

S T A N D A R D



Command Response Code Specification

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Table of Contents

| | |
|--|----|
| Preface..... | 7 |
| Introduction..... | 9 |
| 1. Scope | 11 |
| 2. References..... | 11 |
| 2.1 HART Field Communications Protocol Specifications..... | 11 |
| 2.2 Related HART Documents | 11 |
| 3. Definitions | 11 |
| 4. Symbols/Abbreviations..... | 12 |
| 5. Response Codes | 12 |
| 5.1 Response Code Classifications | 12 |
| 5.2 Command Not Implemented..... | 15 |
| 5.3 Busy | 15 |
| 5.4 Command Requirements..... | 15 |
| 5.5 Choosing Response Codes for New Commands | 16 |
| 6. Response Code Definitions..... | 17 |
| 6.1 RC #0 Success..... | 17 |
| 6.2 RC #1 (Single Definition Error) | 17 |
| 6.3 RC #2 (Single Definition Error) | 18 |
| 6.4 RC #3 (Single Definition Error) | 18 |
| 6.5 RC #4 (Single Definition Error) | 18 |
| 6.6 RC #5 (Single Definition Error) | 19 |
| 6.7 RC #6 (Single Definition Error) | 19 |
| 6.8 RC #7 (Single Definition Error) | 20 |
| 6.9 RC #8 (Multi-Definition Warning)..... | 20 |
| 6.10 RC #9 (Multi-Definition Error) | 21 |
| 6.11 RC #10 (Multi-Definition Error) | 22 |
| 6.12 RC #11 (Multi-Definition Error) | 23 |
| 6.13 RC #12 (Multi-Definition Error) | 24 |
| 6.14 RC #13 (Multi-Definition Error) | 25 |
| 6.15 RC #14 (Multi-Definition Warning)..... | 26 |
| 6.16 RC #15 (Multi-Definition Error) | 26 |

| | |
|--|----|
| 6.17 RC #16 (Single Definition Error) | 27 |
| 6.18 RC #17 (Single Definition Error) | 27 |
| 6.19 RC #18 (Single Definition Error) | 27 |
| 6.20 RC #19 (Single Definition Error) | 28 |
| 6.21 RC #20 (Single Definition Error) | 28 |
| 6.22 RC #21 (Single Definition Error) | 29 |
| 6.23 RC #22 (Single Definition Error) | 29 |
| 6.24 RC #23 (Single Definition Error) | 29 |
| 6.25 RC #24-#27 (Single Definition Warning) | 30 |
| 6.26 RC #28 (Multi-Definition Error) | 30 |
| 6.27 RC #29 (Multi-Definition Error) | 30 |
| 6.28 RC #30(Multi-Definition Warning)..... | 31 |
| 6.29 RC #31(Multi-Definition Warning)..... | 31 |
| 6.30 RC #32 (Single Definition Error) | 32 |
| 6.31 RC #33 (Single Definition Error) | 32 |
| 6.32 RC #34 (Single Definition Error) | 33 |
| 6.33 RC #35 (Single Definition Error) | 33 |
| 6.34 RC #36 (Single Definition Error) | 33 |
| 6.35 RC #37-#59 (Single Definition Error) | 34 |
| 6.36 RC #60 (Single Definition Error) | 34 |
| 6.37 RC #61 (Single Definition Error) | 34 |
| 6.38 RC #62 (Single Definition Error) | 35 |
| 6.39 RC #63 (Single Definition Error) | 35 |
| 6.40 RC #64 (Single Definition Error) | 35 |
| 6.41 RC #65 (Multi-Definition Error) | 36 |
| 6.42 RC #66 (Multi-Definition Error) | 37 |
| 6.43 RC #67 (Multi-Definition Error) | 38 |
| 6.44 RC #68 (Multi-Definition Error) | 38 |
| 6.45 RC #69 (Multi-Definition Error) | 39 |
| 6.46 RC #70 (Multi-Definition Error) | 39 |
| 6.47 RC #71 (Multi-Definition Error) | 39 |
| 6.48 RC #72-#95 (Multi-Definition Error)..... | 40 |
| 6.49 RC #96-#111 (Single-Definition Warning) | 40 |
| 6.50 RC #112-#127 (Multi-Definition Warning) | 40 |

| | |
|--|----|
| 7. Delayed Slave Responses | 41 |
| 7.1 Normal DR Operation..... | 42 |
| 7.2 Use of DR_CONFLICT Response Code | 43 |
| 7.3 Multiple DR Buffers | 44 |
| 7.4 Bridge Device Use of DRM..... | 45 |
| Annex A. Revision History..... | 46 |
| A1. Changes From 5.0 to 6.0 | 46 |
| A2. Changes From 4.1 - Final to 5.0 | 46 |
| A3. Changes From 4.0 - Final to 4.1 | 46 |
| A4. Changes From 3.0 - Final to 4.0A - Preliminary | 48 |
| A5. Major Modifications Rev 2 to Rev 3.0 - Final..... | 49 |
| A6. Major Modifications from Rev 1 to Rev 2 | 49 |
| A7. Major Modifications Incorporated into Rev 1 | 49 |

Preface

This preface is included for informational purposes only.

From Revision 5.0 to 6.0, this document was updated to include specifications for the Delayed Response Mechanism and Response codes were updated to reflect the codes used in the new HART 7 commands.

Introduction

In the HART Protocol, a slave device supplies information to a master in its message response about the execution of a particular command. This information is specified for Universal and Common Practice Commands as either a warning or an error. The type of warning or error communicated is determined by a Response Code imbedded in the message response.

