CONITEL

Protocol Definition

Revision: 2.02
18/7/02

CONTENTS

1. Overview

This document attempts to define the **Conitel** protocol, used for SCADA and telemetry applications. The information contained here has been pieced together from various sources. As a result, accuracy and completeness cannot be guaranteed. This document was not produced by Leeds & Northrup, and has no official standing.

1. 1. Document Revision Summary

Revision	Date	Description
1.x	1993	Document first developed
2.00	28/8/94	Converted from Wordstar format to Ami Pro, added C50 RTU extensions.
2.01	22/9/96	Minor format changes
2.02	18/7/02	Converted to PDF format

2. General Description

Conitel was developed by Leeds & Northrup for power distribution SCADA applications. The Conitel protocol is an asynchronous protocol intended for half-duplex, multi-drop applications, where a single **master station** communicates with a number of **remotes**. All communications are initiated by the **master station**, therefore this is a "polled", rather than "exception reporting", protocol. A **remote** is generally referred to as an **RTU**, which stands for "Remote Terminal Unit". The protocol was originally intended to support up to 15 RTUs, however, it can be made to talk to up to 240 RTUs, with some reduction in the amount of data per RTU.

2. 1. Main Advantages

♦ Comparatively simple protocol.
♦ A relatively "open standard" - most other SCADA protocols are closed/proprietry. Third party interfaces to a variety of devices are available.
♦ Very secure (good error detection).
♦ Very efficient for small data blocks.

2. 2. Main Disadvantages

♦ Not byte-base, therefore it is difficult or impossible to implement using a standard UART. Usually, special hardware is required.
♦ Limited number of station addresses.
♦ Limitations on quantity of data. The worst limitation is the number of analogue setpoints (32 per RTU address.).
♦ Inefficient for large blocks of data.
♦ Does not support exception reporting (although SOE functions are available). Exception reporting was proposed for the C5 RTU, but apparently never implemented.
♦ Relies on error detection, rather than correction (as do most SCADA protocols).

2. 3. Third Party Implementations

2. 3. 1. Functions Usually Supported

Most third party implementations of Conitel choose to implement only a subset of the standard Conitel functions. This subset is often referred to as the C2020 protocol.

♦ Except in the case of a read-only interface, it is necessary to implement **functions 0 to 5**.

♦ **Function 9**, the Master Station Request **code B**, should be implemented, but often isn't.

♦ Some interfaces use Master Station Request **code 9** to reset the interface. Other Master Station Request codes are RTU specific, and are generally not implemented unless a specific type of RTU is being emulated.

♦ Very few interfaces implement SOE reporting (**functions A & B**).

♦ **Function D** (Unit Raise/Lower) is rarely used, but sometimes may be implemented, especially if the interface device contains some intelligence (ie: a PLC).

♦ **Functions E & F** should be implemented if the system supports accumulator data types, note that these two functions are implemented incorrectly in some existing protocol interfaces.

2. 3. 2. Data Types Usually Supported

Except in special cases, the interface will always support one-bit status digitals, and 12 bit analogues. Note that analogues should be in **sign magnitude**, and not the more common **two's complement,** format. What other data types are supported depends on the nature of interface. MCDs should be supported if at all possible. Under some circumstances, points that are actually accumulators may be treated as normal analogues. This is generally done when the accumulator accumulates very slowly, and is unlikely to overflow. Remote Status Bits, and SOE data types, are usually not supported.

2. 4. Hardware Standard

Although there is no official hardware standard, Conitel is usually transmitted at 1200 bits per second in CCITT V23 Mode 2 format. Occasionally, Bell 202 format is used instead. Usually a 4-wire connection is used (one pair for transmit, one for receive), but a 2-wire connection can be used because the protocol is genuine half-duplex.

Conitel can be transmitted successfully over a radio link. RTUs generally provide a **PTT** (Push To Talk) relay output to allow the radio transmitter to be keyed. The **PTT** relay is activated at the start of the pre-transmission mark (below) and deactivated some time after the end of the message. This latter time interval is often referred to as a **Post Transmission Mark** and is usually in the range 10-500 mSec.

