STCP 04-6 Issue 001 Offshore Datalink Functional Specification for Telecontrol Communication Interface

STC Procedure Document Authorisation

Company	Name of Party Representative	Signature	Date
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STC Procedure Change Control History

Issue 001	Xx/09/09	New Procedure for Offshore Transmission Regime

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
NETSO	National Electricity Transmission System Operator
GI74	General Indications 1974 (National Grid SCADA communication protocol)
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 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 Communication Protocol, as described in Appendix A.

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 B.

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

Each port shall provide main and alternate communication channels.

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).

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.

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.

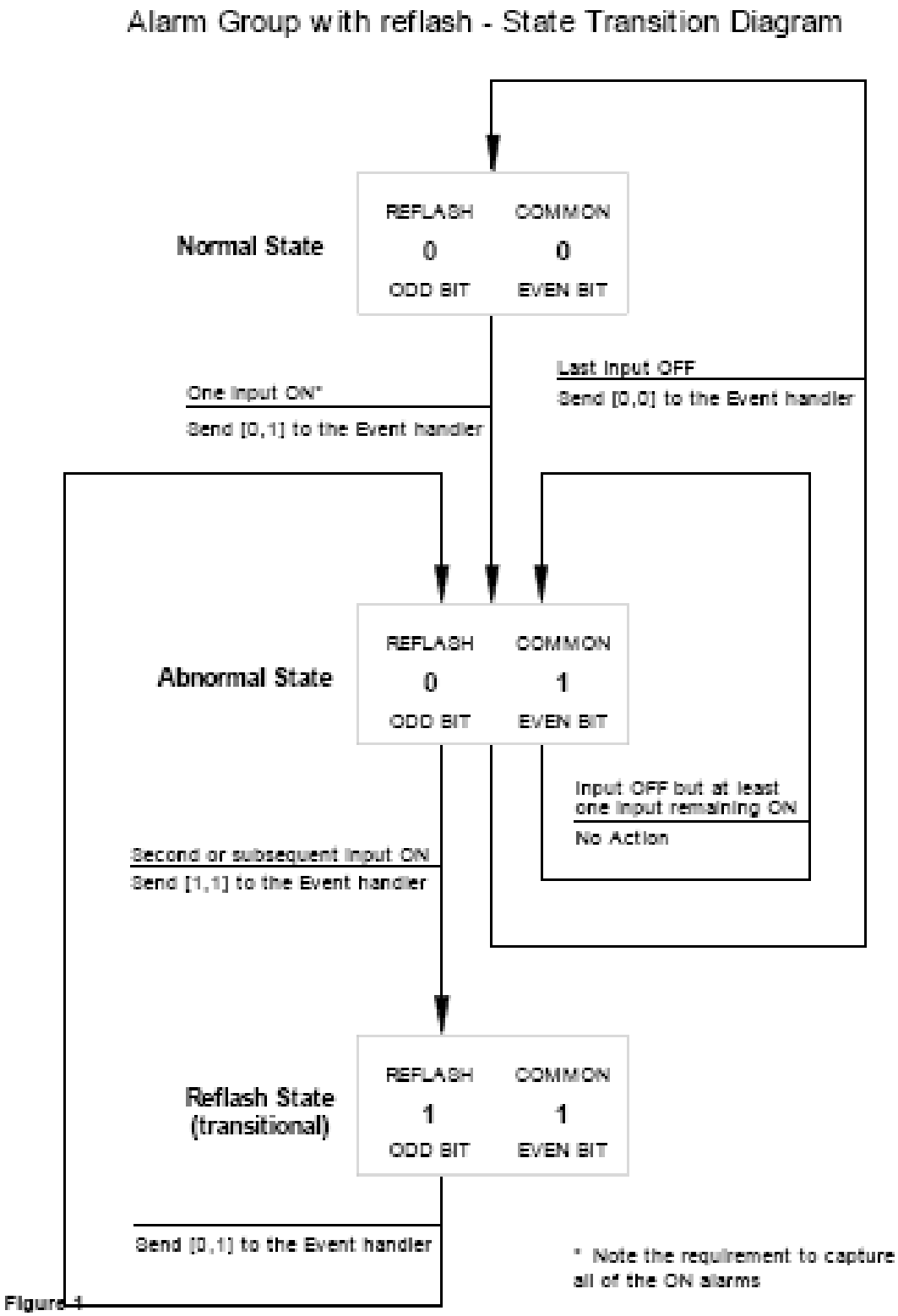

Alarm Group with reflash - State Transition Diagram
Normal State
REFLASH
COMMON
0
0
ODD BIT
EVEN BIT
One Input ON*
Send [0,1] to the Event handler
Last Input OFF
Send [0,0] to the Event handler
Abnormal State
REFLASH
COMMON
0
1
ODD BIT
EVEN BIT
Input OFF but at least one input remaining ON
No Action
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" bit and a "Reflash" bit. The GI74 Protocol restricts the allocation of these bits such that the Common bit must be allocated to an even bit within a single points word and the Reflash bit must be allocated to the adjacent odd bit. Any single points word used for the allocation of these Common and Reflash bits cannot be used for the allocation of simple group alarms or normal single point alarms.