Most commonly, responses will convey only the message that a command was executed without error. However, when some difficulty is encountered, any error or warning response should supply as much detail as possible to simplify correction of any malfunction or misinterpretation of data. The purpose of the *Command Response Code Specification* is to uniformly define all responses available to manufacturers for inclusion in their HART compatible devices.

Since the assignment of response codes for device-specific commands is not handled anywhere else in the protocol specification, this information is also included in this document.

1. SCOPE

This document is an Application Layer specification and, accordingly, builds on the Application Layer Requirements found in the *Command Summary Specification*. Conformance to all requirements of the *Command Summary Specification* is a prerequisite to conforming to this specification.

Response Codes indicate command completion status that may be returned by a Field Device in response to a host application's HART command. The most significant bit of the Response Code is always set to zero to differentiate the Response Code from a Communication Error summary (see the *Command Summary Specification*). As a result, the Response Code is encoded as a 7-bit enumeration (i.e., as an enumeration between 0 and 127).

This document specifies all requirements pertaining to the assignment, classification, definition and application of Response Codes. Response Codes in all commands, whether defined by the Protocol Specifications or device-specific commands defined by a manufacturer, must follow the requirements in this document.

2. REFERENCES

2.1 HART Field Communications Protocol Specifications

HART Field Communications Protocol Specification. HCF_SPEC-12

Command Summary Specification. HCF_SPEC-99

Universal Command Specification. HCF_SPEC-127

Common Practice Command Specification. HCF_SPEC-151

2.2 Related HART Documents

The HART Protocol Specifications frequently reference the manufacturers' device-specific document. Device-specific documents are developed and controlled by the respective manufacturer and should follow the requirements of the following HART Communication Foundation document:

Requirements for Device Specific Documentation. HCF_LIT-18

3. DEFINITIONS

Definitions for terms can be found in *HART Field Communications Protocol Specification*. Terms used in this document include: Data Link Layer, Delayed Response, Delayed Response Mechanism, Device Variable, Busy, Dynamic Variable, Fixed Current Mode, Floating Point, ISO Latin-1, Multi-drop, Not-A-Number, Packed ASCII, Preamble, Request Data Bytes, Response Data Bytes, Units Code

4. SYMBOLS/ABBREVIATIONS

| | |
|------------|--------------------------------------|
| DR | Delayed Response |
| HCF | HART Communication Foundation |
| RC | Response Code |

5. RESPONSE CODES

Response Codes are a 7 bit enumerations with all 128 values controlled by the HCF. All devices and all commands must use Response Codes exactly as specified in this document. This section classifies the Response Codes and defines requirements governing their use in commands.

5.1 Response Code Classifications

Response Codes are classified two ways. The first is by the severity of the exception encountered in the Field Device's execution of the command (see Table 1). Response Codes provide a Notification, Warning or Error indication to the host.

Table 1. Response Code Severity Levels

| Response Code Class | Definition |
|----------------------------|--|
| Notification | Command executed properly with no exceptions. The Response Code equals zero (0) and the Response Data Bytes are returned. |
| Warning | Command executed with the deviation as described in response (e.g., a value was set to its nearest legal value). The Response Data Bytes are returned and indicate the data actually used by the Field Device. |
| Error | Command execution was not properly completed and the Response Code indicates the reason (e.g., the device is in Write Protect mode). While the Extended Command number is included (if appropriate) in the slave response, the Response Data Bytes are NOT returned. |

In addition to classification by severity level, some Response Codes have a single, universal definition and some may have different definitions for different commands. Single-definition Response Codes have the same meaning independent of the command that uses them. Multiple-definition Response Codes have several meanings. However, all Response Codes have a single meaning for a given command at all times. The only legal Response Codes for a command are documented in the HART Protocol Command Specification or, for device-specific commands, the manufacturer's device-specific documentation. Reserved Response Codes must not be used by any device.

All 128 possible Response codes are assigned and classified. The classification of Response Codes is specified in Table 2 and Figure 1. To assure proper interpretation of response codes by hosts, these assignments must be observed whenever new response codes are allocated for existing commands or when allocating response codes for new commands.

All single definition Response Codes must use the definitions exactly as specified in this document. Manufacturers may assign a new meaning to multiple definition codes in their device-specific commands. However, for a given command, the meaning of its Response Codes must not change without the Field Device's Device Type number being changed as well (see the *Command Summary Specification* for complete Field Device revision rules).

Table 2. Response Code Classification

| Response Codes | Definition Type | Number of Definitions |
|-------------------------|-----------------|-----------------------|
| 1-7, 16-23, 32-64 | Error | Single |
| 9-13, 15, 28, 29, 65-95 | Error | Multiple |
| 24-27, 96-111 | Warning | Single |
| 8, 14, 30, 31, 112-127 | Warning | Multiple |

Note: Response Code #0 indicates that the command was executed without any exception (error or Warning).

