEMS Main when the slave station is initialised.

Failure of the iEMS shall not prevent change of the Control Authority (i.e. it should be possible to change the authority from iEMS Main to iEMS DBU from the iEMS DBU port).

Each Control Centre Computer will have control capability but it is required that only one Control Point shall be in control at any one time. Each Control Centre Computer will be able to take control by issuing a "Taking Control" control and an appropriate indication shall be generated.

The Taking Control control shall be a single acting control allocated at data set-up. The appropriate Control Source Status Indication shall be set to zero in response to the change of control source.

Control selections from a Control Centre Computer that is not in control shall be rejected and General Error Reply returned to the select stage unless the selection is Taking Control control. Data interrogations from the Remote Control Point shall always be serviced by the TCI.

3 Maintenance Facilities

When the OFTO set their Network Assets (circuits, plant or equipment) into a maintenance operation state, an indication shall be provided per circuit at the TCI. It shall then be possible for the OFTO to suppress alarms and indications from that circuit either as a group or individually. This is to avoid nuisance traffic being reported to the Remote Control Point during maintenance and testing of OFTO Network Assets.

An indication per circuit shall be provided when alarms and indications are currently suppressed on that circuit. This shall remain in the alarm condition until all suppression on the circuit has been removed.

4 Synchronising

Synchronising is required for the closure of specific circuit-breakers.

For emergency operation, a separate control shall be provided that bypasses the synchronising facilities to enable closure of the circuit breaker directly via the TCI.

5 Plant Data Acquisition Requirements

The data derived from the status of the OFTO Network Assets shall be Digital Inputs (derived from auxiliary contact closures of primary plant and protection, Tap Position Indications and Alarms) and Analogue Inputs for measured values (derived from instrument transformers).

5.1 Digital Inputs

Digital inputs may be either single or double point. Single point digital inputs shall be utilised where the requirement to detect an indeterminate state is not essential. Double point digital inputs shall be utilised where there is a requirement to discriminate between the two states in order to detect an incomplete operation, as for example in the case of disconnectors, earth switches and circuit-breakers.

5.1.1 Single Point Digital Inputs

A Single Point Digital Input has an association with one physical input and is used when there is a need to detect only two discrete states, i.e. an ON/OFF condition. Plant alarm conditions, for example, are signalled to the TCI via Single Point Digital Inputs.

	Logical Representation
State (1)	0
State (2)	1

The representations of states (1) and (2) shall be able to be reversed.

5.1.2 Double Point Digital Inputs

A Double Point Digital Input has an association with two physical inputs and is used when there is a need to detect an ON/OFF condition and an intermediate state. For example, Circuit Breaker, Disconnector position indications are always signalled to the TCI via Double Point Digital Inputs.

	Logical Representation	
State (1)	1	0
State (2)	0	1
State (3)	1	1
State (4)	0	0

States (1) and (2) shall be considered as normal valid states. States (3) and (4) shall be known as "DBI" (Don't Believe It). The representation of states (1) and (2) shall be able to be reversed by configuration.

5.2 Alarm Grouping

The TCI shall support the grouping of inputs and internally generated signals and for these inputs to be assigned to a group alarm. The transition between states shall follow the validation of the individual inputs to any group.

5.2.1 Grouped Alarms (without Reflash)

This type of group alarm has two states: Normal (OFF) or Abnormal (ON). If **any** of the inputs of a group are in the abnormal state, the grouped alarm shall be in the abnormal state. If **all** of the inputs of a group are in the normal state, the grouped alarm shall be in the normal state. The TCI shall be capable of supporting at least 600 groups of this type, with a capability of 128 inputs per group. A capacity of at least 5000 group inputs shall be provided

5.2.2 Grouped Alarms with Reflash

This type of group alarm has three states: Normal (OFF), Abnormal (ON) or Reflash. The State Transition Diagram in Figure 1 describes the events that cause these states to change. It is required that all (except first) ON alarms in a group are reported by the Reflash setting and then re-setting for each ON occurrence. The TCI must be capable of achieving this requirement under situations where a number of alarms go ON simultaneously or in quick succession. The TCI shall be capable of supporting at least 600 groups of this type, with a capability of 128 inputs per group. A capacity of at least 5000 group inputs shall be provided.

Alarm Group with reflash - State Transition Diagram
Normal State
REFLASH
COMMON
0
0
ODD BIT
EVEN BIT
One Input ON*
Send [0,1] to the Event handler
Last Input OFF
Send [0,0] to the Event handler
Abnormal State
REFLASH
COMMON
0
1
ODD BIT
EVEN BIT
Input OFF but at least one input remaining ON
No Action
Second or subsequent Input ON
Send [1,1] to the Event handler
Reflash State (transitional)
REFLASH
COMMON
1
1
ODD BIT
EVEN BIT
Send [0,1] to the Event handler
* Note the requirement to capture all of the ON alarms

Figure 1

5.2.3 Configuration

The configuration of the TCI is required to provide the following facilities for grouped alarms:-

(i) The ability to allocate any single alarm input to a group alarm.
(ii) The ability to assign a text string of at least 30 characters to uniquely identify the group.
(iii) The ability to allocate each group alarm for output to the Remote Control Point.

For simple grouped alarms the status of the grouped alarm shall be sent to the Remote Control Point as a single point alarm.

For Grouped Alarms with Reflash, the status of each group alarm must be sent to the Remote Control Points as a "Common" and a "Reflash" alarm. Common and Reflash alarms should be presented as separate single point indications.

Note: Reflash is generally only required for Category 3 alarms which may not be required in the majority of cases. It is therefore worth checking whether this feature is required for a specific application/project.

5.3 Tap Position Indication

A Transformer Tap Position indication has an association with multiple physical digital inputs. The maximum number of physical digital inputs associated with each indication will be 31. The tap position in GI74 applications is required to be presented at the TCI in Gray code format (see Appendix A).

In IEC101 applications the tap position is required to be presented at the TCI as a step position indication. (see Appendix C)

Optionally the TPI may configured to be sent as an analogue value (see 5.4)

5.4 Operational Metering Data

Operational metering data is required from the OFTO Network/Assets in order for the NETSO to operate the connected system. The following measurements shall be provided as appropriate to the connection and/or plant type and the measurement result delivered at the TCI:

- Voltage
- Current
- Active Power
- Reactive Power
- Frequency
- Plant Temperature
- Wind Speed
- Wind direction
- Oil level indication

5.4.1 Performance and Functional Requirements

Measurement Accuracy, Resolution, and Range requirements for operational metering data delivered at the TCI are given in Table 1

For Voltage, Current, MW and MVAr measurements, accuracy and resolution requirements are inclusive of all errors in the measurement and information transmission chain, with the exception of the errors of the associated plant and interposing CTs and VTs.

For frequency, plant temperature, wind speed, wind direction and oil level indication measurements, accuracy and resolution requirements are inclusive of all errors in the measurement and information transmission chain.

Measurement	Measuring Range	Accuracy (+/-% of measuring range)	Resolution (% of measuring range)
Voltage	5 to 120% of nominal system voltage (kV)	0.2	0.1
Current	5 to 200% of plant rating (Amps)	1.0	0.1
MW/MVAr	5 to 200% of plant thermal rating (MW/MVAr)	0.5	0.1
Frequency	45 to 55 (10) Hz	0.1	0.05
Plant Temperature	0 to 150 deg C	1	0.5
Wind direction	0 – 360 deg	±5	2
Wind speed	0 – 60 m/s	5	1
Oil level indication	0 -100%	1	1

Table 1
Measurement Accuracy, Resolution, and Measuring Range for operational metering data delivered at the TCI

MW and MVAr measurements shall be scaled 3 phase. Single phase measurement is permissible. Bi-directional measurement is required. The sign convention of such measurements shall be agreed with NGESO.

For MW measurements the performance requirements given in Table 1 shall be met at a system Power Factor of unity. At a system Power Factor of 0.5 lag / lead the accuracy shall be within +/- 1 % of the measuring range.

For MVAr measurements the performance requirements given in Table 1 shall be met at a system Power Factor of zero. At a system Power Factor of 0.866 lag / lead the accuracy shall be within +/- 1 % of the measuring range.

For overhead line feeder circuits, higher overload factors will be required to those given in table 1 for MW, MVAR and I measurements. For these circuit types the upper limit of the measuring range shall be the 3 minute thermal circuit rating.

Primary system and interposing CTs and VTs as used to derive MW, MVAr, V and I measurements shall be to IEC class 0.5 or better

For voltage and current measurements, RMS, single phase (or phase to phase voltage) type measurements are required. Voltage measurements shall be scaled phase to phase where derived from a phase to neutral measurement..

For frequency measurement the requirements for accuracy and resolution as stated in Table 1 are in terms of the measurement range (10 Hz).

6 Change of State Validation

Validation filtering shall be applied to all changes of state before they are reported to the TCI. This requirement shall apply to Single Point, Double Point and Transformer Tap Position Digital Inputs. Two levels of validation filtering shall be implemented. The overall requirements differ for Single Point, Double Point and Transformer Tap Position digital inputs but the first level validation shall be common to all three input types.

6.1 First Level Validation

Filtering shall be applied to each physical input to suppress the effects for example of contact bounce and eliminate the possibility of erroneous changes of state being generated by power frequency interference.

6.2 Second Level Validation

For Single Point Digital Inputs, a filter shall be applied to all transitions from State(1) to State(2) and from State(2) to State(1). In each case, the new state shall be reported only if it persists for a configurable period of time. The filter period shall be configurable on a per-input basis and shall be allowed to assume integer values within the range 0 to 60 seconds. The default shall be 0 seconds.

For Double Point Digital Inputs, a filter shall be applied to all transitions to State (3) and to State (4). In each case, the new state shall be reported only if it persists for a configurable period of time. The filter period shall be configurable on a per input basis and shall be allowed to assume integer values within the range 0 to 30 seconds. The default shall be 20 seconds.

For Transformer Tap Position Digital Inputs, a filter shall be applied to all transitions to invalid states. A new (invalid) state shall be reported only if it persists for a configurable period of time. The filter period shall be configurable on a per-Tap Position Indication basis and shall be allowed to assume integer values within the range 0 to 30 seconds. The default shall be 20 seconds.

Transformer Tap Position digital inputs will be presented to the TCI in a “1 of N” format. The following shall therefore represent invalid states:
(i) More than one input is detected to be in the SET state
(ii) All inputs are detected to be in the RESET state

7 Initialisation

Following the initialisation of the OFTO equipment, the initialisation shall be indicated to the Remote Control Point by the setting and re-setting of a configured single point at the TCI. No entries shall be placed on the GI74 change queues as a result of the system initialisation. For IEC101 the signal “End of Initialisation” should be sent.

8 Other Functional Requirements

8.1 Dummy Circuit Breaker

A Dummy Circuit Breaker Control and Indication shall be provided at the TCI. This shall be a pair of special controls (Open and Close), which can be operated by the Remote Control Point, even when it is not the active control point. The operation of this control shall change the state of an associated Dummy Circuit Breaker Double Point Indication.

The Dummy Circuit Breaker is not necessarily a physical piece of equipment and is used to verify that the TCI is healthy

8.2 Half Hour Clock Pulse

The Half Hour Clock Pulse is a dedicated alarm which changes state every 30mins ± 5s.to ensure that the digital event reporting function is healthy.

8.3 Route Fail Alarms

The four communication channels (2 ports, main and alternate) shall be monitored at the TCI and if the loss of communications or carrier signal is detected at the TCI, then an alarm shall be raised.

There shall be one alarm for each communication channel.