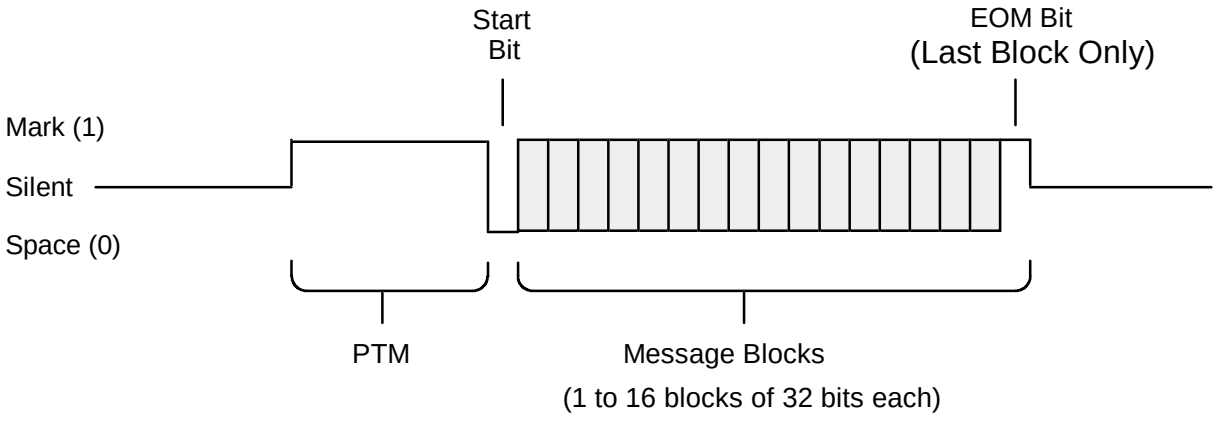
Format	Mark (1)	Space (0)
CCITT V.23	1300 ±10Hz	2100 ±10Hz
BELL 202	1200 Hz	2200 Hz

Note: These tones are quite audible. A common fault-finding practice is to eavesdrop on a Conitel landline using a standard telephone earpiece. With a little practice, it is possible to differentiate between a poll and a reply, and judge PTM length and signal quality by ear.

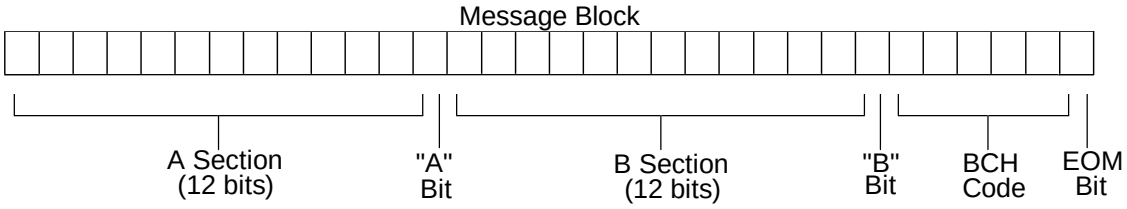
3. Message Block Format

A Conitel message consists of between 1 and 16 **message blocks**. Each **message block** is composed of 32 bits, which are assigned as explained later. The first block in each message is preceded by a pre-transmission mark (**PTM**) and a **start bit**. The **PTM** is a mark "1" and the **start bit** is a space "0".
The length of the PTM is set according to the communications hardware used, usually it is about 20 mSec for a leased line and 300 mSec to 2 Sec for radio.

The receiving clock is synchronised by this first start bit, there are no further synchronising bits between following blocks of the message. This is different from standard asynchronous serial data (eg: RS-232), which is synchronised at the beginning of each byte. As a conitel message may be a maximum of 512 bits long, there is the need for extremely precise hardware timing elements.



Each message block contains the following parts:



Those A and B sections that contain data are called **data blocks.** By convention, these data blocks are referred to by message block number and section number, eg: 1B, 2A, 2B, 3A, 3B, etc.

Bits within a data block are numbered from 1 to 12 starting from the left hand end (most other numbering schemes would go from 0 to 11 and start at the right hand end). Bit 1 is the MSB and is transmitted first.

3. 1. "A" Section

May contain either address information or data. The "A" section of the first block of each message always contains address information and all subsequent sections always contain data. Address information is partitioned into **Function**, **Station** and **Group** fields described below. All of these fields are transmitted MSB first.

Address Section

F	F	F	F	S	S	S	S	G	G	G	G

FFFF: Function (0-15)
SSSS: Station (0-15)
GGGG: Group (0-15)

3. 1. 1. Function

What control or scan function code is requested. The meanings of the various function codes are described later.

3. 1. 2. Station

RTU station number 0 - 15. In theory, station 0 is reserved for general broadcast messages, but some RTUs treat this like any other station number. Station 15 is sometimes also reserved for various purposes in some systems, but this is not defined in the protocol.

3. 1. 3. Group

Which group of data, or set of controls, within the specified RTU is being referred to. May be any number from 0 - 15. As an RTU will only respond if both Station and Group address match the RTU configuration, the Group address can be used as an extension of the Station address. ie: Several RTUs can share the one Station address, as long as they use different Group addresses. This technique is used by the C5 RTU and the NuLec Autorecloser.

A group number used by a scan group may also be used by a control group on the same RTU, because the different **function** number differentiates between the two commands.

3. 2. "A" Bit

Indicates whether the "A" section contains address information or data (0 = address, 1 = data). The "A" bit is therefore "0" in the first block of each message, and "1" thereafter.

3. 3. "B" Section

Usually contains data, but is sometimes unused. If unused, it is set to all zeros.