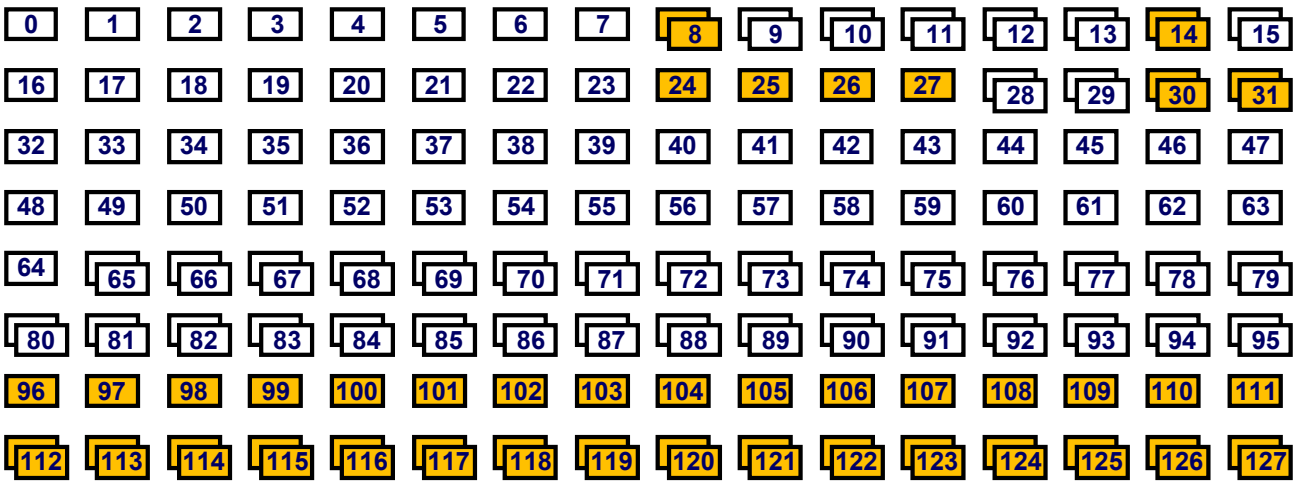


Figure 1. Response Code Classification

5.2 Command Not Implemented

All HART compatible field devices must answer all commands addressed to them. All HART compatible devices must implement all Universal Commands. For any other command, Response Code #64, Command Not Implemented may be returned by the field device.

This is the only Response Code that may be returned by a field device even though it is not listed in the command specification. Any other Response Code may only be returned by the field device if it is explicitly defined in the command specification.

5.3 Busy

If indicated in the command specification, Response Code #32, Busy may be returned in response to a master request. Response Code #32, Busy, indicates to the host application that the field device cannot begin its execution of the command due to other functions being performed. READ commands must not return this Response Code. When receiving a Busy response from a slave, Host applications should continuously retry their request until the field device can execute the command.

New commands should not be designed to return Busy. Instead they should be designed to use the more efficient Delayed Response Mechanism (see the *Command Summary Specification*).

5.4 Command Requirements

All command specifications must indicate the Response Codes that are allowed in a field device's response to the host application's request. Furthermore, a field device may only return a Response Code that is defined in the command specification. There is no fixed number of Response Codes that must be specified for a command. However, sufficient Response Codes must be defined to allow the host application to:

- Clearly determine the status of the command's execution by the field device;
- Diagnose the root cause of the exception (if any) encountered by the field device; and
- Allow the command to be corrected and re-transmitted to the field device.

Since only one Response Code may be returned at a time from the field device, each potential error or warning should be indicated by a separate enumeration.

5.4.1 WRITE Commands

Write commands should only contain a single property or data item (see *Command Summary Specification*) as only one Response Code can be reported in a Field Device reply. If more than one property is written with a single command, then the Command's Response Codes must include definitions that combine possible simultaneous exception cases (e.g. see RC #13 Upper and Lower Range Values Out Of Limits).

5.4.2 Indexed Commands

Index Commands allow a single command access to an array of data items (e.g., properties, Dynamic Variables, or Device Variables). Each Response Code must have a single definition for any value of the index. All Response Codes must be valid for any value of the index.

5.4.3 Multi-Transaction Commands

Multi-transaction commands allow a sub command number to be placed in the Request and Response Data field. Each transaction is treated as a separate command. As a result, the command specification must include a separate Response Code specification for each transaction. Response Code requirements for a transaction are identical to those for a normal HART command (e.g., the definition of a Response Code is constant for a given transaction at all times).

5.5 Choosing Response Codes for New Commands

All Commands must specify a single-definition Response Code wherever possible. Multiple-definition Response Codes may be recycled and used in command specifications when no single definition Response Code is applicable. In other words, multiple-definition Response Codes may be used as needed to return command completion information when no single definition codes are applicable. For multiple-definition Response Codes used in this manner, the definition of the Response Code must be included in the manufacturer's device-specific documentation.

The following requirements must be adhered to when defining a new command specification:

1. Identify the exceptions that may be produced when executing the command.
2. Classify each exception as a warning or an error. A warning indicates that the command was successful although the field device's execution of the command varied somewhat from the host application's actual request (e.g., a value was rounded of or changed)
3. For each exception determine whether a single definition Response Code is applicable. If so, use that Response Code.
4. If the exception does not match a single definition code, then use a multi-definition code adding the new command-specific definition to the command specification. Start re-using the multi-definition Response Codes sequentially from the lowest valued code available.

Unassigned or reserved Response Codes may not be used in any Command.

6. RESPONSE CODE DEFINITIONS

This section provides the actual definition associated with each Response Code. For single definition codes all devices must use the definition indicated in this section.

For multi-definition codes a variety of example definitions found in the Protocol specifications are included. Command specifications may use these definitions or provide their own definition for multi-definition codes. The actual definition for a multi-definition Response Code must be included in the command specification and published to allow proper interpretation by host applications.

Unassigned single definition Response Codes may only be assigned by the HCF and must not be used by any manufacturer. These codes include: 20-27, 37-63, and 96-111.