The alarm and the reset conditions shall be reported to the TCI once the condition has been validated, to avoid nuisance alarms being sent.

9 Performance of the TCI to the Remote Control Point

The system is required to make data available at the Remote Control Point TCI and act on control requests presented at these interfaces within the response times defined in Table 2.

Table 2 TCI - Remote Control Point - Response Times

Description	Activity Level	
	Normal	
	Mean (seconds)	Standard Deviation (seconds)
Time from a single alarm/indication changing state to the change being indicated at the TCI	1.0	0.25
Correct analogue value available at TCI within --	2.0	0.5
Time from receipt of control at the TCI to control execution output	*0.75*	*0.25*

10 TCI Performance

10.1 Channel Utilisation

The TCI reply time to all interrogations at the telecommunications interface shall be consistent with maintaining a channel utilisation of 85% at 300 baud (GI74) for full block scanning of analogues. This figure is based on the assumption that no delay is introduced by either the communications path or the Remote Control Point This performance requirement applies to the working channel on each port, as defined in Appendices B and C. The IEC101 baud rate is 9600 and therefore performance shall at least match the criteria set for GI74.

10.2 Change Queue Mechanism

The two change queues (one on each port) shall operate independently. Changes are to be entered onto the change queue in the correct order of occurrence. For GI74 this shall occur at a rate of not less than 30 per second. This corresponds with the rate at which the changes can be removed at a maximum data rate of 300 bits/s with a channel utilisation of 85%.

For IEC101 performance shall be significantly better due to the higher data rate (9600 bits/s). Please refer to Appendix B for performance requirements.

10.3 Test Requirements

The testing of the system shall be undertaken as:

(i) A Type Test on the initial system TCI.

(ii) Factory Testing of Database Configurations on production systems

10.4 Type Tests

These tests shall be performed to demonstrate that the system offered complies with the functional and performance requirements set out in this specification and that the equipment is capable of operating in a consistent and correct manner within the specified operating environment. The supplier shall be required to have agreed by the NETSO, 4 weeks prior to commencement of the type tests, all documentation relating to the Test Specifications. The NETSO can provide guidance on the scope and content of Test Specifications.

The Type Tests shall exercise all aspects of the systems functionality, simulating, where appropriate the system interfaces to demonstrate the integrity of the specific implementation.

The Type Tests shall include verification of a system configuration by testing from the plant interfaces through to the Remote Control Point. The end to end and performance testing of the Remote Control Point TCI shall be undertaken using an agreed emulation facility.

If the IEC101 protocol is used the OFTO shall also provide a certificate of conformance to the IEC 60870-5 standard from an accredited third party test house. The latest versions of the standards and any published amendments shall be used. The conformance testing shall be in accordance with the principles of IEC 60870-5-6 and the test cases as defined in IEC 60870-5-601.

11. Mains Independence

11.1 Each OFTO who had concluded purchase contracts for its Offshore Transmission Plant and Apparatus on or after XXXX *(12 months after approval of CMo89)* is required to ensure that the Offshore Datalink includes a Mains Independence capability of up to 72 hours from the loss of supplies. In the event of loss of the main Grid supply, the OFTO shall have the following capabilities:-

i) Control room Apparatus and tools for monitoring their System including but not limited to, alarms, real time system operation and operational security analysis including off line network analysis;

ii) The ability to control, protect and monitor those assets necessary for System Restoration including switchgear, tap changers and other network equipment including where available auxiliary equipment and to ensure the safe operation of Plant and personnel; and

iii) Operational Telephony as provided for in STCP 04-5;

for a period of up to 72 hours from the start of the Total Shutdown or Partial Shutdown.

APPENDIX A

TELECONTROL COMMUNICATION INTERFACE
REMOTE CONTROL POINT - GI74 PROTOCOL REQUIREMENTS

FOREWORD

This Appendix forms part of the National Electricity Transmission System Operator(NETSO) Interface Requirements Specification for Offshore Transmission Owner (OFTO) Networks Assets.

1 SCOPE

The scope of this Appendix is limited to the definition of the requirements of a Telecontrol Communication Interface (GI74 TCI) using GI74 communications protocol and provides remote control, data acquisition and monitoring to a Remote Control Point located a the Electricity Network Control Centre (ENCC).

All functions are required, however if the NETSO does not directly operate the OFTO Network Assets, then the appropriate control functions shall not be utilised by configuration.

1.1 *Overview*

The GI74 TCI is required to support the GI74 protocol and there are two distinct requirements:

a) On-line data communications requirement
b) Off-line data set up requirement.

The on-line data communications utilises GI74 protocol. This is an asynchronous word based protocol with 16 data bits and a 5 bit Cyclic Redundancy Check (CRC). The GI74 protocol supports the cyclic scanning of analogue data, the “on change” transfer of points (digital) data, the check scanning of points data and the ability to send plant controls.

The off-line data set up facility is required to allow site specific data to be allocated addresses within the GI74 data structure.

2 REFERENCES

None

3 GENERAL REQUIREMENTS

3.1 On-line Data Communications

GI74 protocol utilises a master/slave relationship, the Remote Control Point being the master, which scans the slave (GI74 TCI) with interrogation words.

The GI74 protocol is described in the following sections using a model with a physical level, a data link level, a network level and a transport level. Higher levels are not within the scope of this specification. This is shown in Figure 1

Figure 1

3.1.1 Physical Level

The GI74 TCI shall be dual-ported, the term used to indicate that it shall support being scanned by two independent systems located at the ENCC. Each port shall possess a main and alternate channel, consequently giving a requirement for four serial communications channels. This is shown in Figure 2.

Since the two systems at the Remote Control Point are independent, **each** of the ports is required to support the GI74 protocol completely independently. Each port must at all times support the receipt of block, word, special request interrogations, the transmission of replies and operation of the send changes mechanism.

At any one time only **one** port must act on the receipt of plant control outputs. Each of the communications channels are required to support the following ITU-T V24 signals at V28 levels:-

Transmit data.	TX DATA
Receive data.	RX DATA
Request to send.	RTS
Data carrier detect.	DCD
Signal ground.	0V

Each channel shall be equipped with a separate connector. The Supplier's Functional Specification is required to detail the proposed connector interface.

Each channel shall support a baud rate of 300baud .

Section 4 states the performance requirements for GI74 communication interfaces.

Figure 2

Each channel shall be required to communicate with the Remote Control Point via modems working over a 4 wire circuit to ITU-T R Series recommendations.

On all channels the RTS signal shall always be in the ON condition so that transmit carrier is sent continuously. Each channel shall provide a status indication giving an alarm for persistent loss of incoming carrier (DCD).

3.1.2 Data Link Level

3.1.2.1 23 Bit Word Structure

Each GI74 channel shall support asynchronous communications with the following word structure:-

1 start bit.
16 data bits (bit 0 is the least significant and follows the start bit).
5 CRC (parity) bits (these are bits produced by the generator polynomial
$1 + x^2 + x^5$ + offset 00011 - see Appendix A2).
1 stop bit.

Each word received by the interface will conform to the above format and the CRC bits shall be used to check that the received word is valid. The action to be taken on CRC (parity) failure is described in Section 3.1.4.3.2. Each word transmitted by the GI74 TCI shall conform to the above format and it shall generate the CRC bits from the 16 data bits.

3.1.2.2 Half Duplex Operation

The GI74 TCI shall provide true half duplex operation on all GI74 communication channels. This means that when the GI74 TCI is transmitting it is required that the receiver is disabled and when the GI74 TCI is receiving it shall not be possible for it to transmit. If for any reason, an interrogation arrives while the GI74 TCI is transmitting; the interrogation is required to be ignored.

3.1.3 Network Level

Each system at the Remote Control Point will normally communicate with its GI74 TCI over a main route. In the case of main route failure, communication will transfer to the alternative route. Replies shall be made to the Remote Control Point along the same route on which the interrogation was received.

3.1.4 Transport Level

The GI74 protocol is based on the GI74 TCI receiving Interrogation Words or Controls and returning Replies. The following sections provide a definition of the Interrogation Words and Controls that may be received from each Remote Control Point and the Replies that the GI74 TCI is to provide. The required GI74 message formats are detailed in a series of drawings in Appendix A1.

3.1.4.1 Interrogation Word Formats and Replies

The 16 data bits within an Interrogation Word (received by the GI74 TCI from a Remote Control Point) contain the outstation address and the data address (function, block, and word) of the data required by this particular Remote Control Point. Section 3.2 of this specification describes the GI74 data structure in terms of the data address.

The general allocation of bits in an interrogation word is as follows; (bit 0 is the least significant):-

Bits 0-7 These bits form the outstation address (see Section 3.2.1).

Bits 5-7 These bits overlap the outstation address and form the block address (see Section 3.2.1).

Bits 8-10 These bits form the word address, allowing up to 7 words to be addressed by the Remote Control Point (words 1-7; word 0 is used for block interrogations - see Section 3.1.4.1.1 and 3.1.4.1.2).

Bits 11-14 These bits form the function address, allowing up to 16 functions to be addressed by the Control Point (functions 0-15).

Bit 15 This bit is the Reset Bit (see Section 3.1.4.4).

The Reply from the GI74 TCI to the Interrogation Word shall consist of a block of up to eight words. The Checkback Word shall be the first word of the Reply. The Change Bit is bit 15 of the Checkback Word and shall be used to indicate to the Remote Control Point that a change of status has occurred. (See Section 3.1.4.4). A number of Data Words shall follow the Checkback Word, the number being dependent on the type of interrogation (block interrogation, word interrogation or special request interrogation) and the format being dependent on the data type.

3.1.4.1.1 Block Interrogation and Reply

When the Remote Control Point requires the GI74 TCI to return a block of Data Words the Interrogation Word consists of the outstation, block and function addresses with the word address set to zero.

The Reply from the GI74 TCI shall consist of a Checkback Word and up to 7 Data Words. Bits 0-7 and bits 11-14 of the Checkback Word shall be identical to the Interrogation Word and bits 8-10 shall contain the word number of the lowest allocated data word in the block. Bit 15 is the change bit.

E.g. If word 4 is the lowest word, then bits 8-10 of the Checkback Word shall contain the binary code 100 (i.e. word 4). Since words are always allocated from word 7 downwards the Checkback Word shall be followed by Data Words 4, 5, 6, and 7.

3.1.4.1.2 Word Interrogation and Reply

When the Remote Control Point requires the GI74 TCI to return a single Data Word, the Interrogation Word consists of the outstation, block and function addresses with the word address set to the data word required.

The Reply from the GI74 TCI shall consist of a Checkback Word and the single Data Word requested. In this case the Checkback Word shall be identical to the Interrogation Word, except perhaps for the Change Bit.

3.1.4.1.3 Special Request Interrogations and Replies

The Special Request Interrogation function and block are defined at data set up time (see Section 3.2.3.1). The GI74 TCI shall be capable of processing the following special requests:-

3.1.4.1.3.1 Send Changes

This consists of a 16 bit word received by the GI74 TCI from the Remote Control Point. The allocation of bits is as follows; (bit 0 is the least significant):-

Bits 0-7	Outstation address as for an Interrogation Word.
Bits 5-7	These bits form the block address allocated at data set up time.
Bits 8-10	These bits form the word address. For the Send Changes Interrogation these bits will be 001 (i.e. word 1).
Bits 11-14	These bits form the function address allocated at data set up time.
Bit 15	This bit is the Reset Bit.

The Send Changes Interrogation is used as part of the Send Changes Mechanism. The Send Changes Mechanism is described in Section 3.1.4.4 where the operation of the Change Bit and Reset Bit are described and the requirements of the Change Queue are defined.

