CROWCON
Detecting Gas Saving Lives

XgardIQ

Intelligent Gas Detector and Transmitter

HART Field Device Specification

HART COMMUNICATION PROTOCOL

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Synopsis:

The XgardIQ complies with HART Protocol Revision 7.5. This document specifies all device specific features of the HART protocol implementation and should be used in conjunction with HART specification documents available from the HART Communication Foundation.

Contents

1. Glossary of Terms 7
2. Introduction 7
2.1 Scope 7
2.2 Purpose 7
2.3 Who should use this document? 7
2.4 References 7
3. Device Identification 8
4. Product Overview 9
5. HART Functional Overview 9
5.1 Connecting a HART Communicator 9
5.1.1 4-20mA HART 9
5.1.2 Local (I.S.) HART 9
6. Notes on the use of HART with the XgardIQ 9
6.1 Password Protection 9
6.2 Interfaces 9
6.3 Sensor Change 10
6.4 Loop Mode Disable 10
6.5 Loop Current 10
7. Device and Dynamic Variables 10
7.1 Device Variables 10
7.2 Dynamic Variables 10
7.2.1 Gas Level (PV) 11
7.2.2 Obscuration (SV) 11
7.2.3 Supply Voltage (TV) 11
7.2.4 Gas Level (no zero suppression, adjusted for cross calibration if set) (QV) 11
8. Status Information 12
8.1 Response Codes 12
8.1.1 New Multi-Definition Warnings 12
8.1.2 New Multi-Definition Errors 12
8.2 Device Status 13
8.3 Additional Device Status (Command #48) 13
9. Universal Commands 17
9.1 Command #0 17
9.2 Command #3 17
9.3 Command #9 17
10. Common Practice Commands 18
10.1 Supported Commands 18
10.1.1 Command #33 Read Device Variables 18
10.1.2 Command #35 Write Primary Variable Range Values 18
10.1.3 Command #40 Enter/Exit Fixed Current Mode 18
10.1.4 Command #42 Perform Device Reset 18
10.1.5 Command #45 Trim Loop Current Zero 18
10.1.6 Command #46 Trim Loop Current Gain 19

10.1.7 Command #89 Set Real-Time Clock 19
10.1.8 Command #90 Read Real-Time Clock 19

10.2 Burst Mode 19

11. Device Specific Commands 20

11.1 Supported Commands 20

11.2 Command #128 Set Inhibit Mode 20
11.2.1 Request Data Bytes 21
11.2.2 Response Data Bytes 21
11.2.3 Command-Specific Response Codes 21

11.3 Command #129 Zero Gas Reading 22
11.3.1 Request Data Bytes 22
11.3.2 Response Data Bytes 22
11.3.3 Command-Specific Response Codes 22

11.4 Command #130 Calibrate Gas Reading 24
11.4.1 Request Data Bytes 24
11.4.2 Response Data Bytes 24
11.4.3 Command-Specific Response Codes 24

11.5 Command #131 Read Sensor Data 26
11.5.1 Request Data Bytes 26
11.5.2 Response Data Bytes 26
11.5.3 Command-Specific Response Codes 26

11.6 Command #132 Read Serial Numbers 27
11.6.1 Request Data Bytes 27
11.6.2 Response Data Bytes 27
11.6.3 Command-Specific Response Codes 27

11.7 Command #133 Read Software Versions 28
11.7.1 Request Data Bytes 28
11.7.2 Response Data Bytes 28
11.7.3 Command-Specific Response Codes 28

11.8 Command #134 Read Password Enable 29
11.8.1 Request Data Bytes 29
11.8.2 Response Data Bytes 29
11.8.3 Command-Specific Response Codes 29

11.9 Command #135 Write Password 30
11.9.1 Request Data Bytes 30
11.9.2 Response Data Bytes 30
11.9.3 Command-Specific Response Codes 30

11.10 Command #136 Read Password Unlock State 31
11.10.1 Request Data Bytes 31
11.10.2 Response Data Bytes 31
11.10.3 Command-Specific Response Codes 31

11.11 Command #137 Write Password to Unlock or Lock 32
11.11.1 Request Data Bytes 32
11.11.2 Response Data Bytes 32
11.11.3 Command-Specific Response Codes 32

11.12 Command #138 Read Alarm Data 33
11.12.1 Request Data Bytes 33
11.12.2 Response Data Bytes 33
11.12.3 Command-Specific Response Codes 33

11.13 Command #139 Write Alarm Data 34
11.13.1 Request Data Bytes 34
11.13.2 Response Data Bytes 35
11.13.3 Command-Specific Response Codes 35

11.14 Command #140 Read Configured Gas Names and Units 36
11.14.1 Request Data Bytes 36
11.14.2 Response Data Bytes 36
11.14.3 Command-Specific Response Codes 36

11.15 Command #141 Read ID String 37
11.15.1 Request Data Bytes 37
11.15.2 Response Data Bytes 37
11.15.3 Command-Specific Response Codes 37

11.16 Command #142 Write ID String 38
11.16.1 Request Data Bytes 38
11.16.2 Response Data Bytes 38
11.16.3 Command-Specific Response Codes 38

11.17 Command #143 Read Hardware ID 39
11.17.1 Request Data Bytes 39
11.17.2 Response Data Bytes 39
11.17.3 Command-Specific Response Codes 39

11.18 Command #144 Read Analogue Output Configuration 40
11.18.1 Request Data Bytes 40
11.18.2 Response Data Bytes 40
11.18.3 Command-Specific Response Codes 40

11.19 Command #145 Write Analogue Output Calibration 41
11.19.1 Request Data Bytes 41
11.19.2 Response Data Bytes 42
11.19.3 Command Specific Response Codes 42

11.20 Command #146 Read Bump Test Configuration 43
11.20.1 Request Data Bytes 43
11.20.2 Response Data Bytes 43
11.20.3 Command-Specific Response Codes 43

11.21 Command #147 Write Bump Test Configuration 44
11.21.1 Request Data Bytes 44
11.21.2 Response Data Bytes 44
11.21.3 Command-Specific Response Codes 44

11.22 Command #148 Read Zero Suppression Configuration 45
11.22.1 Request Data Bytes 45
11.22.2 Response Data Bytes 45
11.22.3 Command-Specific Response Codes 45

11.23 Command #149 Write Zero Suppression Configuration 46
11.23.1 Request Data Bytes 46
11.23.2 Response Data Bytes 46
11.23.3 Command-Specific Response Codes 46

11.24 Command #150 Pellistor Saver Control 47
11.24.1 Request Data Bytes 47
11.24.2 Response Data Bytes 47
11.24.3 Command-Specific Response Codes 47

11.25 Command #151 Enter/Exit Fixed Current Mode with Alarm Test 48
11.25.1 Request Data Bytes 48
11.25.2 Response Data Bytes 48
11.25.3 Command-Specific Response Codes 48

11.26 Command #152 Acknowledge Alarms 49
11.26.1 Request Data Bytes 49
11.26.2 Response Data Bytes 49
11.26.3 Command-Specific Response Codes 49