6.1 RC #0 Success

This code must have the following exact meaning for any command that utilizes this response code.

| | |
|-----------------------------------|--|
| No Command-Specific Errors | No errors or warnings were found in verifying the parameters for this command. |
|-----------------------------------|--|

6.2 RC #1 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

| | |
|------------------|---|
| Undefined | Not defined at this time. This code was used in earlier versions of the Protocol and must not be used in any field device. The definition prior to HART Revision 5 was: "Type Code Mismatch", i.e., "The Field Device Type Code in Data Byte #0 of a Device-Specific command did not match the Type Code of the field device". |
|------------------|---|

6.3 RC #2 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|--------------------------|---|
| Invalid Selection | The code or index was not allowed in this command or for this field device. |
|--------------------------|---|

6.4 RC #3 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|-----------------------------------|---|
| Passed Parameter Too Large | The value of a parameter was too large and the command could not be executed in the field device. |
|-----------------------------------|---|

6.5 RC #4 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|-----------------------------------|---|
| Passed Parameter Too Small | The value of the parameter was too small and the command could not be executed in the field device. |
|-----------------------------------|---|

6.6 RC #5 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

Too Few Data Bytes Received

The number of bytes contained in the message was less than required to execute the command.

6.7 RC #6 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

Device-Specific Command Error

An error has occurred for which a Command-Specific Response Code has not been defined. [This code is indicative of a major device problem. If this code is returned then the "Device Malfunction" and "More Status Available" bits must be set in the Device Status Byte.](#) Further information on this response code must be available in the device-specific documentation. In addition, Command 48, Read Additional Device Status, must allow the identification of the specific error source.

6.8 RC #7 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|------------------------------|---|
| In Write Protect Mode | The field device is Write Protected and cannot accept this write command. |
|------------------------------|---|

6.9 RC #8 (Multi-Definition Warning)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

The command was executed but, a deviation from the host application's request was necessary to complete the command successfully. The values actually used are returned in the field device's Response Data Bytes.

| | |
|-----------------------|--|
| Update Failure | The real-time data returned from the field device has not changed since the last time it was read. |
|-----------------------|--|

| | |
|-------------------------------------|---|
| <u>Update Times Adjusted</u> | <u>The Update Period in the command was invalid. The device has corrected the period in the response.</u> |
|-------------------------------------|---|

| | |
|---------------------------------------|---|
| <u>Update Period Increased</u> | <u>There is insufficient bandwidth to fulfill the publish rate requirement. The Burst Message is enabled at a reduced rate (i.e., the Update Period was increased).</u> |
|---------------------------------------|---|

| | |
|--------------------------------------|--|
| Set to Nearest Possible Value | The data sent to the field device has been rounded or truncated due to limitations within the field device. The command has been accepted. |
|--------------------------------------|--|

| | |
|--|--|
| All but running delayed responses flushed | A delayed response is being performed by the field device that may not be interrupted or canceled by Command 106, Flush Delayed Responses. |
|--|--|

6.10 RC #9 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

Lower Range Value Too High

Lower Range Value was above the Upper Transducer Limit or some other physical device limitation is exceeded.

Applied Process Too High

The process applied to the field device was too high.

Invalid Burst Message

The Burst Message number is not supported by the field device.

Configuration Change Counter Mismatch

The Configuration Change Counter value did not match the current device value. The Configuration Changed bit remains set.

Insufficient bandwidth

There is not enough bandwidth available to enable the designated burst message.

Not In Proper Current Mode

The field device is not in Fixed Current Mode or the current has not been set to the proper value.

6.11 RC #10 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|----------------------------------|--|
| Lower Range Value Too Low | Lower Range Value was below the Lower Transducer Limit or some other physical device limitation is exceeded. |
|----------------------------------|--|

| | |
|--------------------------------|--|
| Applied Process Too Low | The process applied to the field device was too low. |
|--------------------------------|--|

| | |
|--------------------------------------|--|
| Invalid Local Panel Lock Code | The code received by the field device is not supported or is not a legal code. |
|--------------------------------------|--|

6.12 RC #11 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Upper Range Value Too High

Upper Range Value was above Upper Transducer Limit.

In Multi-drop Mode

The device is in multi-drop and, as a result, the command cannot be executed.

Invalid Device Variable Code

This Device Variable is not supported by the requested command or operation. In other words, the Device Variable is valid but you cannot use it with this command.

Invalid Device Variable Classification

The Device Variable Classification code included in the write command was not valid for that Device Variable.

Trim Error, Excess Correction Attempted

The difference between the measured and actual value is so large that the field device is unable to correct the value in its calculation.

Cannot Lock Panel

The field device is in a mode that does not allow the local panel to be locked (e.g., the operator is already using the local panel).

6.13 RC #12 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|----------------------------------|--|
| Upper Range Value Too Low | Upper Range Value was below the Lower Transducer Limit. |
| Invalid Units Code | The requested units code is not supported within the context of this command, Device Variable, or Dynamic Variable. |
| Invalid Slot Number | The requested slot code to capture the Dynamic Variable or Device Variable is not valid for the designated Command Number. |
| Invalid Mode Selection | The requested (e.g., loop current) mode is not valid. |

6.14 RC #13 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|---|--|
| Invalid Transfer Function Code | The requested transfer function is not supported for this Analog Channel or Dynamic Variable. |
| Upper and Lower Range Values Out Of Limits | The Upper and Lower Range Values are outside the transducer limits or some other physical device limitation has been exceeded. |
| Computation Error | An arithmetic error was encountered while the field device was attempting to apply the new values in the host application's command request. |
| Command Number Not Supported | The requested command number to be captured is not supported in this field device. |

6.15 RC #14 (Multi-Definition Warning)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

The command was executed but, a deviation from the host application's request was necessary to complete the command successfully. The values actually used are returned in the field device's Response Data Bytes.