3.1.4.1.3.2 Multiword Cleardown (MWC) and Reply

This consists of a 16 bit word received by the GI74 TCI from the Remote Control Point. The allocation of bits is as follows; (bit 0 is the least significant):-

Bits 0-7	Outstation address as for an Interrogation Word.
Bits 5-7	These bits form the block address allocated at data set up time.
Bits 8-10	These bits form the word address. For the Multiword Cleardown Interrogation these bits will be 010 (i.e. word 2).
Bits 11-14	These bits form the function address allocated at data set up time.
Bit 15	This bit is the Reset Bit.

The GI74 TCI is required to reply to Multiword Cleardown with a General Error Reply (GER). General Error Reply is defined in Section 3.1.4.3.1.

3.1.4.2 Controls and Replies

The GI74 TCI shall support controls for output to the substation which are received from the Remote Control Point as three separate words. The GI74 TCI shall acknowledge each word immediately after it is received with a separate checkback word. The structure of each of the words is described in the following sections.

3.1.4.2.1 Control Selection Word

The first word (the control select word) identifies the control select function as a control output (bits 11-14), block (Part 1 address, bits 5-7) and word (Part 2 address, bits 8-10) within the data structure. The GI74 TCI shall reply with a regenerated copy of the word received, except possible for bit 15, the Change Bit. After the successful receipt of a control select word the GI74 TCI shall interpret the next word received as a data word. The Remote Control Point will not act on a set Change Bit until the control sequence has completed.

3.1.4.2.2 Data Word

The second word (the data word) provides the data for the selected output. It identifies the specific control output bit (Part 3 address). Bits 8-11 contain a binary encoded number between 0 and 15 (bit 8 least significant) that represents the control output. The GI74 TCI shall confirm that bits 12-15 are the compliment of bits 8-11. If this is the case then the GI74 TCI shall reply with a regenerated copy of the word received; otherwise General Error Reply shall be returned.

3.1.4.2.3 Control Execute Word

The third word (the execute word) identifies the control execute function (bits 11-14), block (Part 1 address, bits 5-7) and word (Part 2 address, bits 8-10) within the data structure. The Part 1 and Part 2 addresses should be the same as those previously received in the control select word. If this is the case the GI74 TCI shall reply with a regenerated copy of the word received, except for possibly bit 15, the Change Bit; otherwise the control shall be deemed to have failed and General Error Reply shall be returned.

3.1.4.3 Error Replies

The GI74 TCI shall support the error replies described below. Note that, apart from a No Reply, error replies shall consist of a single word reply.

3.1.4.3.1 General Error Reply (GER)

The GI74 TCI shall return General Error Reply if it recognises the outstation address of the interrogation but the remainder of the interrogation is incorrect. General Error Reply shall be returned in response to the following:-

A word interrogation is received that addresses a word not defined in the database.

A block interrogation is received which addresses a block not defined in the database.

An interrogation for a function that is not defined in the database.

A send changes interrogation is received when no change is outstanding.

A control selection is received which addresses a control output not defined in the database.

A control output selection is received from the Remote Control Point that the system judges does not have Control (other than Taking Control).

A Multiword Cleardown Interrogation is received.

An invalid Execute is received.

General Error Reply shall be a 16 bit word with bits 0-7 being the outstation address (bits 5-7 being the lowest allocated block) and bits 8-14 being set to zero. Bit 15 shall still operate as the Change Bit in the General Error Reply.

3.1.4.3.2 Parity Fail Reply (PFR)

If the GI74 TCI receives any interrogation that fails the 5 bit cyclic redundancy check then Parity Fail Reply shall be returned on the same channel.

Parity Fail Reply shall consist of a 16 bit word containing all zeros and the 5 bit CRC field also containing all zeros. This bad parity reply is returned to deliberately cause a parity failure to be logged by the Remote Control Point system.

3.1.4.3.3 No Reply

If an Interrogation Word with an outstation address (bits 0-7) not matching the outstation address set up in the GI74 TCI is received, then it shall make no reply to the Remote Control Point.

3.1.4.4 Send Changes Mechanism

The GI74 TCI shall return changes to the Remote Control Point independently on each port using the send changes mechanism described in this section.

3.1.4.4.1 Change Bit and Reset Bit

When a change of status of an alarm, indication or binary tap position occurs this shall be signalled to the Remote Control Point by the GI74 TCI setting the Change Bit (bit 15) in the Checkback Word on the next interrogation. When the Remote Control Point detects that a Change Bit is set it will interrogate the GI74 TCI with the Send Changes Interrogation and it shall return a Reply consisting of a Checkback Word followed by the Data Word that contains the changed bit(s).

The Checkback Word shall give the address of the changed word and will be constituted with bits 0-7 as the outstation address, bits 5-7 as the block address, bits 8-10 as the word address and bits 11-14 as the function address. In the case of the reply to a Send Changes Interrogation bit 15 is set to indicate the presence of further changes on the change queue. When the change has been successfully returned, the next Interrogation Word from the Remote Control Point will have the Reset Bit (bit 15) set as an acknowledgement to the GI74 TCI.

3.1.4.4.2 Change Queue

The GI74 TCI shall provide a time ordered Change Queue of at least 500 changes. There shall be a separate change queue for each port. A Send Changes Interrogation shall cause the change at the head of the queue (the oldest change) to be returned. If the Reset Bit is not set in the Interrogation Word immediately following the send changes reply then the change that was returned shall not be removed from the head of the queue.

The Change Bit shall be set in the Checkback Word while there are entries in the queue, and reset while the queue is empty. In the case of the Checkback Word sent in reply to a Send Changes Interrogation the Change Bit is set to indicate that there are further changes on the change queue. In the event of the queue overflowing then the oldest entries shall be removed to make room for new changes.

Note that the change queue mechanism shall ensure that individual changes that occur with more than 10 ms between them are returned sequentially in the order of change occurrence. Changes that occur within 10 ms can be considered to be simultaneous and they can be entered in the change queue in any order.

E.g. If say, 3 changes occur (each more than 10ms after the previous change) that are allocated to the same word, then these changes shall be returned using the change mechanism to return change one in the first Reply, change two in the second Reply and change three in the third Reply. The address of each word returned, and hence the Checkback Word in each Reply, will be the same, except that the Change Bit will be set in the first and second Checkback Words and reset in the third Checkback Word.

If a port is not being interrogated it is required that all changes are stored on the queue. They will be returned via the changes mechanism when the Remote Control Point connected to that port resumes interrogations.

Dual port and dual channel operation and control arbitration is to be implemented as described in section 2 of the main document (TCI and Control Arbitration)

3.2 Off-line Data Set Up

The off-line data set up facility is required to allow the user to allocate plant data to the GI74 data structure and to set up attributes that reflect the operation of the communications link to the Remote Control Point.

The data and attributes given here are those that are a known requirement to allow the system to work with the Remote Control Point. Data and attributes that will need to be input relating to the implementation of GI74 on a particular system are not known and therefore not given in this Specification.

3.2.1 Outstation Address and Size

There are four types of outstation address, which are linked to the size.

(i) Size - 8 block 5 - bit outstation address field and 3 bit block field (maximum of 31 unique outstation addresses)

(ii) Size - 4 block 6 - bit outstation address field and 2 bit block field (maximum of 63 unique outstation addresses)

(iii) Size - 2 block 7 - bit outstation address field and 1 bit block field (maximum of 127 unique outstation addresses)

(iv) Size - 1 block 8 - bit outstation address field and no block field (maximum of 255 unique outstation addresses)

The data set up facility shall allow the input of outstation address and size and there shall be no restriction in the use of any of the above address types.

The outstation address is determined by the lowest equipped block. Outstation address zero is not used. Appendix A3 provides more information on the block / outstation address relationship.

3.2.2 Data Set Up

Data that is to be acquired for the Remote Control Point by the GI74 TCI or outputs controlled by the Remote Control Point via the GI74 TCI are required to be allocated a GI74 address within the GI74 data structure by the use of the an off-line data set up facility. Each port shall be set up with the same database.

Data requires to be allocated a Function address (0-15), a Block address (0-7) and a Word address (1-7). Note that controls may be allocated Word addresses 0-7 (Part 2 address).

A single function contains up to 8 blocks and a single block contains up to 7 words of data. A block of data is all of the same data type (see Section 3.2.2.1). The size of the data structure for any single GI74 TCI is determined by the number of blocks (either 1, 2, 4 or 8).

Data is held in 16 bit words with a maximum of 7 words in each function/block address combination.

E.g. Function 2, Block 0 contains a maximum of 7 sixteen bit data words that may be allocated to dynamic plant data.

Within each block of data, words are to be allocated from word 7 downwards. For this reason, it shall be possible for each function to input, using the data set up facility, the lowest word number in each block.

Note that the definition of the lowest word in the block shall be independent to the allocation of alarm inputs to single points data words. This will allow words to be reserved for future use and returned to block (or word) interrogations as "spare words".

E.g. If, say, word 4 is defined as the lowest word in a particular block, the block has available words 4, 5, 6, and 7 for the allocation of data and words 1, 2 and 3 are not available. However, data need not be allocated to all words that constitute the block (words 4, 5, 6 and 7) thus providing the facility of returning "spare words".

3.2.2.1 Data Types - Data Input from the Substation

The data set up facility shall allow the user to allocate the following types of input data to the GI74 data structure. Appendix A1 details the bit allocations.

3.2.2.1.1 Single Points Status Data

Each bit represents a plant or internally generated alarm or status and shall be allocated to a function, block and word.

Single Points Status data may be grouped and sent with or without a reflash bit. If a reflash is not required, grouped data is treated simply as normal single point status data.

If reflash is required, each Group Alarm has a group common alarm bit and a reflash bit. Group Alarms with reflash and Single Point Status may not be mixed within a word however a combination of Single Points Status data words and Group Alarm data words may exist within a function and block.

3.2.2.1.2 Double Points Status Data

Each pair of bits represents a plant or internal indication and shall be allocated a function, block and word.

3.2.2.1.3 Tap Position Indication Data

Each word represents 3 encoded (5 bit Gray code) values representing the position of transformer tap changers and shall be allocated a function and block. See Appendix A4 for the Gray code format. For tap changers with more than 31 tap positions they are to be reported as a binary value in a Normal Precision Analogue data type.

3.2.2.1.4 Normal Resolution Analogue Data

Each word represents two normal resolution (1% - 7 bits plus sign bit) analogue readings and shall be allocated a function and block.

Values shall be presented as a 7 bit scalar binary value of 0 to 127 with a separate sign bit which will be set to 1 for positive values and 0 for negative values.

The Nominal Maximum Value (NMV) of shall be indicated to the Remote Control Point by a binary value of 100. Overload conditions shall be indicated to the Remote Control Point by values in the range 101 to 126 inclusive. A value of 127 is used to indicate saturation of the input value.

Note that where suppressed zero values are used the zero to NMV range remains as 0 to 100, but an offset must be included in the calculation of the engineering value.

3.2.2.1.5 High Resolution Analogue Data

Each word represents one high resolution (0.1% - 10 bits plus sign bit) analogue reading and shall be allocated a function and block.

Values shall be presented as a 10 bit scalar binary value of 0 to 1023 with a separate sign bit which will be set to 1 for positive values and 0 for negative values.

The NMV of shall be indicated to the Remote Control Point by a binary value of 800. Overload conditions shall be indicated to the Remote Control Point by values in the range 801 to 1008 inclusive. Values above 1008 indicate saturation of the input value.