3. 4. "B" Bit

Always set to "0". This is used to detect a "stuck ones" transmitter condition, which would not be detected by the BCH code (the BCH code of a message which is all ones, is $1F_H$, i.e.: also all ones).

3. 5. BCH Code

A 5 bit Bose-Chaudhuri error detection code, which is described later.

3. 6. EOM Bit

Indicates the end of message. It is set to "1" in the last block in a each message and is otherwise "0".

4. BCH Code

The BCH (Bose-Chaudhuri) error detection code takes the preceding 26 bits of the message, and produces a 5 bit code using the polynomial below.

$$P(x) = x^5 + x^2 + 1$$

This number is transmitted MSB-first.

The BCH code can be generated by the technique of XOR-ing together the sub-remainders in the following table that correspond to each bit set in the message.

Table of Sub-remainders (all in Hex)							
Bit	Code	Bit	Code	Bit	Code	Bit	Code
A1	12	A8	0F	B1	13	B8	11
A2	09	A9	15	B2	1B	B9	1A
A3	16	A10	18	B3	1F	B10	0D
A4	0B	A11	0C	B4	1D	B11	14
A5	17	A12	06	B5	1C	B12	0A
A6	19			B6	0E		
A7	1E	A-Bit	03	B7	07	B-Bit	05

Note: I believe that it is possible to use the BCH code as an error-*correcting* code, however, this is not done in any known implementations of Conitel.

4. 1. BCH Code - Calculation Example

The BCH code of the following message is calculated as shown below:

Message:

0000 0010 1010	0	000000000000	0	?????	1

BCH Code:

Bits Set	Sub-remainder
A7	1E = 11110
A9	15 = 10101
A11	0C = 01100
XOR	07_H = 00111

5. Conitel Functions

All message exchanges between the master and RTUs begin with the master station sending a single-block message as follows:

Func	Stn	Grp	0	B Section	0	BCH	1

The RTU whose address corresponds the **station** number, and which is configured to accept requests associated with the **function** and **group** numbers, accepts this request. This RTU then sends a reply message appropriate to the **function** and **Group** specified. In the event of the RTU detecting an invalid message (eg: BCH code), the RTU does not reply.

Group and **B section** codes have different meanings according to the **Function** specified. All functions currently used are shown below.

Code	Function
0	Scan Data
1	Execute Command
2	Trip
3	Setpoint A
4	Close
5	Setpoint B
6	Not used
7	Not used
8	Reset (Only used by "Miille card" RTU)
9	Master Station Request
A	New SOE events (Not supported by all RTUs)
B	Repeat SOE events (Not supported by all RTUs)
C	Not used
D	Unit Raise/Lower (Not supported by all RTUs)
E	Freeze and scan accumulators
F	Freeze and scan accumulators with reset

5. 1. Scan Data - Function 0

Master to RTU

0000SSSSGGGG	0	000000000000	0	EEEEE	1

RTU to Master

0000SSSSGGGG	0	DDDDDDDDDDDD	0	EEEEE	0
DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	0

. . .

DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	1

SSSS: RTU station address

GGGG: Scan group in RTU

EEEE: BCH error check code

DDDDDDDDDDDD: 12-bit blocks of data associated with this scan group.

1) The RTU may return from 0 to 16 blocks of data. The quantity of data associated with each scan group is configured in the RTU.

2) If an even number of sub-blocks of data is to be returned, the B section of the last message block is set to zero.

3) Data may contain digitals, analogues, accumulators, etc. The data types in use depend on the configuration of the RTU. Available data types are shown in section 6.

5. 2. Execute Command - Function 1

Master to RTU

0001SSSSGGGG	0	000000000000	0	EEEEE	1

RTU to Master

0001SSSSGGGG	0	000000000000	0	EEEEE	1

SSSS: RTU station address

GGGG: Control group in RTU

EEEE: BCH error check code

1) The RTU returns a verification reply identical to the transmitted message.

2) On receiving an execute command, the RTU performs the previously requested control command, if any. The execute command should have the same Control Group as the control command.

3) Section 1B is unused and is set to zero by the master station. It is generally ignored by the RTU.

5. 3. Trip and Close - Functions 2 and 4

Master to RTU

FFFFSSSSGGGG	0	TTTTTTTTTTTT	0	EEEEE	1

RTU to Master

FFFFSSSSGGGG	0	TTTTTTTTTTTT	0	EEEEE	1

FFFF: Function code: 0010 (2) for Trip, 0100 (4) for Close.

SSSS: RTU station address

GGGG: Control group in RTU

EEEE: BCH error check code

TTTTTTTTTTTT: Trip (or Close) bits.

1) The RTU returns a verification reply identical to the transmitted message.

2) Associated with each Trip/Close Control Group in the RTU are 12 Trip/Close outputs. Each of these outputs corresponds to a single bit in the TTTTTTTTTTTT section.