Span Too Small

The Span, as determined from the Upper and Lower Range Values, was below the Minimum Span.

Dynamic Variables Returned for Device Variables

The field device does not expose any Device Variables.
Consequently, Dynamic Variables were returned for codes 0-3 in
Command 9.

Update Rate Uncertain

When a device has not joined a WirelessHART network it does
not yet know if there will be sufficient capacity to meet the
required notification parameters.

New Lower Range Value Pushed Upper Range Value Over Transducer Limit

The field device used the Lower Range Value requested and modified the Upper Range value accordingly. Unfortunately, the Upper Range Value saturated and the span was not maintained.

6.16 RC #15 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Invalid Analog Channel Code Number

The analog channel does not exist in this field device.

6.17 RC #16 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed. No Response Data Bytes are returned from the field device.

Access Restricted

[The command is not allowed with the device in its current operating mode. For example, the device is locked \(see Command 71\).](#)

6.18 RC #17 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed. No Response Data Bytes are returned from the field device.

Invalid Device Variable Index

The requested Device Variable does not exist in this field device.

6.19 RC #18 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed. No Response Data Bytes are returned from the field device.

Invalid Units Code

The requested units code is not supported within the context of this command, Device Variable, or Dynamic Variable.

6.20 RC #19 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

| | |
|--|--|
| Device Variable Index Not Allowed | This Device Variable is not supported by the requested command or operation. In other words, the Device Variable is valid but you cannot use it with this command. |
|--|--|

6.21 RC #20 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

| | |
|--|--|
| Invalid Extended Command Number | The Extended Command Number was less then 512. |
|--|--|

6.22 RC #21 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

Invalid I/O card number The I/O System does not have an I/O card in the (logical) slot indicated in the command's request data bytes.

6.23 RC #22 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

Invalid Channel number The I/O card does not have the channel indicated in the command's request data bytes.

6.24 RC #23 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

Sub-device Response Too Long The I/O systems received a response from the sub-device that contained more bytes then the I/O System can forward in a single response packet.

6.25 RC #24-#27 (Single Definition Warning)

Reserved for future definition by the HCF. These codes may not be used by any manufacturer.

6.26 RC #28 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Invalid Range Units Code The units code included in the command are not supported by the field device for this Analog Channel or Dynamic Variable.

6.27 RC #29 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

No specific definition at this time.

6.28 RC #30(Multi-Definition Warning)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of these codes indicate that the command was executed but, a deviation from the host application's request was necessary to complete the command successfully. The values actually used are returned in the field device's Response Data Bytes.

Command Response Truncated

The device was not able to return as many Device Variables as requested. This normally caused by limited Command Buffer length.

6.29 RC #31(Multi-Definition Warning)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of these codes indicate that the command was executed but, a deviation from the host application's request was necessary to complete the command successfully. The values actually used are returned in the field device's Response Data Bytes.

No specific definition at this time.

6.30 RC #32 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Busy

This code can be caused by one of two conditions: (1) the device is busy performing a function that cannot be interrupted by this command; or (2) the command requested needs the delayed response mechanism. Unfortunately, all delayed response buffers are used.

In either case the host application should retry its request a large number of times (e.g., more than 30 times) until the field device can execute the command.

6.31 RC #33 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

Delayed Response Initiated

The command could not be serviced in the time given by the Data Link Layer. A delayed response was initiated. The host application should retry the exact same request after a time delay (e.g., after delaying several seconds). When communicating via a multiplexer this delay could be as little as half a second.

6.32 RC #34 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|-------------------------------------|--|
| Delayed Response Running | The execution of the delayed response is not yet finished. The process is still running in the field device. |
|-------------------------------------|--|

6.33 RC #35 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|----------------------------------|---|
| Delayed Response Dead | This response is valid for intelligent bridging devices only. This code indicates that the field device did not reply to the request. |
|----------------------------------|---|

6.34 RC #36 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

| | |
|--------------------------------------|---|
| Delayed Response Conflict | The requested command would cause a conflict with a delayed response currently executing in the Field Device. |
|--------------------------------------|---|

6.35 RC #37-#59 (Single Definition Error)

Reserved for future definition by the HCF. These codes may not be used by any manufacturer.

6.36 RC #60 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

This code is used in a WirelessHART ACK. Use of this code indicates that the packet was received correctly by the peer device but was not accepted by the peer device. The DLPDU will not be stored or forwarded by the device generating the ACK.

Payload Too Long

The Command payload does not fit in the WirelessHART PDU.

6.37 RC #61 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

This code is used in a WirelessHART ACK. Use of this code indicates that the packet was received correctly by the peer device but was not accepted by the peer device. The DLPDU will not be stored or forwarded by the device generating the ACK.

No Buffers Available

The device had no buffers available to accept the WirelessHART DLPDU.

6.38 RC #62 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

This code is used in a WirelessHART ACK. Use of this code indicates that the packet was received correctly by the peer device but was not accepted by the peer device. The DLPDU will not be stored or forwarded by the device generating the ACK.

No Alarm/Event Buffers Available

The device had no alarm/event buffers available to accept the WirelessHART DLPDU.

6.39 RC #63 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

This code is used in a WirelessHART ACK. Use of this code indicates that the packet was received correctly by the peer device but was not accepted by the peer device. The DLPDU will not be stored or forwarded by the device generating the ACK.