Note that where suppressed zero values are used the zero to NMV range remains as 0 to 800, but an offset must be included in the calculation of the engineering value.

Frequency is to be reported as High Resolution Analogue data and shall be indicated to the Remote Control Point by a value of +0 for a frequency of 47 Hz and +1000 for 52 Hz.

3.2.2.2 Data Types - Data Output to the Substation

Controls for output to the substation are received from the Remote Control Point as three stage sequences. The first stage selects the output function, block (Part 1 address) and word (Part 2 address) within the data structure. The second stage identifies the output (Part 3 control bit address) and the third stage causes the execution of the output to the substation plant.

The data set up facility shall allow the user to allocate the following types of output data to the GI74 data structure. Appendix A1 details the bit allocations.

3.2.2.2.1 Control Outputs

Each bit (Part 3 address) represents a single control output and shall be allocated a function (0-15), block (0-7) (Part 1 address) and word (0-7) (Part 2 address).

3.2.3 Reserved Data Allocations

The data set up facility shall allow for the following items to be allocated within the GI74 data structure. The data set up facility shall ensure that normal plant data cannot be allocated to the reserved data addresses.

3.2.3.1 Special Requests

The data set up facility shall allow the Special Request Interrogation function and block to be allocated to function 0, lowest block. The special request words are allocated as:-

Word 1	Send Changes.
Word 2	Multiword Cleardown.
Words 3 - 7	Not Used.

3.2.3.2 Execute Function

The data set up facility shall allow for the control execute function to be allocated to function 15.

3.2.3.3 Taking Control Outputs

It shall be possible to define the control output function, block (Part 1), word (Part 2) and bit (Part 3) that constitutes the Taking Control output for each port. This will be a single control output for each Remote Control Point port to select the control source as this port.

The required function of these control outputs is described in Sections 3.1.4.5 (Control Source).

3.2.3.4 Control Source Status Indications

It shall be possible to define the function, block, word and bit that constitute the Taking Control Status Indication for each port. This will be a Single Point Status for each Control Centre Computer that indicates the control source as this port.

The required function of these indications is described in Sections 3.1.4.5 (Control Source).

3.2.4 Other Data

The data set up facility shall allow for the following GI74 TCI attributes to be input. These attributes determine the operation of the GI74 TCI.

3.2.4.1 Communications Network Attributes

The data set up facility shall allow the following attributes to be input relating to each of the communications ports (i.e. where a port consists of two channels).

Outstation address length: - 5, 6, 7 or 8 bits
Outstation address: - 1 - 255 (dependent on length)

Baud Rate
Direct Channel: - 300 bps
Alternate Channel: - 300 bps

3.2.5 Data Checking

The off-line data set up facility shall provide syntax, range checking and cross checking of data at set up time.

4 PERFORMANCE REQUIREMENTS

4.1 Reply Time

The GI74 TCI shall reply to an interrogation within 128 bit times, with no longer than 128 bit times between reply words. Reply times shall be consistent with the channel utilisation requirement in the main specification.

4.2 Specification for GI74 Terminal Asynchronous Communication Interfaces

4.2.1 Introduction

This section describes the parameters required for the asynchronous communication interfaces used in GI74 equipment. The parameters are valid for both hardware and software implementations of the communication interfaces at data communication rates of 300bps.

This Specification is necessary as the ITU-T recommendations and other relevant international specifications that exist do not include the use of 23 bit words, as used in GI74 messages. The parameters have been specified, in line with the ITU-T recommendations, to ensure that 23 bit words can be successfully transmitted and correctly received under normal operational conditions. The tolerances for these parameters have been specified to ensure that the communication performance is maintained at the extreme range of individual component tolerances.

4.2.2 Transmit Clock

The transmit clock is the timing source used to clock individual bits from the terminal equipment to the communications interface. It shall be possible for the user to select the nominal data transmission rate of 300bps. In accordance with ITU-T recommendation S.31 § 1.2, the mean data transmission rate shall not vary by more than ± 0.1% from the nominal data rate, over the operating temperature range. E.g. for 300 bps operation the mean transmitted data rate shall lie in the range 299.7 bps to 300.3 bps.

4.2.3 Receive Clock

The receive clock is the timing source used to clock individual bits from the communications interface to the terminal equipment. It shall be possible for the user to select the nominal data transmission rate of 300bps. The mean data transmission rate, determined from the receive clock, shall not vary by more than ± 0.1% from the nominal data rate over the operating temperature range.

Explanation:

The specified tolerance for the transmit and receive clocks allows a crystal oscillator (or software) deviation of 100 ppm which will cope with the calibration, temperature drift and ageing drift of a normal, non-temperature compensated, AT cut crystal.

4.2.4 Isochronous Distortion

Isochronous distortion is the displacement of a bit edge from its nominal position. The combination of isochronous distortion and transmit clock tolerance together account for the maximum displacement of a bit edge from its nominal position at the nominal data rate. ITU-T recommendation S.31 § 2.1 specifies a maximum gross distortion for transmitted signals of 5%. The transmit clock tolerance can give rise to a displacement of 0.1% x 23 = 2.3% on the 23rd bit, therefore the isochronous distortion component introduced at the transmit interface shall not exceed 2.7%.
The receiver interface shall be capable of tolerating at least ± 40% gross distortion of the incoming data stream in accordance with ITU-T recommendation S.31 § 3.1. As the receive clock can give rise to an additional displacement error of 0.1% x 23 = 2.3% on the 23rd bit, the receiver interface circuitry and/or software shall be capable of tolerating a bit edge displacement of at least 42.3% from its nominal position relative to the receive clock reference.

Explanation:

The specified tolerances leave an operating margin of 35% distortion for the communications equipment installed between the transmit interface and the receive interface.

The present generation of Modem equipment used for GI74 communications can exhibit back to back distortion of up to 20% on a tandem connection. This distortion will increase on leased line circuits due to amplitude and group delay distortion. The operating margin of 35% is judged to allow adequate margin for moderate performance modems operating on a typical rented PW.

APPENDIX •A-1

GI74 MESSAGE FORMATS

CONTENTS

FIGURE	TITLE
A1.1	Interrogation Word Formats.
A1.2	Checkback Word Formats.
A1.3	Special Request Interrogation Word Formats.
A1.4	Control Word Formats.
A1.5	Control Word Reply Formats.
A1.6	Error Reply Formats.
A1.7	Data Word Formats.
A1.8	Control Output Sequence.
A1.9.1	Change Mechanism Sequence.
A1.9.2	Change Mechanism Sequence (cont).

This Appendix uses the following symbols to indicate the fields within the GI74 words.

SYMBOL	FIELD
S1	Start bit (a single bit).
SSSSSBBB	Outstation address (overlaps the block address).
BBB	Block address.
WWW	Word address.
FFFF	Function address.
R	Reset bit.
C	Change bit.
PPPPP	CRC (parity) bits.
S2	Stop bit (a single bit).
DDDD	Control output.

BLOCK INTERROGATION (see Section 3.1.4.1.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	F	F	F	F	0	0	0	B	B	B	S	S	S	S	S	0

From Remote Control Point

000 in the word field indicates a Block Interrogation

(Block BBB, Function FFFF).

WORD INTERROGATION (see Section 3.1.4.1.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	F	F	F	F	W	W	W	B	B	B	S	S	S	S	S	0

From Remote Control Point

WWW in the word field indicates a Word Interrogation

(Word WWW, Block BBB, Function FFFF).

FIRST WORD OF THE REPLY TO A BLOCK INTERROGATION
(see Section 3.1.4.1.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	F	F	F	F	**W**	**W**	**W**	B	B	B	S	S	S	S	S	0

To Remote Control Point

WWW specifies the word number of the lowest allocated word in block BBB, function FFFF.

FIRST WORD OF THE REPLY TO A WORD INTERROGATION
(see Section 3.1.4.1.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	F	F	F	F	**W**	**W**	**W**	B	B	B	S	S	S	S	S	0

To Remote Control Point

WWW in the word field indicates the word requested in block BBB, function FFFF.

This should match the fields in the interrogation.

SEND CHANGES (see Section 3.1.4.1.3.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	0	0	0	0	**0**	**0**	**1**	B	B	B	S	S	S	S	S	0

From Remote Control Point

WWW in the word field is 001, function is zero and block is lowest allocated.

MULTIWORD CLEARDOWN (see Section 3.1.4.1.3.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	0	0	0	0	**0**	**1**	**0**	B	B	B	S	S	S	S	S	0

From Remote Control Point

WWW in the word field is 010, function is zero and block is lowest allocated.

CONTROL SELECTION WORD (see Section 3.1.4.2.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	F	F	F	F	W	W	W	B	B	B	S	S	S	S	S	0

From Remote Control Point

CONTROL OUTPUT DATA WORD (see Section 3.1.4.2.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					$\overline{\text{PART 3}}$ inverted bit address				PART 3 bit address				PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	$\overline{D}$	$\overline{D}$	$\overline{D}$	$\overline{D}$	D	D	D	D	B	B	B	S	S	S	S	S	0

From Remote Control Point

CONTROL EXECUTE WORD (see Section 3.1.4.2.3)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	1	1	1	1	W	W	W	B	B	B	S	S	S	S	S	0

From Remote Control Point

Function 15 is the execute function.

CONTROL SELECTION REPLY WORD (see Section 3.1.4.2.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	F	F	F	F	W	W	W	B	B	B	S	S	S	S	S	0

To Remote Control Point

CONTROL OUTPUT DATA REPLY WORD (see Section 3.1.4.2.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					$\overline{\text{PART 3}}$ inverted bit address				PART 3 bit address				PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	$\overline{D}$	$\overline{D}$	$\overline{D}$	$\overline{D}$	D	D	D	D	B	B	B	S	S	S	S	S	0

To Remote Control Point

CONTROL EXECUTE REPLY WORD (see Section 3.1.4.2.3)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	1	1	1	1	W	W	W	B	B	B	S	S	S	S	S	0

To Remote Control Point

Function 15 is the execute function.

GENERAL ERROR REPLY (see Section 3.1.4.3.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	0	0	0	0	0	0	0	B	B	B	S	S	S	S	S	0

To Remote Control Point

Block bits BBB set to lowest allocated block. Function and word bits set to zero.

PARITY FAIL REPLY (see Section 3.1.4.3.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

To Remote Control Point

All bits, including CRC (parity) bits, set to zero.

Note: Deliberate bad parity to cause a parity fail at the NGCC.

STATUS POINTS DATA WORD (see Sections 3.2.2.1.1 and 3.2.2.1.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					16 SINGLE STATUS POINTS or 8 DOUBLE STATUS POINTS or 8 GROUP ALARMS WITH REFLASH																START
1	P	P	P	P	P																	0

To Remote Control Point

TAP POSITION INDICATOR DATA WORD (see Section 3.2.2.1.3)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					N/A	3rd READING (GRAY CODE)					2nd READING (GRAY CODE)					1st READING (GRAY CODE)					START
1	P	P	P	P	P																	0

To Remote Control Point

ANALOGUE DATA WORD - NORMAL RESOLUTION (see Section 3.2.2.1.4)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					SIGN	ANALOGUE READING B (1%) ±127							SIGN	ANALOGUE READING A (1%) ±127							START
1	P	P	P	P	P																	0

To Remote Control Point

Sign convention: Sign bit set (1) for a positive reading,
reset (0) for a negative reading.

ANALOGUE DATA WORD - HIGH RESOLUTION (see Section 3.2.2.1.5)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					SIGN	ANALOGUE READING (0.1%)±1023										NOT USED					START
1	P	P	P	P	P												0	0	0	0	0	0

To Remote Control Point

Sign convention: Sign bit set (1) for a positive reading,
reset (0) for a negative reading.