11.27 Command #153 Bump Test 50
11.27.1 Request Data Bytes 50
11.27.2 Response Data Bytes 50

11.27.3 Command-Specific Response Codes 51
11.28 Command #154 Read Due Dates 52
11.28.1 Request Data Bytes 52
11.28.2 Response Data Bytes 52
11.28.3 Command-Specific Response Codes 52
11.29 Command #155 Relay Test 53
11.29.1 Request Data Bytes 53
11.29.2 Response Data Bytes 53
11.29.3 Command-Specific Response Codes 53
11.30 Command #156 Full Status 54
11.30.1 Request Data Bytes 54
11.30.2 Response Data Bytes 55
11.30.3 Command-Specific Response Codes 55
11.31 Command #157 Set Cross Calibration Gas 56
11.31.1 Request Data Bytes 56
11.31.2 Response Data Bytes 56
11.31.3 Command-Specific Response Codes 56

1. Glossary of Terms

Term	Glossary
IQ-Display	A component of the XgardIQ that can have local (I.S.) HART. The IQ-Display in conjunction with the IQ-Main forms the Transmitter part of the XgardIQ.
IQ-Main	A component of the XgardIQ that can have 4-20 mA HART. The IQ-Main in conjunction with the IQ- Display forms the Transmitter part of the XgardIQ.
IQ-Sensor	The gas measuring component of the XgardIQ.
I.S.	Intrinsically safe.
IR sensor	Infra-red sensor.
RTC	Real-time clock.
UI	User interface.
XgardIQ	A product consisting of three components: the IQ-Display, IQ-Main and IQ-Sensor. See other product documentation for details.

2. Introduction

2.1 Scope

The XgardIQ complies with HART Protocol Revision 7.5. This document specifies all the device specific features and documents HART Protocol implementation details (e.g., the Engineering Unit Codes supported). The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART capable Host Applications.

2.2 Purpose

This specification is designed to complement other documentation (e.g., the XgardIQ User Guide) by providing a complete, unambiguous description of this Field Device from a HART Communication perspective.

2.3 Who should use this document?

This specification is designed to be a technical reference for HART capable Host Application Developers, System Integrators and knowledgeable End Users. It also provides functional specifications (e.g., commands, enumerations and performance requirements) used during Field Device development, maintenance and testing. This document assumes the reader is familiar with HART Protocol requirements and terminology.

2.4 References

For those new to HART refer to the document:

http://www.hartcomm.org/hcf/documents/appguide.pdf for an overview of the HART protocol (both physical and application layers).

Detailed HART specification documents, available from the HART Communication Foundation, that are necessary to implement a master HART protocol driver include:

HCF_SPEC-99, Command Summary Specification
HCF_SPEC-127, Universal Command Specification
HCF_SPEC-151, Common Practice Command Specification
HCF_SPEC-307, Command Response Specification

For information on how to install and operate and XgardIQ refer to: XgardIQ User Guide (Crowcon part M070030)

3. Device Identification

This specification applies to both the XgardIQ 4-20mA and XgardIQ Local HART interfaces.

Manufacturer Name:	Crowcon Detection Instruments Ltd	**Model Name(s):**	XgardIQ
Manufacture ID Code:	24625 (6031 Hex)	**Device Type Code:**	57596 (E0FC Hex)
HART Protocol Revision	7.5	**Device Revision:**	1
Number of Device Variables	6		
Physical Layers Supported	FSK		
Physical Device Category	Current output (4-20mA) / Maintenance port (Local)		

4. Product Overview

The XgardIQ is a high-function fixed gas detector that can detect a wide variety of gases though a hot-swappable gas sensor. The XgardIQ is compatible with any 4-20mA control system operating in either current source or sink mode. The addition of HART over 4-20 enhances the capabilities of the basic XgardIQ.

Local (I.S.) HART is also available on the XgardIQ's front panel. The XgardIQ HART over 4-20 and the Local (I.S.) HART interfaces are identical, and this specification applies to both interfaces.

Full details of the wiring and function of the XgardIQ given in the XgardIQ User Guide (Crowcon part M070030).

5. HART Functional Overview

5.1 Connecting a HART Communicator

5.1.1 4-20mA HART

A HART communicator can connect to the XgardIQ 4-20 HART interface at any wiring termination point in the loop signal. The HART communicator should be connected across a 250 Ω resistor – refer to the HART communicator's operating manual for details. Note that the XgardIQ will not respond to HART communications until approximately 5 seconds after power has been applied to the XgardIQ.

5.1.2 Local (I.S.) HART

A HART communicator can connect directly to the XgardIQ Local HART interface via the Local HART connection terminals. This sort of HART port is also often called a maintenance port.

The Local HART interface is identical to the XgardIQ 4-20 interface with respect to this specification. Note, however, the following points:

- All references to the current loop (output) within this specification and the standard HCF HART specifications will reference the current in the 4-20mA loop of the XgardIQ transmitter – it is essentially meaningless to refer to current in the Local loop.
- The local HART interface is not designed to be used multi-drop. Using the local HART interface in a multi-drop mode doing **will invalidate the I.S certification** of the XgardIQ.

6. Notes on the use of HART with the XgardIQ

6.1 Password Protection

HART communications interactions can be password protected – see device specific commands #134, #135, #136 and #137 Enable a password disallows all non-read HART operations (except for the writing of the password to unlock the password feature). Read operations are always allowed. If password protection is enabled then the XgardIQ will power-up in a password protected state and, once unlocked, will automatically re-enter the password locked state 5 minutes after the last HART message requiring a response is received. It is therefore necessary to ensure that regular polling of a password protected XgardIQ occurs if an unprotected state is to be maintained.

6.2 Interfaces

There are several means of interaction with the XgardIQ that includes the user interface, HART (4-20mA and local [I.S.]) and Modbus. It is not recommended that more than one interaction method is used at any one time. If this situation does occur then be aware that there could be 'conflicts of interest'. Practically, this means:

- Zero, calibration and bump test are all mutually exclusive – for example, attempting to perform a calibration whilst a zero operation is in progress will fail. Re-triggering an operation that is already in progress will not start a new operation but will be ignored. For

example, if a zero operation is triggered though HART then a zero request through the UI will be ignored.

- Generally, the last operation (e.g. configuration change, inhibit state change, relay test state, etc.) performed will be the action taken.

6.3 Sensor Change

Remove of sensor and change of sensor is not supported. Removing, fitting or changing a sensor without re-initialising the HART communications master will result in incorrect operation.

6.4 Loop Mode Disable

When loop mode is disabled the analogue output will be set to 4mA. Whilst in this mode HART commands that manipulate the analogue output return the response code 11, in multi-drop mode. In addition, UI functions that manipulate the analogue output are disabled, as indicated by a '!' by the menu item. This includes the Test → Analogue Output menu, and the Configure → Analogue Output → Zero Trim and Span Adjust items. The Inhibit menu is still accessible, but will only inhibit relays (if fitted).

6.5 Loop Current

The loop current returned by commands #2, #3 and #9 is the loop current as measured by a feedback mechanism within the XgardIQ. As a consequence there will always be a slight delay between changing or setting the loop current and the change being reflected in these commands. The delay will always be less than 2 seconds.