3) Only one Trip/Close output may be controlled by a single command, therefore only one bit in the TTTTTTTTTTTT section may be "1" at any one time. If multiple bits are set, the command should be ignored by the RTU.

4) The Trip/Close command is not executed by the RTU until an execute command (5.2) is received. With most RTUs, this execute command must be received within a fixed time period (usually about 10 Sec) after the Trip/Close command.

5) The convention is that CLOSE is equivalent to START, ON and AUTO. A TRIP is equivalent to OPEN, STOP, OFF and MANUAL (6.1).

6) Trip and Close outputs may be either **momentary** or **latched**. This output type is selected in the RTU and is not defined as part of the Conitel message.

♦ With a **latched** output, a single physical output is switched **on** on receiving a **close** request, and **off** on receiving an **open**.

♦ With a **momentary** output, there are two physical outputs, a **trip** and a **close**, associated with a single point. The appropriate output is pulsed for a short duration on receiving a trip or close command. This momentary output type was intended specifically for operating circuit breakers, but often will be used for functions such as resetting alarms (in which case, often only the close relay needs to be used). The pulse time of the momentary output is selectable within the RTU, usually on a per-scan-group basis, from 100mSec to 5 Sec.

5. 4. Setpoint A and Setpoint B - Functions 3 and 5

Master to RTU

FFFFSSSSGGGG	0	NNNNNNNNNNNN	0	EEEEE	1

RTU to Master

FFFFSSSSGGGG	0	NNNNNNNNNNNN	0	EEEEE	1

FFFF: Function code: 0011 (3) for Setpoint A, 0101 (5) for Setpoint B.

SSSS: RTU station address

GGGG: Control group in RTU

EEEE: BCH error check code

NNNNNNNNNNNN: Setpoint

1) The RTU returns a verification reply identical to the transmitted message.

2) Each Control Group has only one 12-bit setpoint associated with it. The NNNNNNNNNNNN section gives the actual setpoint data, and not an address, as with Trip/Close. Generally this setpoint is treated as an unsigned binary integer, with a range of 0-4095.

3) There is no functional difference between Setpoint A and Setpoint B. The only reason for having Setpoint B is to expand the number of possible setpoints per RTU address from 16 to 32.

4) With some RTUs, an **execute** command (5.2) must be received before the setpoint is activated (as with Trip/Close), with others an **execute** command is not required. Officially, an **execute** command **is** required.

5. 5. Reset RTU - Function 8

Master to RTU

1000SSSSGGGG	0	000000000000	0	EEEEE	1

RTU to Master

No Reply

SSSS: RTU station address

GGGG: Group code

EEEE: BCH error check code

1) This is a non-standard function which only applies to the "Miille Card" RTU. It causes the RTU to reset itself. As the reset process may take up to two minutes to complete, no further commands should be sent to the RTU during this time. This function is not supported by most master stations.

2) This command roughly corresponds to "master station request, cold start", (function 9, code F).

5. 6. Master Station Request - Function 9

Master to RTU

1001SSSSGGGG	0	BBBBBBBBBBBB	0	EEEEE	1

RTU to Master

1001SSSSGGGG	0	DDDDDDDDDDDD	0	EEEEE	0
DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	0

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DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	1

SSSS: RTU station address

GGGG: Group code

EEEE: BCH error check code

BBBBBBBBBBBB: B Section (sometimes used)

DDDDDDDDDDDD: Data

1) This function causes the RTU to perform various self-checking and diagnostic actions. The action performed depends on the **Group Code** specified and the type of RTU.

2) The meanings of the **Group Code**s, and what data the RTU returns is shown below.

5. 6. 1. Function 9 - Code 0

C5: Reserved for "Call-in mode". Not used by any other RTUs. Do not use.

5. 6. 2. Function 9 - Code 1

C2025 and C25 RTUs. Test RAM.
BBBBBBBBBBBB is set to zero, and should be ignored by the RTU.
Returns 1 block of data, 000= RAM OK, 001 = Error found

5. 6. 3. Function 9 - Code 2

C2025 and C25 RTUs. Test PROM checksum.
BBBBBBBBBBBB is set to zero, and should be ignored by the RTU.
Returns 1 block of data, 000= PROM OK, 001 = Error found

5. 6. 4. Function 9 - Code 3

C2025 and C25 RTUs. Test EPROM checksum.
BBBBBBBBBBBB is set to zero, and should be ignored by the RTU.
Returns 1 block of data, 000= EPROM OK, 001 = Error found

5. 6. 5. Function 9 - Code 4

C50: Not used, no reply.
C2025: Test I/O controller data bus
Returns 1 block of data, 000= I/O controller data bus OK, 001 = Error found
C25: Read I/O board read-back code
Returns 1 block of data, 00A=36 point card fitted, 009=72 point card fitted, 00F=no card fitted.

