HART® Field Device Specification:

MP100/MP300 Smart Positioner

Document (E) IM-MP100-01, rev. 2

Initial release: 17 July 2015

Current release: 28 November 2022

Author: Masaru Kurihara
3S Co., Ltd.
2-6-7, Ukima, Kita-ku
Tokyo
Japan

® HART is a registered trademark of the HART Communication Foundation

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Scope

The 3S valve positioner MP series products comply with HART Protocol Revision 7.0. 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.

1.2 Purpose

This specification is designed to compliment other documentation (e.g., the *MP100 Operating Manual*) by providing a complete, unambiguous description of this Field Device from a HART Communication perspective

1.3 Who should use this document?

The 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.

1.4 Abbreviations and definitions

ADC	Analog to Digital Converter
DAC	Digital to Analog Converter
CPU	Central Processing Unit (of microprocessor)
EEPROM	Electrically-Erasable Read-Only Memory
ROM	Read-Only Memory
RAM	Random Access Memory (Volatile)
E/P	Electronic-Pneumatic (4-20mA demanded, Pneumatic driving)

1.5 References

HART Smart Communications Protocol Specification. HCF_SPEC-12. Available from the HCF.

Operating Manual Smart Positioner (electro pneumatic) MP 100 series,
Document (E)IM-MP100-00. 3S Co., Ltd.

2. DEVICE IDENTIFICATION

Manufacturer Name:	3S Co., Ltd.	**Model Name(s):**	MP100/MP300 series
Manufacture ID Code:	24708 (6084 Hex)	**Device Type Code:**	57997 (E28D Hex)
HART Protocol Revision	7	**Device Revision:**	1 , 2
Number of Device Variables	4		
Physical Layers Supported	FSK		
Physical Device Category	Actuator, Two-wire, Receiving 4-20mA signal from the loop		

3. PRODUCT OVERVIEW

The MP100/MP300 series Smart Positioner is two-wire loop-powered E/P positioner which controls a valve position by the 4-20mA input signal. The auto-tuning feature is available by default.
The input signal is connected on terminals marked "IN+" and "IN-". Refer to the Operating Manual for connection details.

In order to get the valve status, the Feedback signal output or the HART communication is available as an option.

Diagram of the operation principle is shown as follows.

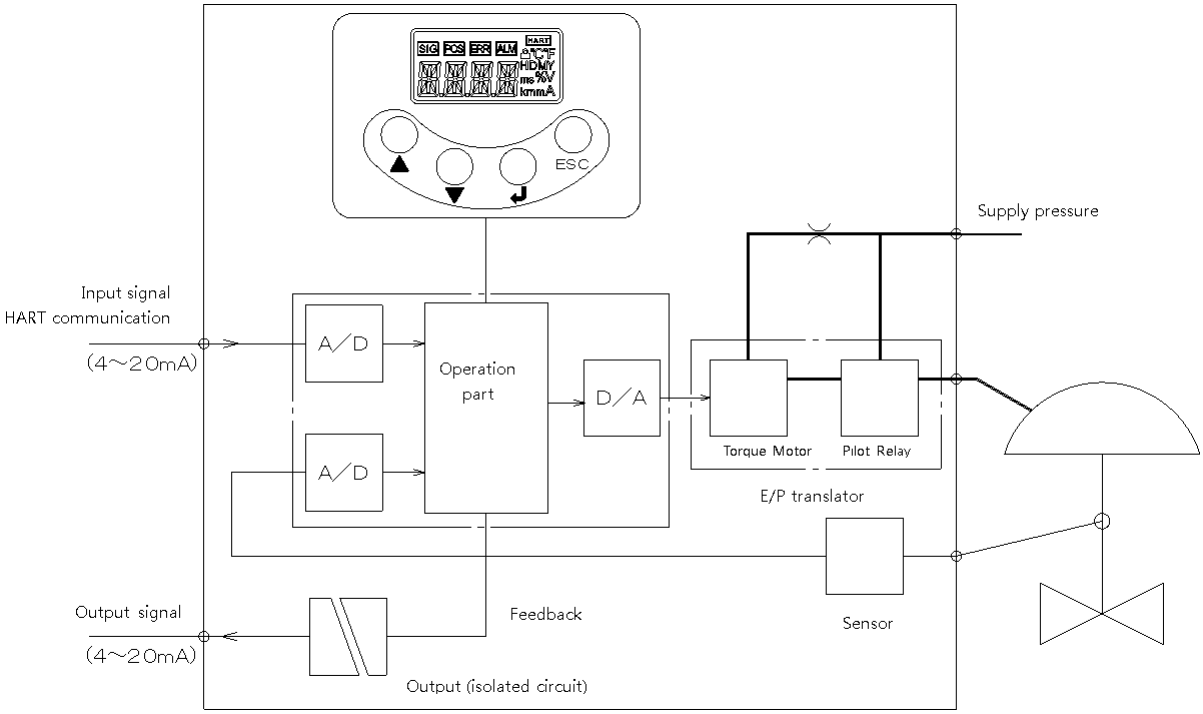

Figure 1. Operation principle

Model number differences in the MP100/MP300 series Smart Positioner are shown below.