7. Device and Dynamic Variables

7.1 Device Variables

The XgardIQ has six device variables. Variables 0 to 3 are the dynamic variables (gas level, optical obscuration, supply voltage and gas level [no zero suppression], see following section for explanation); variables 4 and 5 are the Sensor and transmitter temperature:

	Meaning	Units
0	Gas level	%LEL, ppb, ppm, or %vol
1	Optical obscuration	%
2	Supply voltage	V
3	Gas level (no zero suppression, adjusted for cross calibration if set)	%LEL, ppb, ppm, or %vol
4	Sensor temperature	°C
5	Transmitter temperature	°C

7.2 Dynamic Variables

The XgardIQ has 4 dynamic variables. These variables are:

	Meaning	Units
PV	Gas level	%LEL, ppb, ppm, or %vol
SV	Optical obscuration	%
TV	Supply voltage	V
QV	Gas level (no zero suppression, adjusted for cross calibration if set))	%LEL, ppb, ppm, or %vol

7.2.1 Gas Level (PV)

This is the gas level measured by the XgardIQ. A small amount of zero suppression is applied to this gas level so that measurement noise around the clean air level eliminated.

7.2.2 Obscuration (SV)

This is the percentage obscuration in the measurement system. Obscuration only applies when an IR sensor is attached to the XgardIQ.

For all non-IR sensors this dynamic variable will always read 0%.

For IR sensors: A clean optical system will have no obscuration (0%). If contaminants are deposited on the optical system this percentage will increase. The IR sensors compensate for obscuration up to 90% when the XgardIQ will enter a fault state – this fault state will be indicated on the current loop and will set the HART More Status Available data bit (see command #48). There is a pre-obscuration warning triggered when the obscuration is above 75% and the gas level is less than 10% LEL. This will also be indicated on the current loop and will set the HART More Status Available data bit (see command #48).

7.2.3 Supply Voltage (TV)

This is the XgardIQ supply voltage in V. If the supply voltage falls below 14V or rises above 32V then the HART More Status Available data bit will be set (see command #48).

7.2.4 Gas Level (no zero suppression, adjusted for cross calibration if set) (QV)

This is an alternative representation of the PV Gas level, without zero suppression. If a cross calibration is set then this gas level is adjusted by the cross calibration factor.

8. Status Information

The first two bytes in a field device HART message response correspond to the Response Code byte that indicates communications errors and the Field Device Status byte that gives the current operating status of the XgardIQ. See the reference HCF_SPEC-99, Command Summary Specification for details.

8.1 Response Codes

These are as per the HART specification documents HCF_SPEC-127, Universal Command Specification and HCF_SPEC-151, Common Practice Command Specification.

Note that Response Code 7, In Write Protect Mode, will be returned for all write messages (universal, common practice and device specific) if the XgardIQ is password protected and has not been unlocked.

8.1.1 New Multi-Definition Warnings

The following new multi-definition warnings are defined:

Code	Meaning	
8	**Operation in Progress**	XgardIQ has accepted a zero, calibrate or bump test command and is currently performing the operation.
14	**Calibration required**	The zero succeeded but a calibration is now required

8.1.2 New Multi-Definition Errors

The following new multi-definition errors are defined:

Code	Meaning	
15	**Sensor fail**	Sensor failure detected during zero or calibration operation.
28	**Gas before test**	Attempt to start a bump test with target gas present.
29	**Optics obscured**	The Zero or calibration has failed as optics are obscured (IR sensors only).
65	**Temperature limit error**	Zero or calibration failure as sensor temperature is out of limits.
66	**Pellistor saver**	Zero or calibration failed as sensor is in pellistor saver mode.
67	**Supply error**	Zero or calibration failure as supply is out of limits
68	**No gas when calibrate**	Calibration failure as no gas present.
69	**No sensor module**	Zero, calibration or bump test failure as no sensor module present.
70	**Internal failure**	Zero, calibration or bump test failure due to internal failure within the XgardIQ.
71	**Production failure**	Production process failure results in field calibration failure.
72	**Signal error**	Zero or calibration error because of fault in raw signal from sensor (e.g. sensor over-range).
73	**Busy abort**	Zero, calibration or bump test request aborted as already performing a zero, calibration or bump test.

74	**Calibration level**	Set calibration level invalid – calibration failed (not performed).
75	**Fail status**	Bump test failure because of sensor status (out of temperature limits, zero error, pellistor saver, sensor error, or over gassed).
76	**No response**	Bump test failed: No gas response seen.
77	**Fail timeout**	Speedy bump fail as gas level did not exceed alarm 1 level in the allocated time.
78	**Zero error too large**	Gas reading too far from clean air level to perform zero operation (not O2 sensors).
79	**Abort requested**	Bump test aborted on user request.
80	**O2 not purged**	Attempt to zero O2 sensor without purging with N2.

8.2 Device Status

Bit	Meaning
0	XgardIQ Zero Fault or Span Fault
1	Obscuration error or power supply fault
2	Loop current saturated Loop current < 0.5mA or > 25mA
3	Loop current fixed XgardIQ in inhibit mode or Ramp (manual) mode, or warning or fault state, or loop mode disabled (multi-drop HART).
4	More status available This bit is set whenever a fault or warning condition is detected in the XgardIQ. A fault or warning condition in the XgardIQ would also result in the XgardIQ current output entering a fault state. Command #48 gives further detail.
5	Cold start
6	Configuration changed
7	Device malfunction XgardIQ is in a fault state.

8.3 Additional Device Status (Command #48)

Command #48 returns 9 bytes of device specific status bits as follows:

Byte	Bit	Meaning	Class	Device Status Bits Set
0	0	Initialising (instrument or sensor in power-on warm-up phase)	INFO	N/A
	1	Gas alarm 1	INFO	4
	2	Gas alarm 2	INFO	4
	3	mA output inhibited or in loop mode disabled	INFO	3
	4	Ramp mode active	INFO	3
	5	Relays inhibited	INFO	N/A
	6	Alarm relays in test state (relay test or ramp test with alarm)	INFO	N/A
	7	Fault relay in test state	INFO	N/A
1	0	Sensor hardware fault	ERROR	4,7
	1	Transmitter hardware fault	ERROR	4,7
	2	Sensor firmware fault	INFO	N/A
	3	Transmitter firmware fault	INFO	N/A
	4	Undefined sensor fault	ERROR	4,7
	5	Unused 1	INFO	N/A
	6	Production process incomplete/failed	ERROR	4,7
	7	Analogue output feedback failure	ERROR	4,7
2	0	Sensor failure	ERROR	4,7
	1	Watchdog test failure	ERROR	N/A
	2	Unused 2	INFO	N/A
	3	Sensor configuration version error	ERROR	4,7
	4	Sensor missing	ERROR	4,7
	5	Unused 3	INFO	N/A
	6	Unused 4	INFO	N/A
	7	Gas calibration required	WARNING	4
3	0	Unused 5	INFO	N/A
	1	Error in sensor calibration data	ERROR	4,7
	2	Error in sensor characterization data	ERROR	4,7
	3	Unused 6	INFO	N/A
	4	Unused 7	INFO	N/A