5. 6. 6. Function 9 - Code 5

C2025, C25 and C50 RTUs. Download data to RTU.
The master to remote message may contain more than one message block.
BBBBBBBBBBBB is as follows:

I	I	I	I	N	N	N	N	D	D	D	D

I I I I: Data Index, (0-15) as indicated below
NNNN: Number of blocks in message (including this one)
DDDD: Data.

Data Index 0:
Update Time Request. Valid for C2025 and C50 RTUs. "Not yet implemented" on C5 RTU. This function is intended to synchronize the RTU clock to allow consistent SOE reporting.
Number of blocks in message = 2.

Master to RTU

1B

0	0	0	0	0	0	1	0	0	H	H	H

2A

H	H	M	M	M	M	M	M	S	S	S	S

2B

S	S	L	L	L	L	L	L	L	L	L	L

RTU to Master

Same as Master to RTU message.

HHHHH: (5 bits, 0-24) = Hours
MMMMMM: (6 bits, 0-59) = Minutes
SSSSSS: (6 bits, 0-59) = Seconds
LLLLLLLLL: (10 bits, 0-999) = Milliseconds

Data Indices 1-15
Unused. No reply returned

5. 6. 7. Function 9 - Code 6

Reserved for future "Data Upload" function on C50 RTU (Not yet implemented). Unused on all other RTUs.

5. 6. 8. Function 9 - Code 7

Unused. No reply returned

5. 6. 9. Function 9 - Code 8

C2025, C25 and C50 RTUs . Send Remote Status bits.
BBBBBBBBBBBB is not used and set to 0.
Returns 1 block containing RTU status bits (6.13)

5. 6. 10. Function 9 - Code 9

C2025 and C25 RTUs only. Read input directly. Has slightly different formats on different RTUs:
BBBBBBBBBBBB gives the physical address of the input to read as follows.

Master to RTU

C2025:

0	0	0	0	F	F	C	C	A	A	A	A

FF: File Address
CC: Circuit Address
AAAA: Card Address

C25:

R	R	R	R	C	C	C	C	C	C	C	C

RRRR: Request Type: 1=Status, 6=Analogue
CCCCCCCC: Circuit Number (Status 1-18, Analog 1-8)

RTU to Master

Returns 2 blocks, the first is a copy of the master station message, the second is as follows:

2A

0	0	0	0	0	0	0	0	T	T	T	T

2B

V	V	V	V	V	V	V	V	V	V	V	V

TTTT: Data Type (4 bits). See table below.
VVVVVVVVVVV: Data Value (12 bits)

DATA TYPES
0 - Spare
1 - Digital Status
2 - Analogue low level
3 - Analogue high level (4 channel)
4 - Accumulator (12 bit)
5 - Full Momentary Change Detect (MCD)
6 - Analogue High Level (16 channel)
7 - Sequence of events
8 - MCD type A
9 - MCD type B
A - Setpoint A
B - Setpoint B
C - Trip/Close control
D - Spare
E - Spare
F - Remote Status bytes

5. 6. 11. Function 9 - Code A

Read comms parameters for the specified port. Valid for C2025, C25, C5 and C50 RTUs.

BBBBBBBBBBBB gives the port number as follows:

0	0	0	0	0	0	0	0	P	P	P	P

PPPP: Comms port (C2025: 1-4, C25& C50: 1-2, C5:Ignored), or 0

1) If an invalid port number is specified, no reply is returned.

2) The C5 ignores the BBBBBBBBBBBB section, and always returns the response shown in 5) below.

3) If the port number is valid, but not fitted, the C25 & C2025 return only a single block reply, with 1B set to zero. The C50 returns a two block reply, with 1B set to zero and the second block invalid, the second block should be ignored by the master station.

4) If the RTU is **not** a C5 and BBBBBBBBBBBB=0, the master station wishes to establish the **TCF** (Time Correction Factor) to measure the communications delay. In this case, the RTU sends a single block reply containing only the PTM in mSec. The RTU message processing time must always be a constant for this message, and it is recommended that some sort of interrupt processing be used to ensure this.

5) Otherwise returns two blocks as follows:

1B

P	P	P	P	P	P	P	P	P	P	P	P

2A

S	S	S	S	S	S	S	S	S	S	S	S

2B

0	0	0	0	E	E	E	E	E	E	E	E

PPPPPPPPPPPP: Pre-transmission Mark in mSec (12 Bits)
SSSSSSSSSSSS: Squelch time in mSec (12 bits)
EEEEEEEE: Comms Error Count (8 bits)

6) The Comms Error Count is zeroed after being read by this function.

5. 6. 12. Function 9 - Code B

C2025, C25, C5 and C50 RTUs, C5 Protocol Converter. Repeat Last Message.
BBBBBBBBBBBB is not used and set to 0, it should be ignored by the RTU. If there was no previous message, a single block with section 1B set to zero is sent, otherwise the last message sent is repeated verbatim.

5. 6. 13. Function 9 - Code C

Unused.
No reply returned.