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 is required to be presented at the TCI in Gray code format (see Appendix A).

Optionally TPI may configured to be sent as 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. Import and Export quantities shall be assigned as follows: -

Positive (+) polarity shall indicate "export"
Negative (-) polarity shall indicate "import"

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.

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 GI74 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 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 Appendix A.

10.2 Change Queue Mechanism

The two change queues on each port shall operate independently. Changes are to be entered onto the change queue in the correct order of occurrence 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%.

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 National Grid, 4 weeks prior to commencement of the type tests, all documentation relating to the Test Specifications. National Grid 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.

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

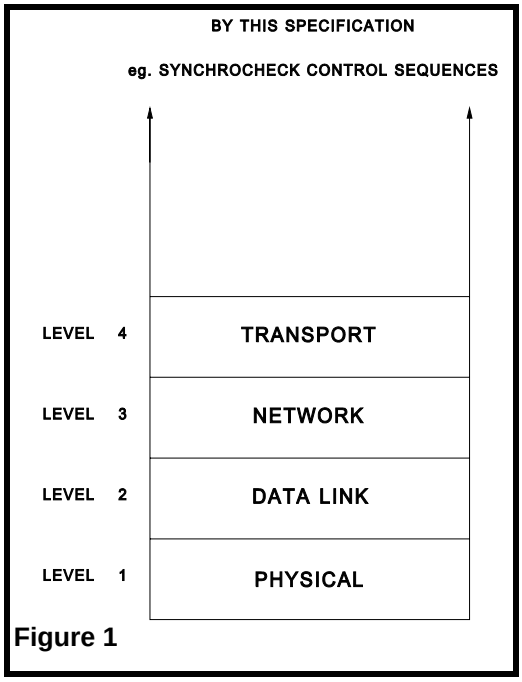


Figure 1

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 rates:-

Section 4 states the performance requirements for GI74 communication interfaces.

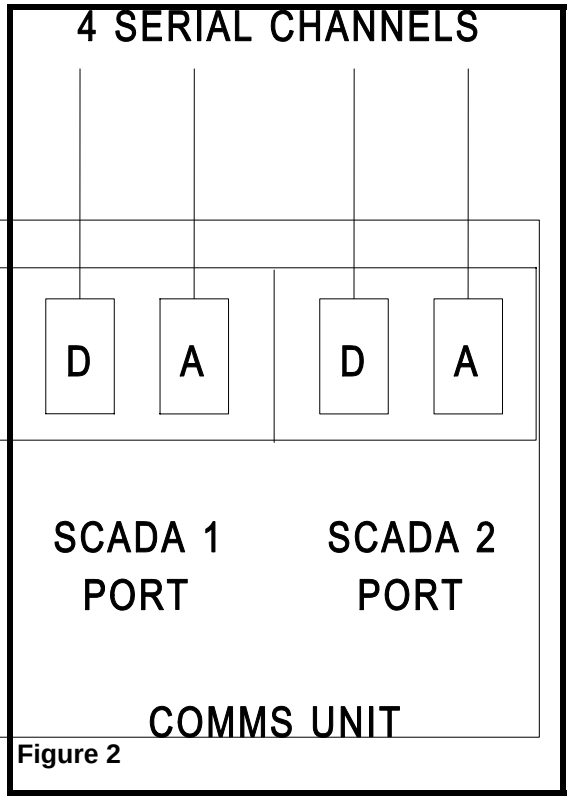


Figure 2

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.