	5	Sensor outside temperature limits	WARNING	4
	6	Gas measurement zero error (reading negative)	ERROR	0,4,7
	7	Gas measurement span error	ERROR	0,4,7
4	0	Sensor optics obscured (IR sensors only)	ERROR	4,7
	1	Sensor over-gassed	INFO	4
	2	Unused 8	INFO	N/A
	3	Unused 9	INFO	N/A
	4	Error in mA output calibration data	ERROR	4,7
	5	Error in transmitter characterization	ERROR	4,7
	6	Unused 10	INFO	N/A
	7	Unused 11	INFO	N/A
5	0	Transmitter supply too low	ERROR	4,7
	1	Transmitter supply too high	ERROR	4,7
	2	Transmitter outside temperature limits	WARNING	4
	3	Transmitter system error	ERROR	4.7
	4	Sensor system warning	INFO	N/A
	5	Event log corrupt (all data lost)	INFO	N/A
	6	Event log busy (some data lost)	INFO	N/A
	7	Unused 12	INFO	N/A
14	0	Display missing or incompatible version	INFO	N/A
	1	Display hardware fault	INFO	N/A
	2	Display firmware fault	INFO	N/A
	3	Configured language data lost	INFO	N/A
	4	Display outside temperature limits	INFO	N/A
	5	Display system warning	INFO	N/A
	6	Unused 13	INFO	N/A
	7	Biased sensor battery failure	INFO	N/A
15	0	Sensor changed; detects different gas	ERROR	4,7

	1	Sensor changed; detects same gas	ERROR	4,7
	2	Sensor changed; new sensor not accepted	ERROR	4,7
	3	Sensor optics nearly obscured (IR sensor only)	WARNING	4,7
	4	Unused 14	INFO	N/A
	5	RTC failure (time/data lost)	WARNING	4,7
	6	Calibration due	WARNING	4,7
	7	Calibration due soon	INFO	N/A
16	0	Bump due	WARNING	4,7
	1	Fault relay is inhibited (configuration option)	INFO	N/A
	2	Unused 15	INFO	N/A
	3	Internal data error	INFO	N/A
	4	+ve safety data lost	INFO	N/A
	5	Configuration download failed or interrupted	INFO	N/A
	6	Unused 16	INFO	N/A
	7	Unused 17	INFO	N/A

"Unused" bits are always set to 0.

9. Universal Commands

9.1 Command #0

The Device Profile code (response data byte 21) will return 2 (discrete device).

9.2 Command #3

Returns 4 dynamic variables (as elaborated in section 7.2, Dynamic Variables) for a total of 24 bytes.

9.3 Command #9

This command can return up to 6 device variables (as elaborated in section 7.1, Device Variables).

10. Common Practice Commands

10.1 Supported Commands

The following commands are supported:

Cmd #	Meaning
33	Read Device Variables
35	Write Primary Variable Range Values
40	Enter/Exit Fixed Current Mode
42	Perform Device Reset
45	Trim Loop Current Zero
46	Trim Loop Current Gain
89	Set Real-Time Clock
90	Read Real-Time Clock

Additional information is given on these commands below, where needed.

10.1.1 Command #33 Read Device Variables

This command can return up to 6 device variables (as elaborated in section 7.1, Device Variables).

10.1.2 Command #35 Write Primary Variable Range Values

The units the range values are set in must be the same units as the Gas Level (PV).

The lower range must always be 0.0 – attempting to set any other value will result in an error response.

The upper range can vary from 5% to 100% of the gas measurement range of the sensor. Attempting to set the upper range outside this limit will result in an error response.

Command #14 gives the units (Transducer Limits and Minimum Span Units Code) and gas measurement range (Upper Transducer Limit) of the sensor.

10.1.3 Command #40 Enter/Exit Fixed Current Mode

Note that the XgardIQ will automatically timeout (exit) the fixed current mode after 15 minutes. If it is required to prevent this timeout then periodically re-send this command.

10.1.4 Command #42 Perform Device Reset

Once this command has been received the XgardIQ will not respond to HART communications until the reset has been completed. The result is identical to power cycling the instrument, and will include all power-on self-tests.

Note that all self-tests (except for the display power-on test pattern and hardware watchdog) are performed continuously in the background as part of the normal instrument function.

10.1.5 Command #45 Trim Loop Current Zero

Write the loop current (as measured by a DVM) with this command. The instrument will calculate the error between this written data and the required loop current and set the appropriate correction factor.

It would be normal to implement this command within a Device Description method: the method would output a constant loop current (normally 4mA) using cmd #40; request the actual loop measurement from the operator; write the actual loop current using cmd #45; and finally re-connect the process to the loop current either using cmd #40 (writing a fixed current of 0.0 to clear the Fixed Current Mode) or device-specific cmd #128.

10.1.6 Command #46 Trim Loop Current Gain

Write the loop current (as measured by a DVM) with this command. The instrument will calculate the error between this written data and the required loop current and set the appropriate correction factor.

It would be normal to implement this command within a Device Description method: the method would output a constant loop current (normally 20mA) using cmd #40; request the actual loop measurement from the operator; write the actual loop current using cmd #46; and finally re-connect the process to the loop current either using cmd #40 (writing a fixed current of 0.0 to clear the Fixed Current Mode) or device-specific cmd #128.

Note that this command assumes that the loop current is set to 20mA to correctly calculate the loop current gain adjustment. If for some reason the loop current is fixed to a different (known) level then scaling of the DVM measurement is required (details not given here).

10.1.7 Command #89 Set Real-Time Clock

Internal time is stored to a resolution of 1 second. Hence trying to use this command with Time-set Code as 0 will be ineffective in determining the round trip time for a transaction. (Transactions will always complete within a second).

The first valid date recognised by the XgardIQ is 1/1/2013. Dates prior to this are considered invalid.

10.1.8 Command #90 Read Real-Time Clock

Internal time is stored to a resolution of 1 second.

10.2 Burst Mode

Not supported.

11. Device Specific Commands

11.1 Supported Commands

The following device specific commands are supported:

Cmd #	Meaning
128	Inhibit Mode
129	Zero Gas Reading
130	Calibrate Gas Reading
131	Read Sensor Gas Identification Data
132	Read Serial Numbers
133	Read Software Versions
134	Read Password Enable
135	Write Password
136	Read Password Unlock State
137	Write Password to Unlock
138	Read Alarm Data
139	Write Alarm Levels
140	Read Configured Gas Name and Units
141	Read ID String
142	Write ID String
143	Read Hardware Module Information (Sensor and optional modules)
144	Read Analogue Output Configuration
145	Write Analogue Output Configuration
146	Read Bump Test Configuration
147	Write Bump Test Configuration
148	Read Zero Suppression Configuration
149	Write Zero Suppression Configuration
150	Pellistor Control
151	Enter/Exit Fixed Current Mode with Alarm Test
152	Acknowledge Alarms
153	Bump Test
154	Read Due Dates
155	Relay Test
156	Read Full Status (including +ve safety)
157	Set Cross Calibration Gas

11.2 Command #128 Set Inhibit Mode

Inhibit mode holds the analogue output and relays (alarm and fault) to prevent spurious alarms at the control panel. The analogue output is held to the configured operational inhibit level (normally

clean) and alarm relays are held according to the alarm relay configuration (normally de-energised or normally energised).