Model number	MP100	MP160	MP300	MP340
Appearance/ Enclosure				
Explosion protection type	No protection	Flameproof Enclosure	No protection	Intrinsic Safe type of protection
Built-in circuit board	Normal circuit board (All three are the same board.)			Intrinsic Safe type circuit board
HART Physical specs	All three are the same specs			Some differences
Microcontroller & HART IC	All the same Microcontroller and HART IC			
Embedded software	All the same embedded software			
HART Logical specs	Since all have the same specs, one EDD/FDI supports all.			
HART Device Revision	#1 and #2			#2 only

4. PRODUCT INTERFACESF

4.1 Process Interface

4.1.1 Sensor Input Channels

This device doesn't have any electrically connected external sensors. (The sensors used in this device are a built-in current sensor, a temperature sensor, and an angle sensor mechanically linked to the outside.)

4.1.2 Actuator Output Channels

This device doesn't have any electrically connected external actuators. (There are two pneumatic outputs to drive the pneumatic actuators.)

4.2 Host interface

4.2.1 Analog Input

The two-wire 4-to-20mA current loop is connected on two terminals marked "IN+" and "IN-". Refer to the Operating Manual for connection details.
This is both a demand signal for the target valve position and a two-wire loop-powered source.

HART Communication is supported on this loop. The value of this input signal (target valve position) corresponds to the Primary Variable.

Current values are shown in the table below.

	Direction	Values (percent of range)	Values (mA or V)
Linear over-range	Down	0%	4.00 mA
	Up	0%	20.00 mA
Maximum current		+10%	22.00 mA
Multi-Drop current draw			N/A
Voltage at 20 mA			< 10.5 V *
Lift-off current (from full function)			< 4.00 mA
Lift-off current			< 3.80 mA

* 9.1V for Intrinsic Safe type of explosion protection

Figure 2. Analog Input Characteristics

4.2.2 Analog Output

Dedicated feedback signal of 4-to-20mA current output in order to get the valve status. HART Communication is NOT supported on this loop.

4.3 Local Interfaces, Jumpers and Switches

4.3.1 Local Controls and Displays

All adjustments can be made at the touch of four buttons while viewing the built-in LCD (Liquid Crystal Display). Refer to the Operating Manual for connection details.

4.3.2 Internal Jumpers and Switches

This device doesn’t have Internal Jumpers and Switches.

5. DEVICE VARIABLES

5.1 Device Variable 0 "DVC_INPUT_SIGNAL"

This variable shows a 4-20 mA input signal, which is the demand of the target valve position.
This variable is mapped to PV.

Device Variable			
Number :	0	Name	DVC_INPUT_SIGNAL
Classification:		Unit Codes	39 or 57

Figure 3. Device Variable 0

5.2 Device Variable 1 "DVC_KAIDO_SIGNAL"

This variable shows a current valve position.
This variable is mapped to SV.

Device Variable			
Number :	1	Name	DVC_KAIDO_SIGNAL
Classification:		Unit Codes	39 or 57

Figure 4. Device Variable 1

5.3 Device Variable 2 "DVC_TEMPARATUER"

This variable shows temperature of internal sensor.
This variable is mapped to TV.

Device Variable			
Number :	2	Name	DVC_TEMPARATUER
Classification:		Unit Codes	32, 33 or 35

Figure 5. Device Variable 2

5.4 Device Variable 3 "DVC_HENSA"

This variable shows a deviation from the ideal valve position.
This variable is mapped to QV.

Device Variable			
Number :	3	Name	DVC_HENSA
Classification:		Unit Codes	39 or 57

Figure 6. Device Variable 3

5.5 Device Variable 244 "PERCENT_RANGE"

This variable shows a 4-20 mA input signal.
The same contents as LOOP_CURRENT, PRIMARY_VARIABLE and PV.

Device Variable			
Number :	244	Name	PERCENT_RANGE
Classification:		Unit Codes	57

Figure 7. Device Variable 244

5.6 Device Variable 245 "LOOP_CURRENT"

This variable shows a 4-20 mA input signal.
The same contents as PERCENT_RANGE, PRIMARY_VARIABLE and PV.