CONTROL OUTPUT SEQUENCE

The following sequence is a typical control output. The control is to be output at the following address:-

OUTSTATION	21
FUNCTION	14
PART 1	4
PART 2	5
PART 3 (Control bit)	3

The EXECUTE word is FUNCTION 15.

The reply after each stage is the same as the word received by the GI74 TCI, except possibly for bit 15 in the Select Reply and Execute Reply.

CONTROL SELECTION WORD AND REPLY (see Section 3.1.4.2.1)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1	
STOP	PARITY BITS					RESET	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START	From Remote Control Point
1	P	P	P	P	P	R	1	1	1	0	1	0	1	1	0	0	1	0	1	0	1	0	

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1	
STOP	PARITY BITS					CHANGE	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START	To Remote Control Point
1	P	P	P	P	P	C	1	1	1	0	1	0	1	1	0	0	1	0	1	0	1	0	

CONTROL OUTPUT DATA WORD AND REPLY (see Section 3.1.4.2.2)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1	
STOP	PARITY BITS					$\overline{\text{PART 3}}$ inverted bit address				PART 3 bit address				PART 1			OUTSTATION ADDRESS					START	From Remote Control Point
1	P	P	P	P	P	1	1	0	0	0	0	1	1	1	0	0	1	0	1	0	1	0	

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1	
STOP	PARITY BITS					$\overline{\text{PART 3}}$ inverted bit address				PART 3 bit address				PART 1			OUTSTATION ADDRESS					START	To Remote Control Point
1	P	P	P	P	P	1	1	0	0	0	0	1	1	1	0	0	1	0	1	0	1	0	

CONTROL EXECUTE WORD AND REPLY (see Section 3.1.4.2.3)

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1	
STOP	PARITY BITS					RESET	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START	From Remote Control Point
1	P	P	P	P	P	R	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0	

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1	
STOP	PARITY BITS					CHANGE	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START	To Remote Control Point
1	P	P	P	P	P	C	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0	

CHANGE MECHANISM SEQUENCE

The following sequence is a typical change notification and interrogation sequence. The changed point is:-

OUTSTATION ADDRESS	21
FUNCTION	2
BLOCK	0
WORD	3
BIT	7

The change occurs while a normal analogue scan (function 5, block 0) is taking place. After the changed data is returned the analogue scanning resumes with function 6, block 0.

INTERROGATION WORD

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION (5)				WORD			BLOCK (0)			OUTSTATION ADDRESS					START
1	P	P	P	P	P	R	0	1	0	1	0	0	0	0	0	0	1	0	1	0	1	0

From Remote Control Point

Single status change occurs at the substation.

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION (5)				WORD (6) LOWEST			BLOCK (0)			OUTSTATION ADDRESS					START
1	P	P	P	P	P	1	0	1	0	1	1	1	0	0	0	0	1	0	1	0	1	0

To Remote Control Point

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					SIGN	ANALOGUE READING B (1%) ±127							SIGN	ANALOGUE READING A (1%) ±127							START
1	P	P	P	P	P	1	0	1	0	1	0	0	1	1	0	1	0	1	1	0	0	0

To Remote Control Point

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					SIGN	ANALOGUE READING B (1%) ±127							SIGN	ANALOGUE READING A (1%) ±127							START
1	P	P	P	P	P	1	0	1	0	1	0	0	1	1	0	1	0	1	1	0	0	0

To Remote Control Point

SEND CHANGES INTERROGATION

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0

From Remote Control Point

SEND CHANGES CHECKBACK

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	CHANGED FUNCTION				CHANGED WORD			CHANGED BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	0	0	0	1	0	0	1	1	0	0	0	1	0	1	0	1	0

To Remote Control Point

Bit 15 is set in the above word if there are any more changes.

(WORD 3) CHANGED STATUS POINTS DATA WORD

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					16 SINGLE STATUS POINTS or 8 DOUBLE STATUS POINTS or 8 GROUP ALARMS WITH REFLASH																START
1	P	P	P	P	P	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0

To Remote Control Point

INTERROGATION WORD

S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					RESET	FUNCTION (6)				WORD			BLOCK (0)			OUTSTATION ADDRESS					START
1	P	P	P	P	P	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0

From Remote Control Point

Reset bit set to clear change from queue.

APPENDIX A-2

CRC ALGORITHM

There are a number of ways of generating the 5 CRC bits from 16 data bits. Two methods are outlined here to assist in the understanding of the requirement. The final implementation does not need to adopt either of these methods, providing the method used produces the required CRC bits for all data patterns.

In all cases the bit significance is least significant bit to the right. The least significant CRC bit becomes bit 16 in the GI74 word.

Method 1

The following is in pseudo code with the 16 data bits in DATA WORD and the required 5 CRC bits in PARITY BITS at the completion of the run:-

```
Write out %0000 0011 to PARITY BITS

FOR n = 0 to 15
        IF bit n of the DATA WORD is set
        THEN
            PARITY BITS = EOR of PATTERN n with PARITY BITS
        FI
NEXT n

END
```

FIXED DATA

Pattern 0	%0000 0110
Pattern 1	%0000 1100
Pattern 2	%0001 1000
Pattern 3	%0001 1001
Pattern 4	%0001 1011
Pattern 5	%0001 1111
Pattern 6	%0001 0111
Pattern 7	%0000 0111
Pattern 8	%0000 1110
Pattern 9	%0001 1100
Pattern 10	%0001 0001
Pattern 11	%0000 1011
Pattern 12	%0001 0110
Pattern 13	%0000 0101
Pattern 14	%0000 1010
Pattern 15	%0001 0100

Method 2

The following is also in pseudo code with the 16 data bits in DATA WORD and the required 5 CRC bits in PARITY BITS at the completion of the run:-

```
PARITY BITS = EOR of DATA WORD with %0000 0000 0001 0100

LOOP until PARITY BITS are right shifted 16 times

        IF LS bit of PARITY BITS is set

        THEN
            PARITY BITS = EOR of PARITY BITS with %0000 0000 0010 1001

        ELSE
            Right shift PARITY BITS once (MS bit becomes 0)
        FI

POOL

END
```

APPENDIX A-3

BLOCK / OUTSTATION ADDRESS RELATIONSHIP

Size - 8 blocks, maximum address length 5 bits.

	BLOCK			OUTSTATION ADDRESS				
Bit No.	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1
Block No.	Binary value			Possible Outstation Addresses				
0	0	0	0	1 - 31				
1	0	0	1					
2	0	1	0					
3	0	1	1					
4	1	0	0					
5	1	0	1					
6	1	1	0					
7	1	1	1					

Size - 4 blocks, maximum address length 6 bits.

	BLOCK			OUTSTATION ADDRESS				
Bit No.	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1
Block No.	Binary value			Possible Outstation Addresses				
0	0	0	0	1 - 31				
2	0	1	0					
4	1	0	0					
6	1	1	0					
or 1	0	0	1	32 - 64				
3	0	1	1					
5	1	0	1					
7	1	1	1					

Size - 2 blocks, maximum address length 7 bits.

	OUTSTATION ADDRESS							
	BLOCK							
Bit No.	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1
Block No.	Binary value			Possible Outstation Addresses				
0	0	0	0	1 - 31				
4	1	0	0					
or 1	0	0	1	32 -63				
5	1	0	1					
or 2	0	1	0					
6	1	1	0	64 - 95				
or 4	0	1	1					
7	1	1	1	96 - 127				

Size - 1 block, maximum address length 8 bits.

	OUTSTATION ADDRESS							
	BLOCK							
Bit No.	7	6	5	4	3	2	1	0
Weight	128	64	32	16	8	4	2	1
Block No.	Binary value			Possible Outstation Addresses				
0	0	0	0	1 - 31				
or 1	0	0	1	32 -63				
or 2	0	1	0	64 - 95				
or 3	0	1	1	96 - 127				
or 4	1	0	0	128 - 159				
or 5	1	0	1	160 - 191				
or 6	1	1	0	192 - 223				
or 7	1	1	1	224- 255				

APPENDIX A-4

TAP POSITION INDICATION - GRAY CODES

Note: a value of 0 is an invalid state. The lowest tap position indication value is 1.

For tap changers with less than 31 positions the values up to the highest tap are valid, values above this are to be considered as in error.

For tap changers with more than 31 tap positions they are to be reported as a binary value in a Normal Precision Analogue data type.

DECIMAL	GRAY CODE
0	00000
1	00001
2	00011
3	00010
4	00110
5	00111
6	00101
7	00100
8	01100
9	01101
10	01111
11	01110
12	01010
13	01011
14	01001
15	01000
16	11000
17	11001
18	11011
19	11010
20	11110
21	11111
22	11101
23	11100
24	10100
25	10101
26	10111
27	10110
28	10010
29	10011
30	10001
31	10000

APPENDIX B

TELECONTROL COMMUNICATION INTERFACE
REMOTE CONTROL POINT – IEC60870-5-101 PROTOCOL REQUIREMENTS

Appendix B defines the requirements for the configuration of the IEC101 SCADA protocol connection to the ENCC.

FOREWORD
This Appendix forms part of the National Electricity Transmission System Operator (NETSO) Interface Requirements Specification for Offshore Transmission Owner (OFTO) Network Assets using the IEC101 protocol.

SCOPE

This Appendix describes the functional and performance requirements for the IEC101 communication protocol.

This protocol is designed for use in Supervisory Control and Data Acquisition (SCADA) applications and this document describes the requirements of the slave system when communicating with a master system.

An example slave system application is a Substation Automation System (SAS), which is polled by the Electricity National Control Centre (ENCC) master system (iEMS). See Figure 1

The protocol standard documents IEC 60870-5-1 to IEC 60870-5-6 and companion standard IEC 60870-5-101 Ed2 define the requirements of the communications protocol. Whilst the IEC 60870 series of standards define the requirements of the communications protocol, they do not describe how to use the protocol when implemented on particular systems.

Figure 1 - Scope

This Protocol Implementation Document (PID) selects options from IEC 60870-5-101 standard for use in slave mode applications. In addition there are some issues outside of the companion standard, which are essential to the correct working of the protocol on the NETSO's telecommunications networks. These include system specific parameters where the standards allow choice, higher level requirements such as backup communications and methods of performing sequences of communication functions.

The particular configuration requirements of IEC 60870-5-101 for an SAS for connection to the Integrated Energy Management System (iEMS) application are described in Appendix C

PART 1 – PROCEDURAL

1 FUNCTIONAL REQUIREMENTS

1.1 Requirements for Data Acquisition

This section gives supplementary information to the Interoperability Statement, which can be found as Appendix C-1 to this specification.

1.1.1 Station Initialisation

Informative: Station initialisation consists of a reset of the communications link, followed by a general interrogation (GI) of the slave station. On completion of the GI the master station will begin its normal scanning (for Class 2 data)

When the slave station is fully operational (ie communications established and local database updated) the signal “End of Initialisation” (ASDU 70) shall be sent to the master station.