If the loop mode is disabled then only the relays will be affected by the inhibit command.

Note that the XgardIQ will automatically timeout from inhibit mode after 15 minutes – if it is required to prevent the timeout then periodically re-send this command to enter inhibit mode..

11.2.1 Request Data Bytes

Byte	Format	Description
0	Enum	Inhibit mode enable state: 0 = exit inhibit mode 1 = enter inhibit mode

11.2.2 Response Data Bytes

Byte	Format	Description
0	Enum	Inhibit mode enable state: 0 = inhibit mode not active 1 = inhibit mode active

Note: The value returned in the response data byte reflects the value actually used by the device.

11.2.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No command-specific errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too few data bytes received
6		Undefined
7	Error	In write protect mode
8-10		Undefined
11-15		Undefined
16	Error	Access restricted (initializing)
17-127		Undefined

11.3 Command #129 Zero Gas Reading

This command is similar to the Common Practice Command #43 (not implemented). It zeroes the gas (Primary Variable) reading in the absence of target gas. Normally this will be clean air; O_2 (oxygen) and CO_2 (carbon dioxide) sensors must be purged with N_2 (nitrogen). If an O_2 sensor is purged with N_2 then the Zero Gas Reading command would normally be combined (in a method) with Cmd #128, Set Inhibit Mode, to avoid spurious alarms.

If the response code 8 is returned from this command then the Zero Gas Reading command should be repeated (poll status) until a status other than 8 is returned indicating the result of the zero operation.

11.3.1 Request Data Bytes

Byte	Format	Description
0	Integer	0 = Poll zero operation status 1 = Request zero operation

11.3.2 Response Data Bytes

Byte	Format	Description
0-1	Integer	Percentage of required operation time completed

11.3.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too few bytes received
6		Undefined
7	Error	In Write Protect Mode
8	Warning	Operation in progress
9-13		Undefined
14	Warning	Zero success, calibration now required
15	Error	Zero failed: Sensor error
16	Error	Access restricted (initializing)
17-28		Undefined
29	Error	Zero failed: Optics obscured (IR sensors only)
30-64		Undefined
65	Error	Zero failed: Sensor temperature limits exceeded
66	Error	Zero failed: Pellistor in pellistor saver
67	Error	Zero failed: Sensor supply voltage limits exceed
68	Error	Undefined
69	Error	Zero failed: No sensor module present
70	Error	Internal failure. Check zero and re-try if needed

71		Undefined
72	Error	Zero failed: Signal error (input under or over-range)
73	Error	Operation aborted as already busy with calibration or bump test
74-77		Undefined
78	Error	Gas reading too far from clean air
79		Undefined
80	Error	O_2 sensor not purged with N_2
81-127		Undefined

11.4 Command #130 Calibrate Gas Reading

Calibrate the gas (Primary Variable~) so it reads the given calibration level with the gas level applied. Typically the XgardIQ will be placed into Inhibit Mode using cmd #128, suitable calibration gas applied, this command issued to calibrate the XgardIQ, the calibration gas purged from the XgardIQ, and then the XgardIQ removed from Inhibit Mode using cmd #128. Following a sequence that includes inhibiting the XgardIQ outputs will prevent spurious alarms at the control panel.

If the response code 8 is returned from this command then the Calibrate Gas Reading command should be repeated (poll calibration status) until a status other than 8 is returned indicating the result of the calibration operation.

11.4.1 Request Data Bytes

Byte	Format	Description
0	Integer	0 = Poll calibration operation status 1 = Request calibration operation
1-4	Float	Calibration level, in %LEL (ignored if requesting poll status or cross cal. has been set)

11.4.2 Response Data Bytes

Byte	Format	Description
0-1	Integer	Percentage of required operation time completed

11.4.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too few bytes received
6		Undefined
7	Error	In Write Protect Mode
8	Warning	Operation in progress
9	Error	Applied process too high – applied gas level too high?
10	Error	Applied process too low – applied gas level too low?
11-14		Undefined
15	Error	Calibration failed: Sensor error
16	Error	Access restricted (initializing)
17-28		Undefined
29	Error	Calibration failed: Optics obscured (IR sensors only)
30-64		Undefined
65	Error	Calibration failed: Sensor temperature limits exceeded
66	Error	Calibration failed: Pellistor in pellistor saver
67	Error	Calibration failed: Sensor supply voltage limits exceed
68	Error	Calibration failed: No gas applied?

69	Error	Calibration failed: No sensor module present
70	Error	Internal failure. Check calibration and re-try if needed
71	Error	Calibration failed: Production calibration failure
72	Error	Calibration failed: Signal error (input under or over-range)
73	Error	Operation aborted as already busy with zero or bump test
74	Error	Calibration failed: Calibration level invalid
75-127		Undefined

11.5 Command #131 Read Sensor Data

This command reads data associated with the fitted sensor. This includes basic identification (fixed name, range and units) and sensitivity data.

11.5.1 Request Data Bytes

Byte	Format	Description
None		

11.5.2 Response Data Bytes

Byte	Format	Description
0-3	Float	Default calibration level (in measurement units)
4-7	Float	Gas measurement range
8-23	Latin-1	Gas name
24-39	Latin-1	Gas units
40-43	Float	Sensitivity. Estimate of sensor sensitivity based on the current sensor gain (calculated on a successful calibration) against the original sensor gain, as a percentage. Updated on successful calibration.
44	Enum	Sensitivity quality 0 = unknown, low; 1 = unknown, high; 2 = OK If a calibration fails for gain reasons (gain error, gain high or gain low) then the sensor gain is suspect (failed calibration because of failed sensor, or because of other errors like incorrect gas applied?). If the failure looks like it is due to low sensor sensitivity then the quality is set to unknown, low. If the failure looks like it is due to high sensor sensitivity then the quality is set to unknown, high. Other calibration failures are unrelated to sensor sensitivity so do not change the data quality and the sensitivity data is unchanged.

11.5.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.6 Command #132 Read Serial Numbers

Reads the serial number of the XgardIQ Transmitter and Sensor.

11.6.1 Request Data Bytes

Byte	Format	Description
None		

11.6.2 Response Data Bytes

Byte	Format	Description
0-15	Latin-1	XgardIQ Transmitter serial number
16-31	Latin-1	XgardIQ Sensor module serial number - will be '---' if no Sensor module fitted

11.6.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.7 Command #133 Read Software Versions

Reads the full software version strings of the XgardIQ Transmitter, Sensor and Display (a component of the Transmitter).

The Software Revision Level returned by the Read Unique Identifier command (cmd #0) returns the software issue of the XgardIQ (i.e. the component of the instrument that implements the HART communications), multiplied up by 100. So, for example, if the XgardIQ software version is V1 i1.01 the Software Revision Level would be 101.