5. 6. 14. Function 9 - Code D

C25, C2025 and C50 RTUs. Place Conitel line in loopback mode.
Has slightly different formats on different RTUs:

BBBBBBBBBBBB specifies the type of loopback to apply, and the port to apply it to as follows:

C2025:

0	0	0	0	D	D	P	P	P	P	T	T

DD: Duration of loopback in seconds.
PPPP: Port number (1-4)
TT: Type of loopback.
1 - Digital Loopback
2 - Analogue Loopback
3 - Software Loopback
4 - Remove Loopback

C25 & C50:

D	D	D	D	D	P	P	P	P	T	T	T

DDDDD: Duration of loopback in Sec (0 = no loopback on C25, indefinite loopback on C50)
PPPP: Port number (1 or 2 on C25, 1-4 on C50)
TTT: Type of loopback (as for C2025)

Returns 1 block of data, 000 = OK, 001 = Was unable to perform function. On the C25 & C2025 this reply is sent after loopback has finished, if loopback was requested on the same channel, otherwise it is sent immediately. On the C50, the reply is always sent immediately.

5. 6. 15. Function 9 - Code E

C2025, C25 and C5 RTUs. Reset RTU (warm start, does not re-initialize RAM).
No reply returned. BBBBBBBBBBBB is not used and set to 0, it should be ignored by the RTU.

5. 6. 16. Function 9 - Code F

C2025, C25, C5 and C50 RTUs. Reset RTU (cold start, re-initializes everything).
No reply returned.

C2025, C25 and C5:
BBBBBBBBBBBB is not used and set to 0, it should be ignored by the RTU.

C50:
BBBBBBBBBBBB selects the software configuration to restart with.

X	X	X	X	S	S	S	S	C	C	C	C

XXXX: Undefined bits, ignored by RTU. (probably zero)
SSSS: Software to start with (1or 2)
CCCC: Configuration to start with (1 or 2)

5. 7. New and Repeat SOE Events - Functions A and B

Master to RTU

FFFFSSSSGGGG	0	000000000000	0	EEEEE	1

RTU to Master (No events present)

FFFFSSSSGGGG	0	000000000000	0	EEEEE	1

RTU to Master (Events present)

FFFFSSSSGGGG	0	DDDDDDDDDDDD	0	EEEEE	0
DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	0

. . .

DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	1

SSSS: RTU station address

GGGG: Group code

EEEE: BCH error check code

BBBBBBBBBBBB: B Section (sometimes used)

DDDDDDDDDDDD: Data

1) SOE (Sequence Of Events) reporting provides a time-tagged record of all points that have changed state since the last scan. These points must be specifically configured as SOE in the RTU, points in normal scan groups are not automatically included.

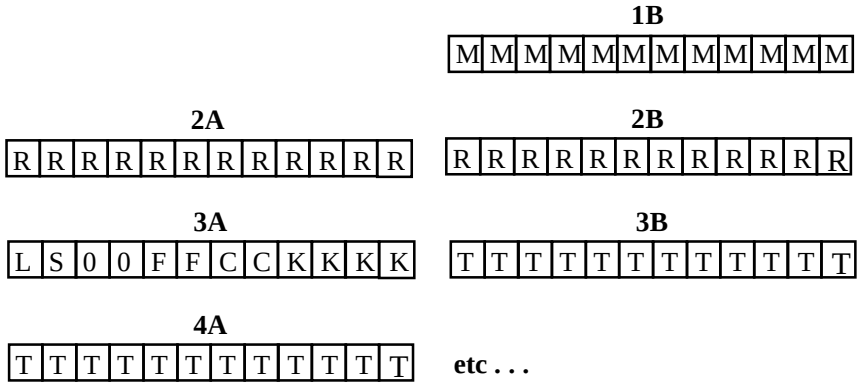
2) Not all RTUs support SOE reporting. Some RTUs with old (pre-1985) firmware may use the "C2025" format described below.

3) If there are SOE events to report, the reply message contains the data as described. Each SOE event occupies 30 or 41 bits, depending on the status of the T-Bit (or 24 bits with the "C2025" format). All SOE events are concatenated together without regard to section boundaries.

4) If the L-Bit is not set in the first reply message, the master station must ask for the remaining events with another "New SOE events" request.

5) A typical RTU may have a buffer of 200-500 SOE events. If this buffer overflows, a bit in the **remote status bits** (see 6.13) is set. On the C50 RTU, buffer overflow also results in a special "buffer overflow message" being added to the SOE buffer. This message has a point number set to 127.

"C2025" Format (Probably obsolete):



3A to 4A refer to first event, 4B to 5B second event and so on.