1.1.2 Normal Acquisition

Informative: At the master station the following parameters will be set: -

a) *Frequency of General Interrogation requests: adjustable between 1 minute and 24 hours. Pre-set to 30 minutes.*

b) *Frequency of Test Command: adjustable between 30 minutes and 24 hours or none (manual). Pre-set to 12 hours.*

c) *Timeout interval for repeated frame transmission: adjustable between 50 ms and 5s. Pre-set to 500 ms.*

d) *Number of repeat frame transmissions: adjustable between 0 and 10. Pre-set to 3.*

e) *The maximum poll interval will be set to 2 seconds.*

f) *The iEMS scanning regime will use the request for Class 1 data to acquire events from the slave station, if a response to a request for Class 2 data has the ACD bit set*

Informative: The master station scanning regime will use polling for Class 2 data.

g) *If in the response to this request, the ACD bit is set, then the master station will subsequently request Class 1 data from the slave station.*

h) *If the response to a scan for Class 2 data repeatedly indicates no data is available a General Interrogation scan will be scheduled.*

i) *If the continued setting of the ACD bit means that a scan for Class 2 data has not been sent for more than the predefined time, a scan for Class 2 data shall be inserted as the next scan.*

j) *The slave station may return Class 1 data in response to a Class 2 request if no Class 2 data is available and Class 1 data is awaiting transmission.*

At the slave station, if a request for Class 2 data is received and no data is available a negative response, data not available, shall be returned to the master station. The negative response may be a fixed length frame (FC=9) or the Single Control Character (E5), which in this case is treated as a NACK.

At the slave station, the processing delay for each frame shall be less than 50 milliseconds and the value to be stated with any statistical variance.

Class 1 data occurring at the slave station shall cause the ACD bit to be set in the next Class 1 or Class 2 data response. The master station shall respond to ACD set by inserting a scan for Class 1 data as the next scan.

The response to a Class 1 data request shall also have the ACD bit set if more Class 1 data is awaiting transmission. In this case a further scan for Class 1 data shall be scheduled by the master station.

At the slave station, if a request for Class 1 data is received and no data is available a negative response, data not available, returned to the master station. The negative response shall be a fixed length frame (FC=9) or the single Control Character (E5), which in this case is treated as a NACK.

The event buffer for each communication port shall be set to limit between 500 and 1500 events.

The event buffer shall not store repeated Class 2 analogue messages, only the latest and current value shall be stored in the event buffer for reporting

1.1.3 General Interrogation (GI)

Informative: General interrogation of each slave station shall be performed periodically by the master station. In the event of loss of communications to a slave station a GI will be performed as part of the re-connection procedure.

Informative: The master station should be aware of the following paragraph from IEC 60870-5-5: "The outstation interrogation procedure can be interrupted by events which may occur in the slave station.

The GI shall return the current status information directly from the slave station's database.

Time tags shall not be used for data items returned as part of the GI response.

If GI groups are supported these will be set up in the database and each of the (up to 16) groups shall be requested/reported individually.

1.1.4 Clock Synchronisation

Informative: Clock synchronisation via the telecommunications network is not required, since each substation has its own highly accurate GPS clock. This method is considered more accurate, due to variable delays on the communications network.

The slave station shall use the local GPS clock as its time synchronisation source.

The invalid bit in the time-stamp shall be set when the time source is not available.

The slave station shall report any time correction by sending a clock synchronisation message (ASDU 103) to the master station, as Class 1 data, with a cause of transmission spontaneous (COT = 3).

1.1.5 Command Transmission

All commands shall be Select before Execute.

Informative: The maximum time between the Select and Execute commands sent by the Master Station shall be 2s.

If the Execute command is not received within 2s of the Select command, the command process shall be terminated.

Activation termination (C_SE_ACTTERM) shall be returned to the master station to signal the end of a control sequence.

Informative: the master station requires certain responses to be received within specific time windows, else error messages are generated.

Positive ACTTERM is required to be sent to the master station, within 5s of the Execute command being received and actioned by the slave station. Note this may need to be before the appropriate indication changes state particularly from slow moving plant.

Informative: If the ACTERM is not received within 5s of the Execute command, then a Deactivation command will be sent by the master station.

Feedback from associated indications shall be sent within 60s of receiving the Execute Command for the associated control.

The QU field of the Qualifier of Command shall be set to zero (0), no additional definition, as there is no requirement for control of the duration of the output pulse.

1.1.6 Test Procedure

Informative: A test command may be issued by the master station at any time to ensure the availability of the communications link and the commands subsystem.

Test commands may be sent to the slave station on the active link. The slave station shall mirror the test command, on the link from which it was received, with a cause of transmission indicating activation confirmation.

An error response should be sent if the command is incorrect, with a cause of transmission indicating negative activation confirmation.

1.1.7 Communications Failure

Informative: Communications to the slave station shall be re-initialised where the frame repeat process has completed without successfully transmitting the frame (i.e. the frame time-out period times the number of repeats).

1.1.8 Slave Station Failure

The slave station shall indicate to the master station that it has initialised by sending a frame indicating End of Initialisation with a Cause of Initialisation (COI) field, which will identify the reason for the initialisation.

1.2 Requirements Specific to Protocol Layers

This section gives supplementary information to the Protocol Interoperability Document, which can be found as Appendix C-1 to this specification.

1.2.1 Physical Layer

The physical layer interfaces for the four communication channels at the slave station, shall conform to the EIA RS232 DE-9 standard.

A separate interface panel/facility shall be provided for connection of the communication services. This shall be fixed within the cubicle to a suitable mounting rail.

Each communication channel interface shall be provided with a parallel connected EIA RS232 DE-9 connector for the “in service” connection and disconnection of communications line monitoring equipment. This shall be part of the interface panel facility.

The physical interfaces for communication services shall be a 9 pin D-SUB male plug.

The interface shall be an unbalanced interchange circuit conforming to ITU-T V.24 with signal levels to ITU-T V28.

The pin connections used shall be as a Data Terminating Equipment (DTE): –

Pin	Service	Slave Station Use
1	DCD	Not Used
2	RXD (104)	Data from Master Station
3	TXD (103)	Data to Master Station
4	DTR	Not Used
5	0V (102)	Signal Ground
6	DSR	Not Used
7	RTS	Not Used
8	CTS	Not Used
9	RI	Not Used

Any additional hardware communication handshaking signals required, shall be provided at the suppliers communications interface.

1.2.2 Link Layer

For any slave station, every communications link to that station will have a unique Link address. The unique Link address is assigned by the NETSO.

1.2.3 Application Layer

The Common Address of ASDU shall be unique for each slave station and is issued by the NETSO.

For any slave station, each data item within that station shall have a unique Information Object Address (IOA allocated according to Appendix C-2

The OFTO is to state which Quality descriptors are supported and how these are implemented. Please note that correctly aquired DBI states shall not be reported with quality descriptor “Invalid” (IV) (eg. if a disconnector is genuinely stuck between the open and closed state).

1.2.4 Time Stamping

Events with Time Stamps shall be sent with ASDU types using “CP56Time 2a” format.

Time stamps shall always use GMT and not be adjusted by 1 hour for BST.

Events shall only be reported by the slave station once they have been validated (e.g. de-bounce filter) and any configured filter times have expired.

The Time Stamp values assigned to the event in the ASDU shall be sent in accordance with the following rules: -

a) Single Points – Time when the validated event is first detected, prior to event validation and any additional change of state filtering.

b) Valid Double points – Time when the validated change of state is first detected, prior to event validation and any additional valid state filtering.

c) Valid Tap Position Indication (TPI) - Time when the validated change of state is first detected, prior to event validation and any additional valid state filtering.

d) Invalid States (e.g. DBI & TPI=0) – Time when the invalid change of state is first detected, prior to event validation and the invalid state filtering. These states shall not be reported with the invalid (IV) quality descriptor if correctly acquired.

1.2.5 Remote Initialisation

The OFTO shall state how the Remote Initialisation function is supported and its effect on station initialisation.

PART 2 - DEFINITIONS

2 DEFINITIONS

ACD	Access Demand – a bit from the slave indicating whether Class 1 data is waiting.
ASDU	Application Service Data Unit – the part of a frame that contains the user data.
BST	British Summer Time
COT	Cause of Transmission – a field indicating why the information is being transmitted
EIA	Electronics Industry Association
ENCC	Electricity Network Control Centre.
GI	General Interrogation – a database check.
GMT	Greenwich Mean Time
GPS	Global Positioning System
IEC	International Electrotechnical Commission
iEMS	integrated Energy Management System – NGESO's master stations
iEMS DBU	iEMS Disaster Back-Up – One of NGESO's master stations
iEMS Main	iEMS Main – One of NGESO's master stations
IOA	Information Object Address – a unique number identifying each information object.
ISO	International Standards Organisation.
PID	Protocol Implementation Document
SAS	Substation automation System

SCADA Supervisory Control and Data Acquisition

PART 3 - GUIDANCE NOTES AND APPENDICES

3 REFERENCES

This document makes reference to, or should be read in conjunction with the following documents: -

International Standards

IEC 60870-1-1	General principles
IEC 60870-1-3	Glossary
IEC 60870-1-4	Guide for basic aspects of telecontrol data
IEC 60870-5	Transmission protocols
IEC 60870-5-1	Transmission frame formats
IEC 60870-5-2	Link transmission procedures
IEC 60870-5-3	Specification for general structure of application data
IEC 60870-5-4	Definition and coding of application information elements
IEC 60870-5-5	Basic application functions
IEC 60870-5-101	Ed2 Companion standard for basic telecontrol tasks
IEC 60870-5-104	Ed2 Network access for IEC 60870-5-101 using standard transport protocols
IEC 60870-5-6	Guidelines for conformance testing for the IEC 60870-5 companion standards
IEC 60870-5-601	Conformance test cases for the IEC60870-5-101 companion standard
IEC 62351-5	Security for IEC 60870-5 and derivatives

APPENDIX C

IEC60870-5-101 PROTOCOL IMPLEMENTATION

APPENDIX C-1 - INTEROPERABILITY STATEMENT

This interoperability statement presents a set of parameters and options that are supported by the master the NETSO SCADA station. The slave station can use all or a subset of these but must not use any functions that are not supported or are incompatible with the master station configuration. Some parameters, such as the listed set of different process information in command and in monitor direction, allow the specification of the complete set or subsets, as appropriate for given applications. Unsupported options or functions shall be agreed with the NETSO.

This clause summarises the parameters to facilitate a suitable selection for a specific application. If a system is composed of equipment stemming from different manufacturers it is necessary that all partners agree on the selected parameters.

The selected parameters are marked in the white boxes as follows:

[ ]	Function or ASDU is not used
[X]	Function or ASDU is required as standardised.
[R]	Function or ASDU is required used in reverse mode
[B]	Function or ASDU is required used in both standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific clause or parameter.

Note
- In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

System or Device

(System specific parameter. Indicate the definition of a system or a device by marking one of the following with an '**X**')

[ ]	System Definition
[ ]	Controlling station definition (Master)
[X]	Controlled station definition (Slave)

Network configuration

(network specific parameter, all configuration that are used are to be marked with an '**X**')

[X]	Point-to-point	[ ]	Multipoint-partyline
[X]	Multiple point-to-point	[ ]	Multipoint-star

Physical Layer

(Network specific parameter, all interfaces & data rates that are used are to be marked with an '**X**'.

Transmission speed (control direction)

Unbalanced interchange Circuit V.24/V.28 Standard (Recommended if >1200bit/s)	Balanced interchange Circuit X.24/X.27

☐	100	☐	2400	☐	2400	☐	56000
☐	200	☐	4800	☐	4800	☐	64000
☐	300	☒	9600	☐	9600		
☐	600			☐	19200		
☐	1200			☐	38400		

10.5

Transmission speed (monitor direction)

Unbalanced interchange
Circuit V.24/V.28 Standard
(Recommended if >1200bit/s)

☐	100	☐	2400
☐	200	☐	4800
☐	300	X	9600
☐	600		
☐	1200		

Balanced interchange
Circuit X.24/X.27

☐	2400	☐	56000
☐	4800	☐	64000
☐	9600		
☐	19200		
☐	38400		

Link Layer

(Network specific parameter, all options that are used are to be marked with an '**X**'. Specify the maximum frame length. If a non-standard assignment of class 2 messages is implemented for unbalanced transmission, indicate the type ID and COT of all messages assigned to class 2.)