3.1.4.2.3Control 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.

3.1.4.3.1General 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.

3.1.4.3.2Parity 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.

3.1.4.5 Control Source Controls and Indications

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 (see section 3.2.3.3). The appropriate Control Source Status Indication (see Section 3.2.3.4) shall be set to zero in response to the change of control source.

On system start up the control source status shall default to SCADA 1

Control selections from the Control Centre Computer that is in control shall be dealt with as normal.

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 a Taking Control control. Data interrogations from the Remote Control Point shall always be serviced by the GI74 TCI.

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

10.4.1 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.

5 TECHNICAL DATA REQUIRED

5.1 Functional Specification

This document is a Requirements Specification. The Contractor shall provide a Functional Specification that will be the first level of his software design. The Functional Specification is required to state any non-compliance with this Requirements Specification.

6 TEST REQUIREMENTS

A Functional Acceptance Test (FAT) specification shall be produced by the Contractor for acceptance by the National Grid Company. This test specification shall form the basis of the Acceptance Testing of the GI74 TCI and will provide documentary evidence of the correct functionality.

The test specification shall provide a test strategy and schedules for ensuring that the GI74 communications and data set up facility meets the agreed Functional Specification. System test data shall be provided by the Contractor so that all functions specified can be tested. Tests shall be specified to ensure that the performance requirements are met.

GI74 implementation will be required to be proven against National Grid defined test equipment known as the GI74 Emulator and test equipment for Isochronous distortion.

APPENDIX A1

GI74 MESSAGE FORMATS

CONTENTS

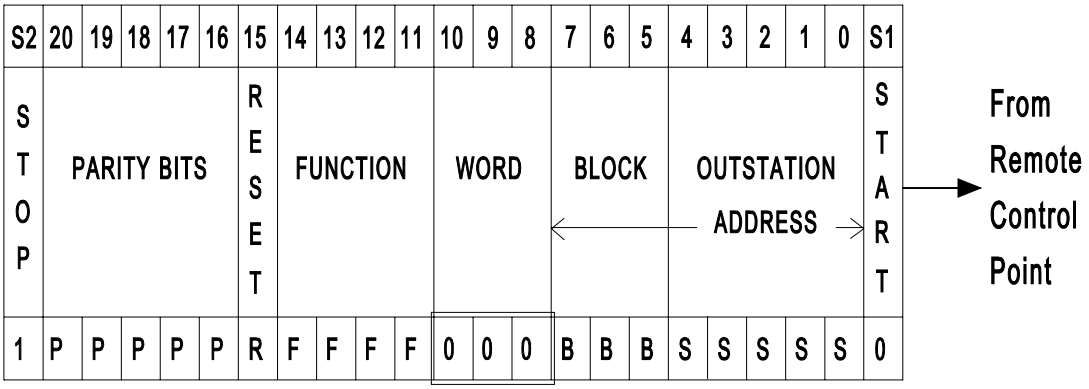
FIGURE TITLE

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.

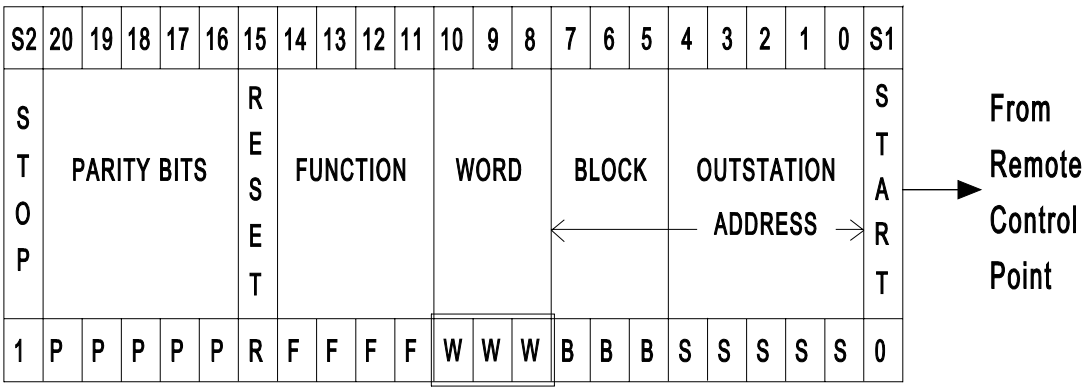
BLOCK INTERROGATION (see Section 3.1.4.1.1)



000 in the word field indicates a Block Interrogation

(Block BBB, Function FFFF).