Priority Too Low

The priority of the DLPDU was too low for the device to accept the WirelessHART DLPDU.

6.40 RC #64 (Single Definition Error)

This code must have the following exact meaning for any command that utilizes this response code.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Command Not Implemented

The requested command is not implemented. This response is not valid for Universal Commands. For any other command this code may be returned by the field device even if Response Code #64 is not defined in the command specification itself.

6.41 RC #65 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Declined. Operator overridden.

Force Join Declined

Invalid Network ID

Invalid timer type

Invalid Time-to-Live

Invalid Join Priority

Unknown Nickname

Invalid Nickname

Service Request denied

Link not found

No more entries available

Entry not found

Illegal frequency channel bits

Unknown Unique ID

Key change failed

Session with given peer device does not exist

Invalid suspend time

6.42 RC #66 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Invalid number of slots

Session type invalid

Invalid execution time

**Unknown Notification
Flag**

Device List Conflict

**Invalid neighbor
property**

Invalid Service Id

Invalid Graph Id

Invalid resume time

Link already exists

Invalid Reason Code

Unknown service flag

Invalid timer interval

6.43 RC #67 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

Invalid Graph Id

Unknown Superframe ID

Invalid Superframe mode

Reason Code rejected,
Service not deleted

Unknown application
domain

6.44 RC #68 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device.

Unknown nickname

Invalid execution time

Invalid slot number

6.45 RC #69 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Unknown link options

6.46 RC #70 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Invalid channel offset

6.47 RC #71 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of this code indicates that the command was not executed . No Response Data Bytes are returned from the field device .

Invalid link type

6.48 RC #[72](#)-#95 (Multi-Definition Error)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of these codes indicate the command was not executed . No Response Data Bytes are returned from the field device's .

No specific definitions at this time

6.49 RC #96-#111 (Single-Definition Warning)

Reserved for future definition by the HCF. These codes may not be used by any manufacturer.

6.50 RC #112-#127 (Multi-Definition Warning)

The exact meaning of this response code varies by command. See the command specification for exact meaning. Manufacturers may define another meaning for this code when used by their device specific commands as long as only one meaning is applicable for a given command.

Use of these codes indicate the command was executed, but a deviation from the host application's request was necessary to complete the command successfully. The values actually used are returned in the field device's Response Data Bytes.

No specific definition at this time.

7. DELAYED SLAVE RESPONSES

The Delayed Response Mechanism (DRM) enables the (wired or Transport Layer) slave to indicate to a master that it received the request but is not able to immediately formulate a reply. This mechanism provides an informative and flexible convention for slave devices needing additional time to perform operations like self diagnostics, calibration, configuration or bandwidth requests. Unlike the Response Code BUSY, the master knows that the slave has understood the command and is still communicating.

DRM implementation in a wired-only slave is optional and limited to WRITE commands only. In other words, if the wired-only slave can ensure that a response can be generated and meet protocol timing requirements, then DRM does not need to be implemented. Wireless enabled devices must support DRM.

All slave devices supporting the DRM must adhere to the following rules:

1. Only new WRITE commands may use delayed response. All Commands must explicitly state in their specification whether the DRM Response Codes may be used.
2. To maintain compatibility with HART 5 and earlier hosts, any device specific commands supported in a HART 5 Field Device implementation must not use the DRM. In other words, all commands existing prior to HART 6 must continue to begin the slave response within the slave time out (see the *Data Link Layer Specification*).
3. If a command is received that would normally initiate a DR and no buffers are available then the slave will respond with a Busy.
4. A field device must always respond to an Identity Command even if a DR is in progress. Furthermore, field devices should always successfully execute READ commands even if a DR is in progress.
5. If a DR is being processed that will prevent a slave from responding to a master request then the slave must answer with a DR_CONFLICT. For example, DR_CONFLICT is returned if a master tries to initiate a transducer trim while one is already in process.
6. Once DR processing is complete, the slave must answer READ commands even if the master has not fetched the result of the DR.
7. Bridging devices (e.g., multiplexers and I/O systems) may use the DRM on all commands since they generally communicate with the host at higher bit rates than supported by the FSK Physical Layer. Bridging devices should support one DR buffer for each HART communication channel supported.

Slave devices must use the Response Codes listed in Table 3 to synchronize DR operation with master devices. Any Command Specification not listing these Response Codes may not use the DRM with the single exception listed in Rule 7 above.

Table 3. DRM Related Response Codes

| <u>Mnemonic</u> | <u>Value</u> | <u>Description</u> |
|--------------------|--------------|---|
| <u>Busy</u> | <u>32</u> | <u>Indicates the device is busy performing an indivisible operation. For Commands supporting DRM, Busy indicates that no more DR buffers are available.</u> |
| <u>DR_INITIATE</u> | <u>33</u> | <u>Indicates the start of a DR. The slave device needs additional time to process the command</u> |
| <u>DR_RUNNING</u> | <u>34</u> | <u>Indicates that the slave device is still processing the command.</u> |
| <u>DR_DEAD</u> | <u>35</u> | <u>Used by HART multiplexers to indicate that no response at all was received from the slave device.</u> |
| <u>DR_CONFLICT</u> | <u>36</u> | <u>Indicates that the command cannot be processed because it is in conflict with DR currently being processed.</u> |

All HART compatible masters must support DRM. When a master encounters a DR_INITIATE the exact command (including the data) must be reissued to retrieve the results. The master need not reissue the command immediately, in the interim he can service other slaves.