11.7.1 Request Data Bytes

Byte	Format	Description
None		

11.7.2 Response Data Bytes

Byte	Format	Description
0-15	Latin-1	XgardIQ Transmitter software version (e.g. V1 i1.03)
16-31	Latin-1	XgardIQ Sensor software version (e.g. V4 i2.05)
32-47	Latin-1	XgardIQ Display (component of transmitter) software version (e.g. V4 i2.05)

11.7.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.8 Command #134 Read Password Enable

This command is used to determine if password protection is currently configured - it reads the password enable/disable configuration. Note that this is not the same as the password lock/unlock state: HART communications will always be unlocked if the password is disabled; HART communications will be locked if the password is enabled and has not been unlocked by writing a valid password to the instrument (Write Password, cmd #135). When an instrument is password locked all write commands will give the Response Code 7, In Write Protect mode.

11.8.1 Request Data Bytes

Byte	Format	Description
None		

11.8.2 Response Data Bytes

Byte	Format	Description
0	Enum	Password enabled state: 0 = password protection not enabled 1 = password protection enabled

11.8.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.9 Command #135 Write Password

Write password enable state and password to instrument. This turns password protection off/on, and sets the password that must be entered (using command Write Unlock Password, cmd #137) to unlock an instrument that is in password protected mode (locked). Note that passwords are case sensitive.

When changing the password protection state from password disabled to password enabled, the instrument will remain in a password unlocked state – in other words, when password protection is enabled it is not necessary to immediately send the password (through cmd #137) to unlock the instrument. The XgardIQ will automatically enter the password locked state 5 minutes after the last valid HART message requiring a response is received. The XgardIQ will always power-up in the locked state if password protection is enabled.

Passwords can be up to 16 bytes long. Shorter passwords can be set.

Note that the instrument must be in an unlocked state (see command #137) to use this command.

11.9.1 Request Data Bytes

Byte	Format	Description
0	Enum	Password enable state: 0 = disable password protection 1 = enable password protection
1-16	Latin-1	Password needed to unlock a password locked instrument

11.9.2 Response Data Bytes

Byte	Format	Description
0	Enum	Password enable state: 0 = disable password protection 1 = enable password protection
1-16	Latin-1	Password needed to unlock instrument

Note: The values returned in the response data bytes reflect the values actually used by the device.

11.9.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-127		Undefined

11.10 Command #136 Read Password Unlock State

Read the current password lock/unlock state. An instrument that is password locked will return the Response Code 7, In Write Protect Mode, for all non-read commands.

11.10.1 Request Data Bytes

Byte	Format	Description
None		

11.10.2 Response Data Bytes

Byte	Format	Description
0	Enum	Password lock state: 0 = unlocked (write access in not protected) 1 = locked (write access is protected)

11.10.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.11 Command #137 Write Password to Unlock or Lock

Write password to unlock a password protected instrument. This command has no effect if password protection has not been enabled (through cmd #135). Note that passwords are case sensitive.

If an incorrect password is sent to the instrument then the instrument will remain protected, or, if password protected and unlocked, will enter the locked (password protected) state.

Passwords can be up to 16 bytes long. A password is correct if it is the right length and all characters match.

11.11.1 Request Data Bytes

Byte	Format	Description
0-15	Latin-1	Password to unlock instrument

11.11.2 Response Data Bytes

Byte	Format	Description
0	Enum	Password enable state: 0 = disable password protection 1 = enable password protection
1-16	Latin-1	Password sent (in Request data) to unlock instrument

Note: The values returned in the response data bytes reflect the values actually used by the device.

11.11.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Bytes Received
6-127		Undefined

11.12 Command #138 Read Alarm Data

Read the alarm data for the requested alarm.

11.12.1 Request Data Bytes

Byte	Format	Description
0	Enum	Alarm to read 0 = Alarm 1 1 = Alarm 2

11.12.2 Response Data Bytes

Byte	Format	Description
0-3	Float	On threshold (in measurement units)
4-7	Float	Off threshold (in measurement units)
8-9	Unsigned-16	On delay, in seconds
10-11	Unsigned-16	Off delay, in seconds
12	Enum	Latching 0 = not latching 1 = latching
13	Enum	Relay default (not in alarm) state 0 = normally de-energised 1 = normally energised
14	Enum	Alarm direction 0 = falling 1 = rising

11.12.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too few bytes received
1-127		Undefined

11.13 Command #139 Write Alarm Data

Write new alarm data to the selected XgardIQ alarm.

11.13.1 Request Data Bytes

Byte	Format	Description
0	Enum	Alarm to write 0 = Alarm 1 1 = Alarm 2
1-4	Float	On threshold (in measurement units)
5-8	Float	Off threshold (in measurement units)
9-10	Unsigned-16	On delay, in seconds, valid range 0 to 300
11-12	Unsigned-16	Off delay, in seconds, valid range 0 to 300
13	Enum	Latching 0 = not latching 1 = latching
14	Enum	Relay default (not in alarm) state 0 = normally de-energised 1 = normally energised
15	Enum	Alarm direction 0 = falling 1 = rising

For alarm threshold to be valid, they must be set to greater then 0 and equal to or less than the configured analogue output range (as read by universal command cmd #15 and set by common practice cmd #35).

In addition for rising alarms, the off threshold must be less than the on threshold – this condition is reversed for falling alarms.

Failure to set valid data will trigger the response code 3 (invalid selection) and all data in the message will be ignored.

It is usual to have alarm 2 set as the most severe alarm – doing this will ensure that the alarm LED on the front-panel responds correctly. Failure to obey this rule does not impair the safety function of the instrument.

11.13.2 Response Data Bytes

Byte	Format	Description
0-3	Float	On threshold (in measurement units)
4-7	Float	Off threshold (in measurement units)
8-9	Unsigned-16	On delay, in seconds
10-11	Unsigned-16	Off delay, in seconds
12	Enum	Latching: 0 = not latching 1 = latching
13	Enum	Relay default (not in alarm) state 0 = normally de-energised 1 = normally energised
14	Enum	Alarm direction 0 = falling 1 = rising

11.13.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection – this includes invalid alarm number selection and invalid alarm data (e.g. invalid delay time)
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-127		Undefined

11.14 Command #140 Read Configured Gas Names and Units

Read the configured gas name and units, including cross gas levels, names, units and factors.

If a cross gas is not defined then the level and factor will read as 0.0, and the name and units will be all null (0) bytes.

11.14.1 Request Data Bytes

Byte	Format	Description
None		

11.14.2 Response Data Bytes

Byte	Format	Description
0-15	Float	Target gas name
16-31	Latin-1	Target gas units
32-33	Integer	Number of cross gases (0 to 2)
34-49	Float	Cross gas 1 level
50-53	Latin-1	Cross gas 1 name
54-69	Latin-1	Cross gas 1 units
70-73	Float	Cross gas 1 factor
74-77	Float	Cross gas 2 level
78-93	Latin-1	Cross gas 2 name
94-109	Latin-1	Cross gas 2 units
110-113	Float	Cross gas 2 factor

11.14.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.15 Command #141 Read ID String

Read the instrument identification string. This is an (optional) string that is shown during power-on initialisation.