Device Variable			
Number :	245	Name	LOOP_CURRENT
Classification:		Unit Codes	39 or 57

Figure 8. Device Variable 245

5.7 Device Variable 246 "PRIMARY_VARIABLE"

This variable shows a 4-20 mA input signal.
The same contents as PERCENT_RANGE, LOOP_CURRENT and PV.

Device Variable			
Number :	246	Name	PRIMARY_VARIABLE
Classification:		Unit Codes	39 or 57

Figure 9. Device Variable 246

5.8 Device Variable 247 "SECONDARY_VARIABLE"

This variable shows a current valve position.
The same contents as SV.

Device Variable			
Number :	247	Name	SECONDARY_VARIABLE
Classification:		Unit Codes	39 or 57

Figure 10. Device Variable 247

5.9 Device Variable 248 "TERTIARY_VARIABLE"

This variable shows temperature of internal sensor.
The same contents as TV.

Device Variable			
Number :	248	Name	TERTIARY_VARIABLE
Classification:		Unit Codes	32, 33 or 35

Figure 11. Device Variable 248

5.10 Device Variable 249 “QUATERNARY_VARIABLE”

This variable shows a deviation from the ideal valve position.
The same contents as QV.

Device Variable			
Number :	249	Name	QUATERNARY_VARIABLE
Classification:		Unit Codes	39 or 57

Figure 12. Device Variable 249

6. DYNAMIC VARIABLES

6.1 Fixed Dynamic Variables

	Meaning	Units
PV	Process Value (Input Signal)	mA, %
SV	Position	mA, %
TV	Temperature of internal sensor	degC, degF, degK
QV	Deviation	mA, %

Figure 13. Fixed Dynamic Variables

6.2 Fixed Dynamic Variables, Referred to Device Variables

Dynamic Variable	Device Variable number	Name
PV	0	DVC_INPUT_SIGNAL
SV	1	DVC_KAIDO_SIGNAL
TV	2	DVC_TEMPARATUER
QV	3	DVC_HENSA

Figure 14. Fixed Dynamic Variables, Referred to Device Variables

6.3 Dynamic Variable with Configurable Mapping

This device doesn’t have Dynamic Variable with Configurable Mapping.

7. STATUS INFORMATION

7.1 Device Status

Bit 7 ("Device Malfunction") doesn't have a chance to be set in this device.

Bit 4 ("More Status Available") is set whenever any failure status is changed. Command #48 gives further detail.

Bit 1 ("Non-Primary Variable Out Of Limits") doesn't have a chance to be set in this device.

7.2 Extended Device Status

Bit 5 ("Function Check") isn’t supported on this device.

Bit 4 ("Out of Specification") is set when one of following two error is detected.
1. 4-20 mA input is too low
2. Internal temperature sensor shows wrong voltage

Bit 3 ("Failure") is set when one of following two error is detected.
1. 4-20 mA input is too low
2. Internal temperature sensor shows wrong voltage

Bit 2 ("Critical Power Failure") is set when 4-20 mA input (power source) is lower than 3.9 mA.

Bit 1 ("Device Variable Alert") is set when one of following six alarm is declared.
1. Alarm of Minimum Input (ALARM_ID_INPUT_MIN)
2. Alarm of Maximum Input (ALARM_ID_INPUT_MAX)
3. Alarm of Minimum Position Sensor (ALARM_ID_KAIDO_MIN)
4. Alarm of Maximum Position Sensor (ALARM_ID_KAIDO_MAX)
5. Alarm of Minimum Temperature Sensor (ALARM_ID_TEMP_MIN)
6. Alarm of Maximum Temperature Sensor (ALARM_ID_TEMP_MAX)

Bit 0 ("Maintenance Required") is set when one of following three alarm is declared.
1. Alarm of Maintenance Timer (ALARM_ID_MAINT_TIME)
2. Alarm of Maintenance Stroke Counter (ALARM_ID_MAINT_CYCLE)
3. Alarm of Maintenance Trip-meter of Sum of valve travel (ALARM_ID_MAINT_STROKE)

7.3 Additional Device Status (Command #48)

Command #48 returns 25 bytes of data, with the following status information:

Byte	Bit	Meaning: System errors/warnings	Class	Device Status Bits Set
0	0	ERROR_ID_CPU1	Error	4
	1	ERROR_ID_CPU2	Error	4
	2	ERROR_ID_EEPROM1	Error	4
	3	ERROR_ID_EEPROM2	Error	4
	4	ERROR_ID_TEMP1	Error	4
	5	ERROR_ID_SW	Error	4
	6	ERROR_ID_INPUT	Error	4
	7	ERROR_ID_DRIVE	Error	4
1	0	ERROR_ID_FB	Error	4
	1	ERROR_ID_TORQ	Error	4
	2	ERROR_ID_SHUT	Error	4
	3	ERROR_ID_FULL	Error	4
	4	ERROR_ID_FBM	Error	4
	5	ERROR_ID_FBP	Error	4
	6	ERROR_ID_TEMP2	Error	4
	7	ERROR_ID_PST	Error	4
2	0	Not used		
	1	Not used		
	2	Not used		
	3	Not used		
	4	Not used		
	5	ERROR_ID_AT_TIME_OUT	Error	4
	6	ERROR_ID_KAIDO_MIN1	Error	4
	7	ERROR_ID_KAIDO_MAX1	Error	4
3	0	ERROR_ID_KAIDO_MIN2	Error	4
	1	ERROR_ID_KAIDO_MAX2	Error	4
	2	ERROR_ID_SPLIT_RANGE	Error	4
	3	ERROR_ID_CHAR_USER	Error	4

	4	ERROR_ID_EEPROM_DISABLE	Error	4
	5	ERROR_ID_HART_LOCKED	Error	4
	6	Not used		
	7	Not used		
4	0	ALARM_ID_INPUT_MIN	Warning	4
	1	ALARM_ID_INPUT_MAX	Warning	4
	2	ALARM_ID_MAINT_TIME	Warning	4
	3	ALARM_ID_KAIDO_MIN	Warning	4
	4	ALARM_ID_KAIDO_MAX	Warning	4
	5	ALARM_ID_MAINT_CYCLE	Warning	4
	6	ALARM_ID_MAINT_STROKE	Warning	4
	7	ALARM_ID_TEMP_MIN	Warning	4
5	0	ALARM_ID_TEMP_MAX	Warning	4
	1	ALARM_ID_PST_EXEC	Warning	4
	2	Not used		
	3	Not used		
	4	Not used		
	5	Not used		
	6	Not used		
	7	Not used		
Byte	**Enum**	**Meaning: Auto-tuning monitoring**	**Class**	**Device Status Bits Set**
14	0	Auto-tuning mode is not working	Mode	
	1	Step 1: Finding lowest position	Mode	4
		Step 2: Finding highest position		
		Step 3: Finding lowest position		
	2	Step 1: Going to lowest position	Mode	4
		Step 2: Finding torque to start moving		
		Step 3: Going to highest position		
		Step 4: Finding torque to start moving		
	3	Step 1: Going to lowest position	Mode	4
		Step 2: PID measurement		
		Step 3: Parameter setup		

15	0	(initial value)	Mode	4
	1	Step 1	Mode	4
	2	Step 2	Mode	4
	3	Step 3	Mode	4
	4	Step 4	Mode	4
	254	Finished with error.	Mode	4
	255	All done without error.	Mode	4
Byte	**Enum**	**Meaning: Auto-tuning error**	**Class**	**Device Status Bits Set**
16	0	No error	Mode	4
	10	Torque error	Mode	4
	21	Timeout	Mode	4
	22	Lowest position too low	Mode	4
	23	Highest position too high	Mode	4
	24	Lowest position too high	Mode	4
	25	Highest position too low	Mode	4
	26	EEPROM error	Mode	4

Figure 15. Additional Device Status (Command #48)

"Not used" bits are always set to 0.
These bits are set or cleared by the self-test executed at power up, and also set (but not cleared) by any failure detected at self-test which is always being executed with normal tasks.

8. UNIVERSAL COMMANDS

[Remarks]
Command #15 Byte 15 returns 251. Write protection is not implemented to this device.

9. COMMON-PRACTICE COMMANDS

9.1 Supported Commands

The following common-practice commands are implemented:

33 Read Device Variables

41 Perform Self-Test

42 Perform Device Reset

44 Write Primary Variable Units

47 Write Primary Variable Transfer Function

50 Read Dynamic Variable Assignment

53 Write Device Variable Unit

54 Read Device Variable Information

59 SET Number of Preambles

71 Lock Device

76 Read Lock Device Status

95 Read Device Communications Statistics

9.2 Burst Mode

This Field Device does not support Burst Mode.

9.3 Catch Device Variable

This Field Device does not support Catch Device Variable.