7.1 Normal DR Operation

A simple DR transaction is shown in Figure 2. The master sends a command that the slave cannot immediately complete. The slave initiates the DR and begins processing the command for later retrieval by the master. Some time later the master issues the same exact command. The slave is not finished and issues a DR_RUNNING. Later the command completes and the master retrieves the result.

Master(s)

Master 1 requests Cmd X

Master 1 can do something else and waits some time, so slave can complete Cmd X

Master 1 reissues Cmd X

Master 1 reissues Cmd X

Slave

Slave cannot immediately answer,
Sends DR_INITIATE

Slave has not completed Cmd X,
Sends DR_RUNNING

Slave completes Cmd X

Slave sends result of Cmd X with the
Normal Response Code (e.g. SUCCESS)

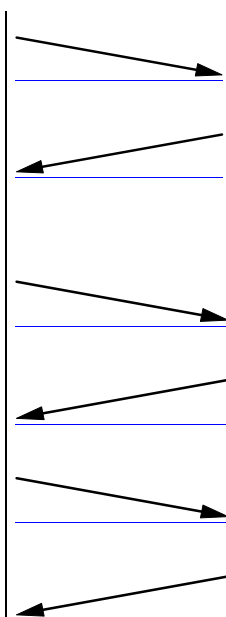


Figure 2. Normal DRM Operation

7.2 Use of DR CONFLICT Response Code

If a DR CONFLICT is received, the master delays its retry to allow slave to complete the pending DR. Masters should follow this procedure to minimize repetitive polling that, in turn, would delay the field device's completion of the DR.

Master(s)

Master 1 requests Cmd X

Master 1 reissues Cmd X

Master 2 sends Cmd 0

Master 2 issues Cmd X

Master 2 reissues Cmd X

Master 1 reissues Cmd X

Master 2 reissues Cmd X

Master 2 waits for slave to complete Cmd X

Master 1 issues Cmd Y

Master 2 reissues Cmd X

Master 1 sends Cmd Y

Slave

Slave cannot immediately answer Cmd X, Sends DR_INITIATE

Slave still working on Cmd X Issues DR_RUNNING

Slave should answer to Cmd 0

Slave cannot handle two Cmd X's Sends DR_CONFLICT

Slave completes Cmd X for Master 1

DR not complete for Master 1 (data not retrieved)
Sends DR_CONFLICT again.

Slave sends result of Cmd X

Slave cannot immediately answer, Issues DR_INITIATE

Slave needs the DRM to complete Cmd Y and no buffer is available,
Issues DR_CONFLICT

Slave completes Cmd X

Slave sends result of Cmd X .

Slave cannot complete Cmd Y,
Issues DR_INITIATE

Figure 3. Command Responses During DR Processing

7.3 Multiple DR Buffers

More sophisticated slave devices will have two DR buffers, one for each master. Some devices (e.g., multiplexers and I/O systems) may have many more. Multiple DR buffers allow a DR from each master to be queued. However, the slave must be careful to protect against inconsistencies. If implemented properly, out-of-order-completion of pending delayed responses is possible.