11.15.1 Request Data Bytes

Byte	Format	Description
None		

11.15.2 Response Data Bytes

Byte	Format	Description
0	Enum	Has ID string been defined? 0 = ID string not defined 1 = ID string defined
1-32	Latin-1	ID string

11.15.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.16 Command #142 Write ID String

Write the instrument identification string. This is an (optional) string that is shown during power-on initialisation.

11.16.1 Request Data Bytes

Byte	Format	Description
0-31	Latin-1	ID string

The ID string can be up to 32 characters long; fewer characters will set a shorted ID string.

11.16.2 Response Data Bytes

Byte	Format	Description
0	Enum	Has ID string been defined? 0 = ID string not defined 1 = ID string defined
1-32	Latin-1	ID string

11.16.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-6		Undefined
7	Error	In Write Protect Mode
8-127		Undefined

11.17 Command #143 Read Hardware ID

Read the technology of the sensor and whether optional modules are fitted.

11.17.1 Request Data Bytes

Byte	Format	Description
None		

11.17.2 Response Data Bytes

Byte	Format	Description
0	Enum	Sensor technology 0 = No sensor module fitted 1 = Electrochemical toxic sensor 2 = Electrochemical oxygen sensor 3 = Electrochemical biased toxic 4 = Pellistor 5 = Infra-red 6 = MOS 7 = PID 8 = IRmax iModule
1	Enum	Identifies if the sensor measures CO2 0 = not CO2 1 = CO2
2	Enum	Relay fit 0 = Relay module not fitted 1 = Relay module fitted
3	Enum	Foundation Fieldbus fit 0 = Foundation Fieldbus module not fitted 1 = Foundation Fieldbus module fitted

11.17.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.18 Command #144 Read Analogue Output Configuration

Reads the configured analogue output levels used for various conditions in the XgardIQ.

11.18.1 Request Data Bytes

Byte	Format	Description
None		

11.18.2 Response Data Bytes

Byte	Format	Description
0	Enum	Analogue output level used to indicate fault state 0 = 1mA 1 = 2mA 2 = 3mA
1	Enum	Analogue output level used to indicate warning state 0 = 1mA 1 = 2mA 2 = 3mA Note: If the instrument is in alarm then the gas level output takes priority over the warning state output.
2	Enum	Analogue output level used for inhibit 0 = 1mA 1 = 2mA 2 = 3mA 3 = Clean air (4mA for toxics, 17.4mA for O2 (0-25% range) or 4.3mA for CO2 (0-5% range)
3	Enum	Analogue output level used for power-on inhibit 0 = 1mA 1 = 2mA 2 = 3mA 3 = Clean air (4mA for toxics, 17.4mA for O2 (0-25% range) or 4.3mA for CO2 (0-5% range)

11.18.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.19 Command #145 Write Analogue Output Calibration

Writes the configured analogue output levels used for various conditions in the XgardIQ.

11.19.1 Request Data Bytes

Byte	Format	Description
0	Enum	Analogue output level used to indicate fault state 0 = 1mA 1 = 2mA 2 = 3mA
1	Enum	Analogue output level used to indicate warning state 0 = 1mA 1 = 2mA 2 = 3mA
2	Enum	Analogue output level used for inhibit 0 = 1mA 1 = 2mA 2 = 3mA 3 = Clean air (4mA for toxics, 17.4mA for O2 (0-25% range) or 4.3mA for CO2 (0-5% range)
3	Enum	Analogue output level used for power-on inhibit 0 = 1mA 1 = 2mA 2 = 3mA 3 = Clean air (4mA for toxics, 17.4mA for O2 (0-25% range) or 4.3mA for CO2 (0-5% range)

11.19.2 Response Data Bytes

Byte	Format	Description
0	Enum	Analogue output level used to indicate fault state 0 = 1mA 1 = 2mA 2 = 3mA
1	Enum	Analogue output level used to indicate warning state 0 = 1mA 1 = 2mA 2 = 3mA
2	Enum	Analogue output level used for inhibit 0 = 1mA 1 = 2mA 2 = 3mA 3 = Clean air (4mA for toxics, 17.4mA for O2 (0-25% range) or 4.3mA for CO2 (0-5% range)
3	Enum	Analogue output level used for power-on inhibit 0 = 1mA 1 = 2mA 2 = 3mA 3 = Clean air (4mA for toxics, 17.4mA for O2 (0-25% range) or 4.3mA for CO2 (0-5% range)

11.19.3 Command Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-127		Undefined

11.20 Command #146 Read Bump Test Configuration

Read the configuration used for speedy and smart bump tests.

11.20.1 Request Data Bytes

Byte	Format	Description
None		

11.20.2 Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Initial gas response timeout, in seconds
2-3	Unsigned-16	Test time, in seconds for Smart bump; maximum test time for Speedy bump
4-7	Float	Smart bump lower test limit
8-11	Float	Smart bump upper test limit

11.20.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.21 Command #147 Write Bump Test Configuration

Write configuration used for speedy and smart bump tests.

11.21.1 Request Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Initial gas response timeout, between 5 and 300 seconds.
2-3	Unsigned-16	Test time, in seconds for Smart bump; maximum test time for Speedy bump, between 5 and 300 seconds.
4-7	Float	Smart bump lower test limit, between 0 and gas range.
8-11	Float	Smart bump upper test limit, between 0 and gas range, must be higher than low limit.

11.21.2 Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16	Initial gas response timeout, in seconds.
2-3	Unsigned-16	Test time, in seconds for Smart bump; maximum test time for Speedy bump.
4-7	Float	Smart bump lower test limit.
8-11	Float	Smart bump upper test limit.

11.21.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-127		Undefined

11.22 Command #148 Read Zero Suppression Configuration

Zero suppression allows small levels of gas to be suppressed to remove noise from the display.

11.22.1 Request Data Bytes

Byte	Format	Description
None		

11.22.2 Response Data Bytes

Byte	Format	Description
0	Enum	Suppression level: 0 = None 1 = Light 2 = Medium 3 = Heavy

11.22.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.23 Command #149 Write Zero Suppression Configuration

Zero suppression allows small levels of gas to be suppressed to remove noise from the display.

11.23.1 Request Data Bytes

Byte	Format	Description
0	Enum	Suppression level: 0 = None 1 = Light 2 = Medium 3 = Heavy

11.23.2 Response Data Bytes

Byte	Format	Description
0	Enum	Suppression level: 0 = None 1 = Light 2 = Medium 3 = Heavy

11.23.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-127		Undefined

11.24 Command #150 Pellistor Saver Control

Allows the pellistor saver function to be turned off to prevent a poorly calibrated pellistor spuriously entering a pellistor saver state and causing calibrations to fail.

Disabling the pellistor saver function has a 15 minute timeout.

Warning: Exposing a pellistor to 100% LEL gas can damage the pellistor. Pellistor saver should only be disabled when controlled calibrations are being performed.