WORD INTERROGATION (see Section 3.1.4.1.2)

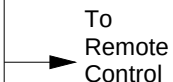


WWW in the word field indicates a Word Interrogation

(Word WWW, Block BBB, Function FFFF).

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

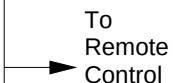
S2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	S1
STOP	PARITY BITS					CHANGE	FUNCTION				WORD			BLOCK			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	F	F	F	F	**W**	**W**	**W**	B	B	B	S	S	S	S	S	0



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

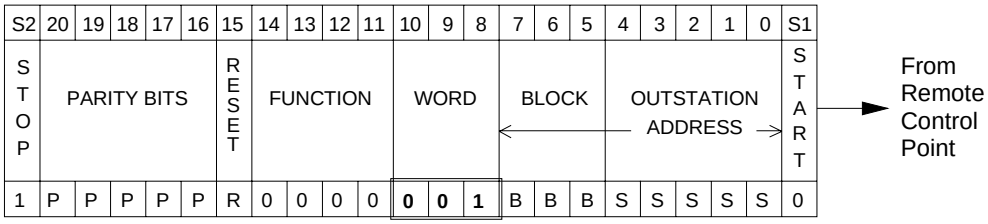
FIRST WORD OF THE REPLY TO A WORD INTERROGATION
(see Section 3.1.4.1.2)

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



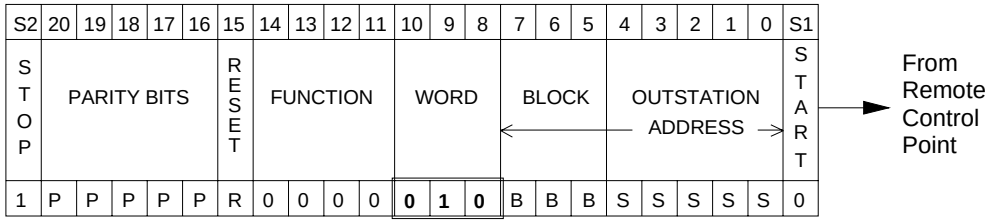
WWW in the word field indicates the word requested in
block BBB, function FFFF.
This should match the fields in the interrogation.

SEND CHANGES (see Section 3.1.4.1.3.1)



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)



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 → To Remote Control Point
1	P	P	P	P	P																	0

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 → To Remote Control Point
1	P	P	P	P	P																	0

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 → To Remote Control Point
1	P	P	P	P	P																	0

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 → To Remote Control Point
1	P	P	P	P	P												0	0	0	0	0	0

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
1	P	P	P	P	P	R	1	1	1	0	1	0	1	1	0	0	1	0	1	0	1	0

From 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					CHANGE	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	1	1	1	0	1	0	1	1	0	0	1	0	1	0	1	0

To Remote Control Point

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
1	P	P	P	P	P	1	1	0	0	0	0	1	1	1	0	0	1	0	1	0	1	0

From 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					$\overline{\text{PART 3}}$ inverted bit address				PART 3 bit address				PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	1	1	0	0	0	0	1	1	1	0	0	1	0	1	0	1	0

To Remote Control Point

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
1	P	P	P	P	P	R	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0

From 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					CHANGE	FUNCTION				PART 2			PART 1			OUTSTATION ADDRESS					START
1	P	P	P	P	P	C	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0

To Remote Control Point

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 A2

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 A3

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 A4

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

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.

11 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.

12 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.

13 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.

14 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 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.

15 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	Issue update for NETSO not directly operating OFTO Network Assets	J E Fitch 14th July 2008		