MMMMMMMMMM: (12 Bits) Turn-around time of message (mSec)
RRRRRRRRRRRRRRRRRRRRRR: (24 Bits) Time message received, MSB first. (Format unknown)

The following fields are repeated for each event:

L: L-Bit (1=Last Event, 0=Not Last Event)
S: Status of point after change
FFCCKKK: Point Number as follows:
FF: File Address
CC: Circuit Address
KKKK: Card Address
TTTTTTTTTTTTTTTTTTTTTT: (24 Bits) Time of event (Format unknown)

C25 and C50:

1B

N	N	N	I	I	I	I	I	I	I	S	Q

If T-Bit = 0

2A

T	t	t	t	t	t	t	t	t	t	t	t

2B

t	t	t	t	t	L	-	-	-	-	-	-

If T-Bit = 1

2A

T	t	t	t	t	t	t	t	t	t	t	t

2B

t	t	t	t	t	t	t	t	t	t	t	t

3A

t	t	t	t	L	-	-	-	-	-	-	-

etc . . .

The following fields are repeated for each event:

NNN I I I I I I I : (10 Bits) Point Number as follows:
NNN: Last 3 bits of scan group
I I I I I I I : (7 Bits) Point index (1-72 on C25, 1-120 on C50)
S: Status Bit - Status of input point
Q: Quality Bit - Not yet implemented (Probably 0)
T : Time Bit (0=Time contains 16 bits, 1=Time contains 27 bits)
t t t t t . . . t : Time of status change (16 or 27 Bits) as follows:
hhhhhh : (5 Bits, 0-23) Hours - Only present of T-Bit = 1
mmmmmm : (6 Bits, 0-59) Minutes - Only present if T-Bit = 1
ssssss : (6 Bits, 0-59) Seconds
mmmmmmmmmm : (10 Bits, 0-9999) mSec
(Note that on some RTUs, the time reported may not be accurate to the nearest mSec, often an error of ±5 mSec is quoted.)
L : Last Event Bit (1=Last Event, 0=Not Last Event)
- - - . . - : Data for following event, if any.

5. 8. Unit Raise/Lower - Function D

Master to RTU

1101SSSSGGGG	0	AAAABBBBCCCC	0	EEEEE	1

RTU to Master

1101SSSSGGGG	0	AAAABBBBCCCC	0	EEEEE	1

SSSS: RTU station address

GGGG: Raise/Lower Control group in RTU

EEEE: BCH error check code

AAAA , BBBB and CCCC : Raise/Lower setpoints

1) The RTU returns a verification reply identical to the transmitted message.

2) Each Raise/Lower Control Group can control up to three raise/lower outputs.

3) The raise/lower function is considered to be associated with a pair of digital outputs, one of which is pulsed on for the duration specified by the command. It is intended to be used to control a motor-controlled setpoint device, such as a proportional valve, or the speed setpoint (often set by a motorised pot) of a generator governor. If implemented in software, this function can increment or decrement a setpoint by a given amount.

4) In the event of a second or subsequent Raise/Lower being received when a previous Raise/Lower is still in progress, the previous command is terminated, and the latest command is used.

5) Unlike Trip and Close controls, no Execute command is required to activate the Raise/Lower.

6) The **clock period** (below) is usually configurable on the RTU and is generally a multiple of 10mSec. Some RTUs may also have a configurable **offset**, which is added to the number of clock periods specified.

Raise/Lower setpoint:

D : Direction (0=Lower, 1=Raise)
AAA : Action (0=No action on this point, 1-7 = Number of **clock period**s to raise/lower for)

5. 9. Freeze and Scan Accumulators (and reset) - Functions E and F

Master to RTU

FFFFSSSSGGGG	0	000000000000	0	EEEEE	1

RTU to Master)

FFFFSSSSGGGG	0	DDDDDDDDDDDD	0	EEEEE	1
DDDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	0

. . .

DDDDDDDDDDD	1	DDDDDDDDDDDD	0	EEEEE	1

FFFF: Function code: 1110 for freeze and scan. 1111 for freeze, scan and reset.

SSSS: RTU station address

GGGG: Scan group in RTU

EEEE: BCH error check code

DDDDDDDDDDDD: 12-bit blocks of accumulator data.

1) Some third party emulations treat this command as a **control** request and don't return any accumulator data, but merely return a verification reply identical to the transmitted message. This is officially wrong and can cause problems with some master station configurations.

2) The RTU should return the accumulator data, if any, associated with the specified scan group. Some RTUs (eg: C5) may also return the **remote status bits** (See 6.13) in section 1B of the reply.

3) If the RTU address 0 is specified, all accumulators in all RTUs are frozen/reset as appropriate. No RTU returns a reply message. This function is not implemented on the C50 RTU.

4) Depending on RTU setup, accumulators may also be read by use of **function 0** (scan data). Generally, the data returned by function 0 is the value of the accumulator(s) at the last "Freeze & Scan" request. Some master stations impose restrictions on the use of accumulators in scan data.