11.24.1 Request Data Bytes

Byte	Format	Description
0	Enum	0 = disable pellistor saver 1 = enable pellistor saver (normal operational state)

11.24.2 Response Data Bytes

Byte	Format	Description
None		-

11.24.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-15		Undefined
16	Error	Access Restricted (instrument initialising)
17-127		Undefined

11.25 Command #151 Enter/Exit Fixed Current Mode with Alarm Test

This command is identical to the common practice command #40, Enter/Exit Fixed Current mode, except that this command will also trigger the alarm relays exactly as if the instrument was being gassed for real – this includes on and off delay times.

Like cmd #40, a level of '0' exits this mode as does power removal or device reset.

11.25.1 Request Data Bytes

Byte	Format	Description
0-3	Float	PV Fixed current level (mA)

11.25.2 Response Data Bytes

Byte	Format	Description
0-3	Float	Actual PV current level

11.25.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Passed Parameter too Large
4	Error	Passed Parameter too Small
5	Error	Too Few Data Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-10		Undefined
11	Error	In Multi-drop Mode
12-15		Undefined
16	Error	Access Restricted (instrument initialising)
17-127		Undefined

11.26 Command #152 Acknowledge Alarms

Acknowledge (accept) latched alarms. Command has no effect if there are no latched alarms to acknowledge.

11.26.1 Request Data Bytes

Byte	Format	Description
None		

11.26.2 Response Data Bytes

Byte	Format	Description
None		

11.26.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.27 Command #153 Bump Test

Initiate, or poll the status of, a bump test.

There are two forms of bump test: speedy and smart. Once a test is initiated the instrument will inhibit the analogue output and alarm relays and wait until a gas response is detected; once this response is detected the test proper will commence. If a gas response is not detected the test is terminated and considered a fail. A gas response is considered to be a gas reading that is 20% or more of the alarm 1 threshold from the clean air gas level.

For a test that is not terminated, a speedy bump test passes if the alarm 1 threshold is exceeded within the test time; a smart bump test the passes if at the end of the test time the gas level lies between a lower and upper threshold. On completion of the test a purge phase is entered during which gas should be removed from the sensor so that alarms are not triggered at the control panel.

A bump test may be aborted at any time. Aborting a test takes the instrument out of inhibit mode.

See cmd #146 and cmd# 147 for bump test configuration.

11.27.1 Request Data Bytes

Byte	Format	Description
0	Enum	0 = Do nothing (poll for Response Data only) 1 = Initiate speedy bump 2 = Initiate smart bump 3 = Terminate/Abort
1	Enum	0 = Target gas 1 = Cross gas 1 (if available) 2 = Cross gas 2 (if available) This byte is not required if polling status

11.27.2 Response Data Bytes

Byte	Format	Description
0	Enum	Test state: 0 = Idle (no test performed) 1 = Waiting for initial gas response 2 = Test in progress 3 = Test passed, purging 4 = Test failed, purging 5 = Test failed, no purge required
1-2	Unsigned-16	Seconds remaining in current test state (only applicable to states 1, 2, 3 and 4)

11.27.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8	Warning	Operation in progress (busy)
9		Applied process high (smart bump test failed)
10		Applied process low (smart bump test failed)
11-15		Undefined
16	Error	Access restricted (initializing or restricted by UI)
17-27		Undefined
28	Error	Bump test failed: Gas present before test start
29-68		Undefined
69	Error	Bump test failed: missing sensor module
70	Error	Internal failure in XgardIQ
71-72		Undefined
73	Error	Bump test aborted
75	Error	Bump test failed: instrument status
76	Error	Bump test failed: no gas response
77-78		Undefined
77	Error	Bump test failed: speedy bump timeout waiting for alarm 1
78		Undefined
79	Error	Bump test aborted (user request)
80-127		Undefined

11.28 Command #154 Read Due Dates

Due times expire at midnight on the given day.

11.28.1 Request Data Bytes

Byte	Format	Description
None		

11.28.2 Response Data Bytes

Byte	Format	Description
0-2	Date	Bump due date
3-5	Date	Calibration due date

11.28.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.29 Command #155 Relay Test

Test the alarm and fault relays.

11.29.1 Request Data Bytes

Byte	Format	Description
0	Enum	0 = Cancel test 1 = Test alarm relays (both inactive) 2 = Test alarm relays (alarm 1 relay active; alarm 2 relay inactive) 3 = Test alarm relays (alarm 1 relay inactive; alarm 2 relay active) 4 = Test alarm relays (both active) 5 = Test fault relay (active) 5 = Test fault relay (inactive)

11.29.2 Response Data Bytes

Byte	Format	Description
0	Enum	Same as request bytes.

11.29.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-11		Undefined
12	Error	Invalid mode selection (relays not fitted)
13-15		Undefined
16	Error	Access restricted (instrument initializing)
17-127		Undefined

11.30 Command #156 Full Status

Returns the full status of the instrument. Much of this data is also returned by cmd #48, but this command also return the +ve Safety status.

11.30.1 Request Data Bytes

Byte	Format	Description
None		

11.30.2 Response Data Bytes

Byte	Format	Description	
0	Bit field	**+ve safety byte 1**	
		Bit	**Meaning**
		0	Pellistor saver occurred
		1	Optics obscured
		2	Optics nearly obscured
		3	Gas reading under range
		4	Sensor over gassed
		5	Sensor temperature too low
		6	Sensor temperature too high
		7	Calibration due soon
1	Bit field	**+ve safety byte 2**	
		Bit	**Meaning**
		0	Bump test due
		1	Configuration update failed
		2	Loop mode disabled
		3	Outputs inhibited
		4	Fault state
		5	Warning state
		6	Calibration due
		7	Unused status
2	Bit field	Additional status byte 0 (see section 8.3, Additional Device Status (Command #48)	
3	Bit field	Additional status byte 1 (see section 8.3, Additional Device Status (Command #48)	
4	Bit field	Additional status byte 2 (see section 8.3, Additional Device Status (Command #48)	
5	Bit field	Additional status byte 3 (see section 8.3, Additional Device Status (Command #48)	
6	Bit field	Additional status byte 4 (see section 8.3, Additional Device Status (Command #48)	
7	Bit field	Additional status byte 5 (see section 8.3, Additional Device Status (Command #48)	
8	Bit field	Additional status byte 6 (see section 8.3, Additional Device Status (Command #48)	
9	Bit field	Additional status byte 7 (see section 8.3, Additional Device Status (Command #48)	

11.30.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-127		Undefined

11.31 Command #157 Set Cross Calibration Gas

Set cross gas for calibration. Pellistors and IR sensors may have cross calibrations defined (see command #140). If they are, then this command can be used to set a cross calibration or reset the cross calibration selection back to target gas.

11.31.1 Request Data Bytes

Byte	Format	Description
0	Enum	0 = Target gas 1 = Cross gas 1 (if available) 2 = Cross gas 2 (if available)

11.31.2 Response Data Bytes

Byte	Format	Description
0	Enum	0 = Target gas 1 = Cross gas 1 (if available) 2 = Cross gas 2 (if available)

11.31.3 Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid selection
3-4		Undefined
5	Error	Too Few Bytes Received
6		Undefined
7	Error	In Write Protect Mode
8-11		Undefined
12	Error	Invalid mode selection (busy with zero, calibrate or bump test)
13-127		Undefined

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