Frame format FT 1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard

Link transmission procedure

☐	Balanced transmission
X	Unbalanced transmission

Address field of the link

☐	not present (balanced transmission only)
☐	One octet
X	two octets
☐	Structured
X	Unstructured

Frame length

255	Maximum length L (control direction)
255	Maximum length L (monitor direction)

3	Time during which repetitions are permitted (Trp) or number of repetitions

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

☐ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission

X A special assignment of ASDUs to class 2 messages is used as follows: (full compliance mandatory)

Type identification	Cause of transmission
1,3,5,7,9,11,13	<20> to <36>
9,11,13	<3>
15, 37	<3>, <37> to <41>
34,35,36	<3>

Note: In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

Application Layer

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 60870-5-4, is used exclusively in this companion standard.

Common address of ASDU

(System specific parameter, all configurations that are used are to be marked with an '**X**')

☐	One octet	X	Two octets

Information object address

(System specific parameter, all configurations that are used are to be marked with an '**X**')

☐	One octet	X	Structured
☐	Two octets	☐	Unstructured
X	Three octets		

Cause of transmission

(System specific parameter, all configurations that are used are to be marked with an '**X**)

X	One octet	☐	Two octets (with originator address) Originator address is set to zero if not used

Selection of Standard ASDUs

Process information in monitor direction

(station specific parameter, mark each Type ID with an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction and '**B**' if used in both directions)

X	<1> := Single-point information	M_SP_NA_1
	<2> := Single-point information with time tag	M_SP_TA_1
X	<3> := Double-point information	M_DP_NA_1
	<4> := Double-point information with time tag	M_DP_TA_1
X	<5> := Step position information	M_ST_NA_1
	<6> := Step position information with time tag	M_ST_TA_1
X	<7> := Bitstring of 32 bit (optional)	M_BO_NA_1
	<8> := Bitstring of 32 bit with time tag	M_BO_TA_1
X	<9> := Measured value, normalised value	M_ME_NA_1
	<10> := Measured value, normalised value with time tag	M_ME_TA_1
X	<11> := Measured value, scaled value (preferred)	M_ME_NB_1
	<12> := Measured value, scaled value with time tag	M_ME_TB_1
	<13> := Measured value, short floating point value	M_ME_NC_1
	<14> := Measured value, short floating point value with time tag	M_ME_TC_1
X	<15> := Integrated totals (optional)	M_IT_NA_1
	<16> := Integrated totals with time tag	M_IT_TA_1
	<17> := Event of protection equipment with time tag	M_EP_TA_1
	<18> := Packed start events of protection equipment with time tag	M_EP_TB_1
	<19> := Packed output circuit information of protection equipment with time tag	M_EP_TC_1
	<20> := Packed single-point information with status change detection	M_PS_NA_1
	<21> := Measured value, normalised value without quality descriptor	M_ME_ND_1
X	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
X	<31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
X	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
	<33> := Bitstring of 32 bit with time tag CP56Time2a	M_BO_TB_1
	<34> := Measured value, normalised value with time tag CP56Time2a	M_ME_TD_1
	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1

☐	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒	<37> := Integrated totals with time tag CP56Time2a (optional)	M_IT_TB_1
☐	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40> := Packed output cct. information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Either ASDU's of the set <2>, <4>, <6>, <8>, <10>, <12>, <14>, <16>, <17>, <18>, <19> or of the set <30 –40> are used.

Process information in control direction

(station specific parameter, mark each type ID with an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction and '**B**' if used in both directions)

☒	<45> := Single command	C_SC_NA_1
☒	<46> := Double command	C_DC_NA_1
☒	<47> := Regulating step command (optional)	C_RC_NA_1
☒	<48> := Set point command, normalised value (optional)	C_SE_NA_1
☐	<49> := Set point command, scaled value	C_SE_NB_1
☐	<50> := Set point command, short floating point value	C_SE_NC_1
☐	<51> := Bitstring of 32 bit	C_BO_NA_1

System information in monitor direction

(station specific parameter, mark each type ID with an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction and '**B**' if used in both directions)

☒	<70> := End of initialisation	M_EI_NA_1

System information in control direction

(station specific parameter, mark each type ID with an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction and '**B**' if used in both directions)

☒	<100> := Interrogation command	C_IC_NA_1
☒	<101> := Counter interrogation command	C_CI_NA_1
☐	<102> := Read command	C_RD_NA_1
☒	<103> := Clock synchronise command	C_CS_NA_1
☒	<104> := Test command	C_TS_NA_1
☐	<105> := Reset process command	C_RP_NA_1
☒	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station specific parameter, mark each type ID with an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction and '**B**' if used in both directions)

☐	<110> := Parameter of measured value, normalised value	P_ME_NA_1
☐	<111> := Parameter of measured value, scaled value	P_ME_NB_1
☐	<112> := Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113> := Parameter activation	P_AC_NA_1

File Transfer

(station specific parameter, mark each type ID with an '**X**' if it is only used in the standard direction, '**R**' if only used in the reverse direction and '**B**' if used in both directions)

☐	<120> := File ready	F_FR_NA_1
☐	<121> := Section ready	F_SR_NA_1
☐	<122> := Call directory, select file, call file, call section	F_SC_NA_1
☐	<123> := Last section, last segment	F_LS_NA_1
☐	<124> := Ack file, ack section	F_AF_NB_1
☐	<125> := Segment	F_SG_NC_1
☐	<126> := Directory (blank or X, only available in monitor (standard) direction	F_DR_TA_1

Type Identifier and Cause of Transmission Assignments

(station specific parameters)

Type Identification		Cause of Transmission (COT)																		
Shaded boxes are not required. Blank = Function or ASDU is not used. Mark Type/COT combinations: '**X**' if used only in the standard direction '**R**' if used only in the reverse direction '**B**' if used in both directions		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1			X											X					
<2>	M_SP_TA_1																			
<3>	M_DP_NA_1			X											X					
<4>	M_DP_TA_1																			
<5>	M_ST_NA_1			X											X					
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1			X											X					
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1			X											X					
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1			X											X					
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1																			
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1																			
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X																
<31>	M_DP_TB_1			X																
<32>	M_ST_TB_1			X																
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1																			
<36>	M_ME_TF_1																			
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X	X	X	X						X	X	X	X
<46>	C_DC_NA_1						X	X	X	X	X						X	X	X	X
<47>	C_RC_NA_1						X	X	X	X	X						X	X	X	X
<48>	C_SE_NA_1						X	X	X	X	X						X	X	X	X
<49>	C_SE_NB_1																			
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X	X	X	X						X	X	X	X
<101>	C_CI_NA_1						X	X	X	X	X						X	X	X	X

Type Identification		Cause of Transmission (COT)																		
Shaded boxes are not required. Blank = Function or ASDU is not used. Mark Type/COT combinations: '**X**' if used only in the standard direction '**R**' if used only in the reverse direction '**B**' if used in both directions		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<102>	C_RD_NA_1																			
<103>	C_CS_NA_1			R																
<104>	C_TS_NA_1						X	X									X	X	X	X
<105>	C_RP_NA_1																			
<106>	C_CD_NA_1						X	X									X	X	X	X
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1																			

BASIC APPLICATION FUNCTIONS

Station initialisation

(Station specific parameter, mark with an '**X**' if function is used)

[X] Remote initialisation

Cyclic data transmission

(station specific parameter, mark with an '**X**' if it is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

[ ] Cyclic data transmission

Read procedure

(station specific parameter, mark with an '**X**' if it is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

[ ] Read procedure

Spontaneous transmission

(station specific parameter, mark with an '**X**' if it is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

[X] Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station specific parameter. Mark each information type with an '**X**' where both a Type ID without time and corresponding type ID with time are issued in response to a single spontaneous change of a monitored object)

The following type identifications may be transmitted in succession caused by a single status change of an information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

- [ ] Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1
- [ ] Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
- [ ] Step position information M_ST_NA_1, M_ST_TA_1and M_ST_TB_1
- [ ] Bit-string of 32 bit M_BO_NA_1, M_BO_TA_1and M_BO_TB_1 (if defined for a specific project)
- [ ] Measured value, normalised value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
- [ ] Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
- [ ] Measured value, short floating point number M_ME_NC_1, M_ME_TC_1, and M_ME_TF_1

Station interrogation (supported but details to be agreed with the NETSO)

(station specific parameter. mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

- [X] global

X	group 1	X	group 7	X	group 13
X	group 2	X	group 8	X	group 14
X	group 3	X	group 9	X	group 15
X	group 4	X	group 10	X	group 16
X	group 5	X	group 11		
X	group 6	X	group 12		

Information Object Addresses assigned to each group must be shown in a separate table

Clock synchronisation

(Station specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

- [X] Clock synchronisation (time message from controlled station only)
- [ ] Day of Week Used
- [ ] RES1, GEN (time tag substituted/not substituted) used
- [ ] SU-bit (summertime) used

Command transmission

(object specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

- [ ] Direct command transmission
- [ ] Direct set point command transmission
- [X] Select and execute command transmission
- [X] Select and execute set point command transmission
- [X] C_SE ACTTERM used
- [X] No additional information
- [ ] Short pulse duration (duration determined by a system parameter in the controlled station)
- [ ] Long pulse duration (duration determined by a system parameter in the controlled station)
- [ ] Persistent output

Transmission of integrated totals

(station or object specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

- [ ] Mode A: Local freeze with spontaneous transmission
- [X] Mode B: Local freeze with counter interrogation
- [ ] Mode C: Freeze and transmit by counter interrogation commands
- [ ] Mode D: Freeze by counter interrogation command, frozen values reported spontaneously
- [X] Counter read
- [X] Counter freeze without reset
- [ ] Counter freeze with reset
- [ ] Counter reset

- [ ] General request counter
- [ ] Request counter group 1
- [ ] Request counter group 2
- [ ] Request counter group 3
- [ ] Request counter group 4

Parameter loading

(object specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

- [ ] Threshold value
- [ ] Smoothing factor
- [ ] Low limit for transmission of measured values
- [ ] High limit for transmission of measured values

Parameter activation

(object specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure

(object specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

☒ Test procedure

File transfer

(station specific parameter, mark with an '**X**' if function is used)

File transfer in monitor direction

☐ Transparent file
☐ Transmission of disturbance data of protection equipment
☐ Transmission of sequences of events
☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background Scan

(object specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

☐ Background scan

Acquisition of transmission delay

(station specific parameter, mark with an '**X**' if function is used only in the standard direction, '**R**' if used only in the reverse direction and '**B**' if used in both directions)

☒ Acquisition of transmission delay

APPENDIX C-2 - IEC 60870-5-101 PROTOCOL IMPLEMENTATION REQUIREMENTS

FOREWORD

This Appendix forms part of the National Electricity Transmission System Operator (NETSO) Interface Requirements Specification for Offshore Transmission Owner (OFTO) Network Assets.

PURPOSE AND SCOPE

The protocol standard documents IEC 60870-5-1 to IEC 60870-5-6 and companion standard IEC 60870-5-101 define the requirements of the communications protocol.

This appendix describes the address and configuration requirements of the IEC 60870-5-101 protocol for a slave station application, such as an OFTO Substation Automation System (SAS). These address and configuration requirements are essential for the correct working of the SAS to the NGESOiEMS SCADA system, which are outside the scope of the above documents.