6. Data Types

Data returned by the "Scan Data" command may use the data types defined below. Note the following:

♦ The term "MCD" stands for "Momentary Change Detect".
♦ Generally the master station allows groups of bits within block to be defined as "unused".
♦ 12 bit types must occupy a whole block, and not overlap between blocks. 2, 4, 6 and 8 bit types need not start on an even bit number, but must not overlap between blocks.
♦ See note 6 in section 5.3 for output data types.

6. 1. One-bit Status

1 Bit. An ordinary on/off digital point. The on and off states are referred to as "A" and "B", and are generally interpreted as follows:

"A" State = 1 = ON, RUNNING, IN SERVICE, AUTOMATIC, CLOSED, INHIBITED.
"B" State = 0 = OFF, STOPPED, OUT OF SERVICE, MANUAL, OPEN, ENABLED.

6. 2. Two-bit Status

2 Bits. A four-state digital point occupying two bits. Intended to be used for circuit breakers and valves with separate "open" and "closed" limit switches.

"0" State = 00 = In Transit
"A" State = 10 = Closed
"B" State = 01 = Open
"AB" State = 11 = Invalid State

6. 3. One-bit MCD Type A

2 Bits. Consists of a **Change** bit followed by a **Status** bit. The **Change** bit is set to 1 if the status bit being monitored has changed from open (0) to closed (1) one or more time since this data was last scanned. The **Status** bit is the same as the "One-bit Status" point in 5.1 above, except that it is inverted (Closed=0, Open=1).
This data type is designed to cope with fleeting inputs.

6. 4. One-bit MCD Type B

2 Bits. As for MCD type A, only the Change bit is set to 1 on a closed (1) to open (0) transition and the Status bit is not inverted (Open=0, Closed=1).

6. 5. One-bit MCD Type C

2 Bits. As for MCD type A, only the Change bit is set to 1 on more than one transition (1-0-1 or 0-1-0) of the associated status and the Status bit is not inverted (Open=0, Closed=1).

6. 6. Two-bit MCD Type A

4 Bits. Is to a one-bit MCD Type A what a two-bit status is to a one-bit status. Consists of two consecutive one-bit MCD Type A points ie: $C_1S_1C_2S_2$.

6. 7. Two-bit MCD Type B

4 Bits. As for MCD type A, only the Change bit is set to 1 on a closed (1) to open (0) transition.

6. 8. Two-bit MCD Type C

4 Bits. As for MCD type A, only the Change bit is set to 1 on more than one transition (1-0-1 or 0-1-0) of the associated status.

6. 9. Twelve-bit Accumulator

12 Bits. Treated as a 12 bit unsigned binary integer. Transmitted MSB first. Generally, these numbers are returned in response to functions E & F and are not used in a normal scan request (function 0). In an RTU which does not return data in response to functions E & F, accumulators are part of the scan data. In this case, the number returned is not the current value of the accumulator, but the value at the last freeze command. Some master stations impose certain restrictions on scan groups containing accumulators.

6. 10. Twenty-Four-bit Accumulator

24 Bits. The most significant 12 bit word is transmitted first. Generally the same as a 12-bit accumulator. Some master stations do not support this data type.

6. 11. Bipolar Analogue

12 Bits. A standard sign-magnitude binary integer analogue. Transmitted Sign bit (0=Positive, 1= Negative) first, then MSB to LSB. Generally, this is raw data, with scaling to engineering units being done by the master station.

6. 12. 1 to 5 Digit BCD

4, 6, 8, 12, 16 or 20 Bits, corresponding to 1, 1.5, 2, 3, 4 and 5 digit BCD. Transmitted MSB first. A non-signed BCD integer. BCD integers are traditionally derived from digital inputs monitoring devices driving LED displays, such as transformer tap-changers.

6. 13. Remote Status Bits

12 Bits. Gives the status of the RTU, as follows:

E	E	E	E	I	R	F	L	C	S	O	P

EEEE : Error Code, described in table below (Displayed on lamps E0-E3 on C25, C225 and C2025 RTUs. Not used on C5 or C50)
I : Controls Isolated (0=Normal, 1=Isolated) Not supported on C5 RTU.
R : Watchdog timer (or other CPU) reset occurred
F : Field Interrogator Supply Low. Not supported on C5 RTU.
L : Internal Power Supply Low.
C : Accumulator Overflow Change (Note: This and the following bit form a "One-Bit MCD" type point)
S : Accumulator Overflow Status.
O : SOE Events Overflow. Not supported on C5 RTU.
P : SOE Events Present. Not supported on C5 RTU.

	RTU ERROR CODE
0	No Error
1	Power Fail
2	Spare
3	Control Error
4	Comms Error (Normally will be present)
5	Configuration / Scan Error
6	Timer Overrun
7	Address Error
8	Bus Error
9	Software Error
A	Spare
B	RAM Error
C	I/O Controller Hardware Test Failure
D	Configuration PROM Checksum Test Failure
E	Program PROM Checksum Test Failure
F	Reset Operation (Function 9, Code E or F) In Progress