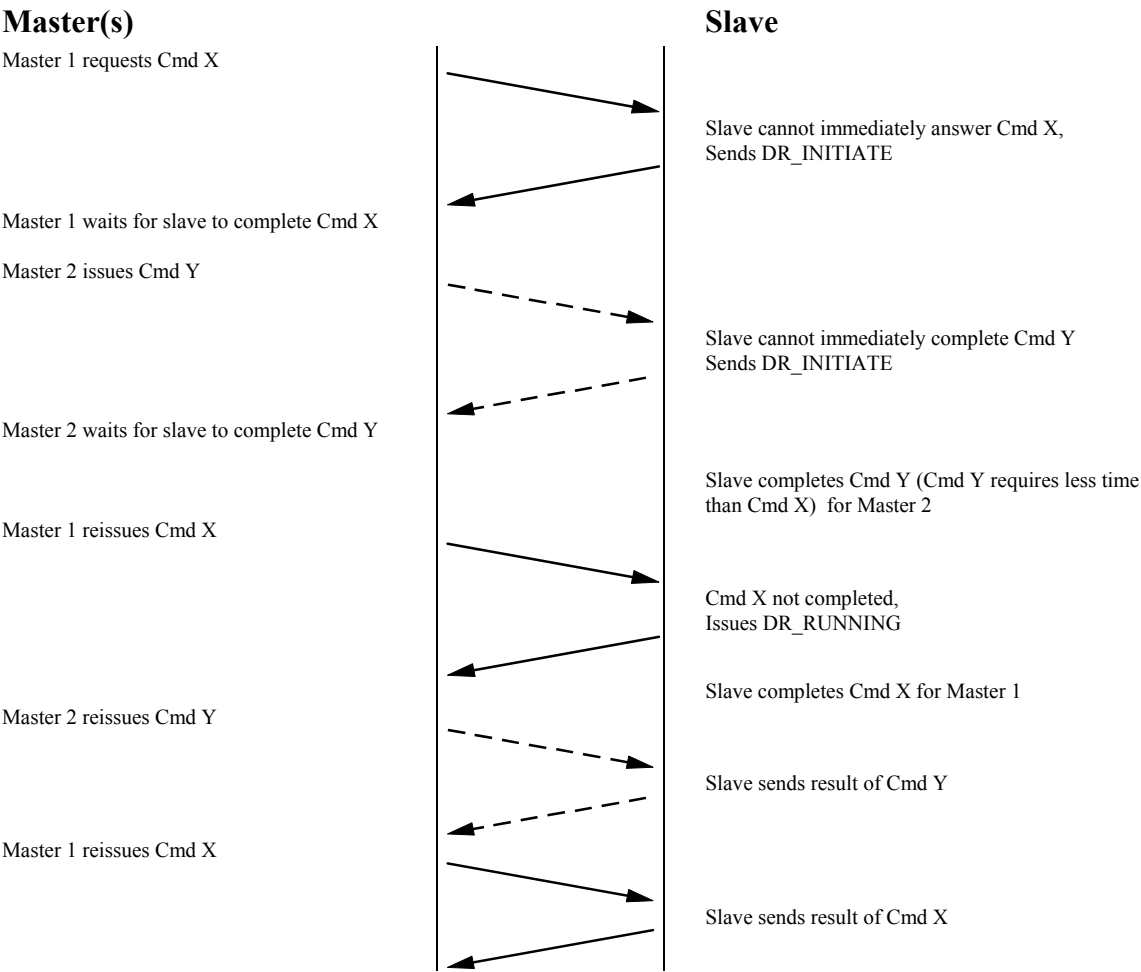


Figure 4. Slave with Multiple DR Buffers

7.4 Bridge Device Use of DRM

Bridge devices (e.g., multiplexers and I/O systems) function as slaves for the master that issues a request and as master for slaves that are addressed. Such devices are identified by setting the Protocol_Bridge_Device bit in the Flags byte of Identity Commands.

Bridge devices may introduce delays in relaying a command to and from the HART Field Device or Sub-Device. As a result, bridge devices are allowed to use the Delayed Response Mechanism on every command.

An additional Response Code (DR_DEAD) is used if the slave connected to the bridge device fails to reply at all. A master receiving DR_DEAD must assume that a serious error has occurred. Since an intelligent bridge should automatically retry the command if the slave does not answer, the master should immediately notify the user that the slave device is not responding.

ANNEX A. REVISION HISTORY

A1. Changes From 5.0 to 6.0*

The discussion of specification of the Delayed Response Mechanism was moved to this document from the *Command Summary Specification* .

Response Codes 60-63 were added to support WirelessHART

A2. Changes From 4.1 - Final to 5.0

The document was reformatted to align with the standards of the HCF. The response codes for the Delayed Response Mechanism were added. The wording was changed to accommodate other slaves than transmitters.

Some response codes were removed since they are not applicable anymore:

#30 Warning: end of transmission (slave to master)

Entries added to response codes:

#13 Computation Error

A3. Changes From 4.0 - Final to 4.1

The document was translated from an ASCII text document to Microsoft Word. As a result of this translation, the document format was altered. No other modifications were made.

* October 2008 – document updated to reflect the new HCF logo and copyright information.

A4. Changes From 3.0 - Final to 4.0A - Preliminary

Summarized Release Notes from Rev 2 to Rev 3.0 - Final.

| <u>Page</u> | <u>Line</u> | <u>Change</u> | <u>Text</u> |
|-------------|-------------|---------------|--|
| TP | 4 | Replace | "3.0 - Final" by "4.OA - Prel." |
| TP | 5 | Replace | "11 February" by "18 October" |
| TP | 6 | Replace | "11 February 1990" by "18 October 1990" |
| TP | 7 | Replace | "PRINTED: 15 February" by "PRINTED: 18 October" |
| 4 | 15 | Insert | "Not In Proper Analog Output Mode - The field..." |
| 4 | 37 | Insert | "Invalid Level Units Filter Auto-Adjust Error..." |
| 5 | 33 | Insert | "Trim Location Not Set To User - Trim Location..." |
| 6 | 24 | Insert | "Invalid Base Flow Units Code - The Base Flow..." |
| 6 | 35 | Insert | "Invalid Transmitter Variable Code Invalid..." |
| 7 | 34 | Insert | "Invalid Units Code Invalid Sensor Connection..." |
| 8 | 26 | Insert | "Invalid Transfer Function Code. Invalid..." |
| 9 | 2 | Insert | "#15" |
| 9 | 4 | Insert | "Invalid Analog Output Number Code. Invalid Analog..." |
| 9 | 18 | Replace | "#15, #28," by "3.8. RESPONSE CODE" |
| 11 | 38 | Insert | "Warning: Default Value Set For User Trim..." |
| 11 | 44 | Insert | "#30" |
| 11 | 46 | Insert | "Warning: End Of Transmission (Slave to Master)..." |
| 11 | 54 | Replace | "#30, #31," by "5.5. RESPONSE CODE" |
| 20 | 19 | Move | "Data Byte" from page 18 line 17 |

A5. Major Modifications Rev 2 to Rev 3.0 - Final

1. Expanded the Command-Specific Response Code space to 127.
2. Added information indicating that the Command-Specific Response Codes have been changed from Bit #0 - #3 to Bit #0 - #6.
3. Added summary information to the beginning of the document. Included information contained in the opening paragraphs, deleted information referring to Block Number and Device Type, assigned codes for Single and Multiple Error and Warning definitions, added summary table, and clarified description.
4. Changed titles of sections to include Error and Warning definition types and assigned response codes accordingly.
5. Added response codes for 3044c, 8712, and 3680.

(Refer to document Revision 3, D8900077, for detailed information)

A6. Major Modifications from Rev 1 to Rev 2

1. Added description for response codes that begin with "Warning:"
2. Added response codes for the 3044 and the 9712.

(Refer to document Revision 2, D8900076, for detailed information.)

A7. Major Modifications Incorporated into Rev 1

3. Added information indicating which codes have only one description and which codes may have multiple descriptions.

(Refer to document Revision 1, D8800002, for detailed information.)