Whilst the IEC 60870 series of standards define the technical requirements of the communications protocol, they do not address how to use the protocol in a target SAS. This document describes the detailed addressing requirements for the NGESOspecific application of the IEC 60870-5-101 protocol.

4 GUIDANCE

4.1 Link Address

For each individual SAS the preferred Link Addresses allocation is shown below:

a) iEMS Main DIRECT LINK = LINK ADDRESS 1

b) iEMS Main ALTERNATE LINK = LINK ADDRESS 2

c) iEMS DBU DIRECT LINK = LINK ADDRESS 3

d) iEMS DBU ALTERNATE LINK = LINK ADDRESS 4

4.2 Common Address of ASDU (Station Address)

This shall be unique for each slave outstation and will be allocated by the NETSO.

For any slave station, the same Common Address shall be used on each Link.

The range of available addresses is 1 – 65534.

Address 65535 is reserved for use as a Global Address for all slave stations.

4.3 Information Object Address (IOA)

The Information Object Address is made up 3 data octets divided into 2 parts: -

a) A Node Address.

b) An Information Item Address (IIA).

The data octets are allocated as follows: -

Octet 1	Node Address
Octet 2	Information Item Address
Octet 3	

4.4 Node Address

Substations will be subdivided into nodes.

4.4.1 Within the SAS configuration, a node will define: -

a) The whole substation (e.g. KEAD).

b) Each substation voltage level (e.g. KEAD4).

c) Each circuit (KEAD 2).

d) Each leg of any 'teed' circuit (KEAD).

4.4.2 Within the SAS configuration: -

a) Every node will be allocated a unique address, known as a Node Address.

b) The Node Address allocation will be sequential starting at 1, up to a maximum of 254.

c) Node Address 1 will be allocated to the whole substation node.

4.5 Information Item Address

4.5.1 Within the SAS configuration: -

a) Each Plant Item (e.g. X120 cb; SUND1 feeder; compressor 1) will be associated with a node (e.g. a voltage level, a circuit, etc.).

b) Each Plant Item will comprise a number of Data Items (e.g. Alarms, Controls, Indications, Analogues).

c) Consequently each Data Item will be associated with a particular node.

4.5.2 Within a node: -

a) Each Data Item will be allocated a unique address known as an Information Item Address (IIA).

b) There are prescribed address ranges for the allocation of Information Item Addresses. These ranges are dependant upon the Data Type; see Table in Section 1.6.

c) For each Data Type, it is preferred that the allocation of Information Item Addresses (to Data Items) is consecutive and commence from the lowest available address in the prescribed range.

4.6 Information Item Address Ranges for Data Types

For completeness the table below shows the Information Item Address ranges applicable to all Data Types; however the NETSO implementation does not use every type.

Data Type	Type ID (ASN.1)	Information Item Address	
		Minimum value	Maximum value
Single point information	M_SP	1	1,999
Double point information	M_DP	2,000	2,999
Step position information	M_ST	3,000	3,999
Bitstring	M_BO	4,000	4,999
Measured value, normalised	M_ME_A	5,000	5,999
Measured value, scaled	M_ME_B	6,000	6,999
Measured value, short float	M_ME_C	7,000	7,999
Integrated totals	M_IT	8,000	8,999
Reserved for further data types		9,000	9,999
Single command	C_SC	10,000	10,999
Double command	C_DC	11,000	11,999
Regulating step command	C_RC	12,000	12,999
Set point command, normalised	C_SE_A	13,000	13,999
Set point command, scaled	C_SE_B	14,000	14,999
Set point command, short float	C_SE_C	15,000	15,999
Bitstring	C_BO	16,000	16,999
Reserved for further data types		17,000	19,999
Parameter of measured value, normalised	P_ME_A	20,000	20,999
Parameter of measured value, scaled	P_ME_B	21,000	21,999
Parameter of measured value, short float	P_ME_C	22,000	22,999
Reserved for further data types		23,000	29,999
File (or directory)	F, D	30,000	30,999
Reserved for further data types		31,000	32,767
Single Point Information (overflow range)		32,768	65,535

5 CLASSES OF DATA

5.1 Class 1 Data

All Class 1 data responses from the slave station shall be configured as time-tagged messages.

At the slave station, the following data will be configured as Class 1 data: -

a) All data messages where the Cause of Transmission is spontaneous (i.e. COT=3) except those ASDUs defined as class 2 which are 9, 11, 13, 15, 37, 34, 35, 36

b) All command response messages.

5.2 Class 2 Data

Values returned as Class 2 data will not have a time tag

At the slave station, the following data will be configured as Class 2 data: -

a) All data messages sent as a result of a General Interrogation (GI) request from the master station. (i.e. COT=20 to COT=41).

b) Messages explicitly defined as class 2 data as defined in Appendix C-1 above, in particular analogue data.

6 REQUIREMENTS FOR DATA TYPES

6.1 General

'Seven octet' time tag messages (CP56Time2a) shall be sent by the slave station in response to all requests for Class 1 data.

6.2 Analogues

6.2.1 All Analogues messages shall be sent by the slave station as Scaled Value messages (ASDU type 11). Note that for:

a) Max positive value of engineering units Nominal Maximum Value (NMV), the 'information element' bit count shall be 20,000.

b) Zero (or offset) value of engineering units, the 'information element' bit count shall be 0.

c) Negative values of engineering units, the information element bit count shall be sent in the 2's complement format.

d) See Appendix C-3 for example analogue quantities.

6.2.2 The default configuration for analogue messages shall be as spontaneous on-change (i.e. COT=3).

6.3 Commands and Information responses

Informative: The criteria as to whether a command message is sent from the master station as a Single or Double Command is dictated by the type of response required from the plant item. Please request details whether double or single point information is required from any particular plant item type from the NETSO. These command responses shall be returned following the activation termination.

A 'Single-point Information' data message (ASDU type 30) shall be configured to be sent by the slave station in response to a 'Single Command' message (ASDU type 45) from the master station.

A 'Double-point Information' data message (ASDU type 31) shall be configured to be sent by the slave station in response to a 'Double Command' message (ASDU type 46) from the master station.

A "Step position information" data message (ASDU type 32) shall be configured to be sent by the slave station in response to a "Regulating Step Command" message (ASDU type 47) from the master station.

7 REFERENCES

This Technical Guidance Note makes reference to, or should be read in conjunction with the following documents: -

7.1 International Standards

IEC 60870-5	Transmission protocols
IEC 60870-5-1	Transmission frame formats
IEC 60870-5-2	Link transmission procedures
IEC 60870-5-3	Specification for general structure of application data
IEC 60870-5-4	Definition and coding of information elements
IEC 60870-5-5	Basic application functions
IEC 60870-5-6	Guidelines for conformance testing for the IEC 60870-5 companion standards
IEC 60870-5-101	Companion standard for basic telecontrol tasks
IEC 61850-80-1	Guideline to exchanging information from a CDC based data model using IEC 60870-5-101 and IEC 60870-5-104

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

8 DEFINITIONS

ASDU Application Service Data Unit – the part of a frame that contains the user data.

CDC Common Data Class – see IEC 61850-80-1

COT Cause of Transmission – a field indicating why the information is being transmitted.

DBU Disaster Back-Up – Master station used in case of iEMS failure.

GI General Interrogation – a database check.

IEC International Electrotechnical Commission.

iEMS Integrated Energy Management System – the NETSO's master stations

iEMS DBU iEMS Disaster Back-Up – One of the NETSO's master stations

iEMS Main iEMS Main – One of the NETSO's master stations

IIA Information item Address

IOA Information Object Address

NMV Nominal Maximum Value

SAS Substation Automation System

SCADA	Supervisory Control and Data Acquisition

PART 3 – GUIDANCE NOTES AND APPENDICES

APPENDIX C-3 – EXAMPLES OF ANALOGUE SCALING

MEASURED QUANTITY	Example values	IEC information item bit count (Scaled value)	Normalised	Binary
Full range volts (unidirectional) Offset = 0kV NMV = 400kV	0kV	0	0	0000 0000 0000 0000
	200kV	10,000	0.30517578125	0010 0111 0001 0000
	400kV	20,000	0.6103515625	0100 1110 0010 0000
Suppressed zero volts (unidirectional) Offset = 340kV NMV = 440kV	340kV	0	0	0000 0000 0000 0000
	400kV	12,000	0.3662109375	0010 1110 1110 0000
	440kV	20,000	0.6103515625	0100 1110 0010 0000
MVars (bi-directional) Offset = 0MVArs NMV = 1000MVArs	0MVAr	0	0	0000 0000 0000 0000
	100MVAr	2,000	0.06103515625	0000 0111 1101 0000
	1000MVAr	20,000	0.6103515625	0100 1110 0010 0000
	-1000MVAr	45,536	- 0.6103515625	1011 0001 1110 0000
	-100MVAr	63,536	-0.06103515625	1111 1000 0011 0000
Frequency (unidirectional) Offset = 47Hz NMV = 52Hz	47Hz	0	0	0000 0000 0000 0000
	52Hz	20,000	0.6103515625	0100 1110 0010 0000

APPENDIX D

NETSO ADDITIONAL REQUIREMENTS FOR OFFSHORE TRANSMISSION OWNED NETWORK AND ASSETS

FOREWORD

This Appendix forms part of the National Electricity Transmission System Operator (NETSO) Interface Requirements Specification for Offshore Transmission Owner (OFTO) Networks Assets.

SCOPE

This document describes additional functions and information that will be required to be provided by the OFTO.

1 **Data Archiving**

A Data Archiving facility shall be provided to record all events, plant changes of state and control actions. The events shall be time stamped with the time the event was first detected to change state. The time stamp shall be to a resolution of 10ms (or better) with time referenced to UTC. All events shall be archived in chronological order.

The system shall be capable of capturing simultaneous occurrence of events, without loss of information. Extracts of the archived data shall be made available on request.

2 **Fault Recording**

Fault Recorders shall be provided on all feeder circuits to capture fault records of all Protection Operations. The required digital signals and analogue measurements and their performance will be subject to agreement.

3 **Interlocking**

OFTO Network Assets shall be mechanically and electrically interlocked in accordance with agreed rules.

The function shall provide a means of interlocking the circuit-breakers, disconnectors and earth switches against erroneous operation. The interlock mechanism shall prevent the operation of the selected switch unless an agreed interlock chain, represented by associated circuit-breakers, disconnectors and earth switch positions is valid.

4 **Configuration, Testing and Validation**

The TCI GI74 configuration data shall be prepared in accordance with agreed rules and to an agreed format. This format is described as “300 sheets”. The IEC101 configuration data shall be prepared in a standardised spreadsheet format which the NETSO will issue on request.

The TCI GI74 configuration shall be validated using a Test Tool identified as the Portable Telecontrol Equipment (PTE) which shall use the 300 sheet configuration data to validate the TCI GI74 configuration off line, prior to a connection to the

Remote Control Point communication services. The IEC101 configuration shall be validated using an automated test tool.

5 Generator Data

The OFTO shall carry certain pre-defined Generator digital indications and analogue metering data from the Generator connection bays to the TCI, for onward transmission to the Remote Control Point.

ISSUE NUMBER	CHANGES	AUTHOR/DATE	AUTHORISED	DATE
Draft B	2nd Draft following review 21/11/07	J E Fitch 29th November 2007		
Issue 1	Typographical Update and clarification following comments	J E Fitch 6th April 2008		
Issue 2	Updated to include IEC60870-5-101	T Charton 11 November 2013		