10. DEVICE-SPECIFIC COMMANDS

The following device-specific commands are implemented:

128 Read Distribution Map (10.1)

129 Reset Distribution Map (10.2)

132 Write P50P (10.3)

142 Start Auto-tuning (10.4)

143 Read Display Mode (10.5)

144 Write Display Mode (10.6)

145 Read Split Range (10.7)

146 Write Split Range (10.8)

147 Calibrate Zero/Span Range (10.9)

148 Write Span Range as Relative Update (10.10)

149 Read CW or CCW of Position Sensor (10.11)

150 Write CW or CCW of Position Sensor (10.12)

151 Read Position Sensor Angle (10.13)

153 Read PID Parameters (10.14)

154 Write PID Parameter (10.15)

157 Read Threshold of Forced Full Opening/Closing (10.16)

158 Write Threshold of Forced Full Opening/Closing (10.17)

159 Read User Defined Characteristic Map (10.18)

160 Write User Defined Characteristic Map (10.19)

161 Read Dead-band Width (10.20)

162 Write Dead-band Width (10.21)

163 Read DA/RA Setting (10.22)

164 Write DA/RA Setting (10.23)

165 Read Linear/Rotary Setting (10.24)

166 Write Linear/Rotary Setting (10.25)

167 Read Single/Double Setting (10.26)

168 Write Single/Double Setting (10.27)

169 Read Feed Forward Value (10.28)

170 Write Feed Forward Value (10.29)

171 Read Torque Min/Max (10.30)

172 Write Torque Min/Max (10.31)

182 Calibrate Input Signal (10.32)

183 Read Input Signal Alarm (10.33)

184 Write Input Signal Alarm (10.34)

185 Read Shutdown Cycle Counter (10.35)

186 Reset Shutdown Cycle Counter (10.36)

187 Read Operating Time (10.37)

188 Write Operating Time (10.38)

189 Read Position Sensor Alarm (10.39)

190 Write Position Sensor Alarm (10.40)

191 Read Stroke Counter (10.41)

192 Write Stroke Counter (10.42)

193 Read Sum of Valve Travel Odometer (10.43)

194 Write Sum of Valve Travel Odometer (10.44)

195 Read PST (10.45)

196 Write PST (10.46)

197 Read Temperature Unit on LCD (10.47)

198 Write Temperature Unit on LCD (10.48)

199 Read Temperature Alarm (10.49)

200 Write Temperature Alarm (10.50)

10.1 Command #128: Read Distribution Map

Reads the Distribution Map of internal statistical analysis.

Request Data Bytes

Byte	Format	Description
0	Enum	Distribution Map Code (see Section 11.1)

Response Data Bytes

Byte	Format	Description
0	Enum	Distribution Map Code (see Section 11.1)
1-4	Float	Distribution Rate of < -20.0 degC [%]
5-8	Float	Distribution Rate of -20.0 – 0.0 degC [%]
9-12	Float	Distribution Rate of 0.0 – 20.0 degC [%]
13-16	Float	Distribution Rate of 20.0 – 40.0 degC [%]
17-20	Float	Distribution Rate of 40.0 – 60.0 degC [%]
21-24	Float	Distribution Rate of > 60.0 degC [%]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6-127		Undefined

Figure 16. Command #128 Specification Format

10.2 Command #129: Reset Distribution Map

Resets the Distribution Map of internal statistical analysis.

Request Data Bytes

Byte	Format	Description
0	Enum	Distribution Map Code (see Section 11.1)
1	Enum	0xFE

Response Data Bytes

Byte	Format	Description

0	Enum	Distribution Map Code (see Section 11.1)
1	Enum	0xFE

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 17. Command #129 Specification Format

10.3 Command #132: Write P50P

Set the adjustment value of half position. (Not supported in device revision 1.)

Request Data Bytes

Byte	Format	Description
0-3	Float	Adjustment value of half position [%]

Response Data Bytes

Byte	Format	Description
0-3	Float	Adjustment value of half position [%]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Adjustment value of half position > 6.35%
4	Error	Adjustment value of half position < -6.35%
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined

Code	Class	Description
16	Error	Manual operation is in active
17-127		Undefined

Figure 18. Command #162 Specification Format

10.4 Command #142: Start Auto-tuning

Starts the Auto-tuning. Progression can be monitored by Command #48.

Request Data Bytes

Byte	Format	Description
0	Enum	Auto-tuning Level (see Section 11.2)

Response Data Bytes

Byte	Format	Description
0	Enum	Auto-tuning Level (see Section 11.2)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 19. Command #142 Specification Format

10.5 Command #143: Read Display Mode

Gets the LCD display mode.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Display Mode (see Section 11.3)

Command-Specific Response Codes

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

Figure 20. Command #143 Specification Format

10.6 Command #144: Write Display Mode

Set the Display Mode.

Request Data Bytes

Byte	Format	Description
0	Enum	Display Mode (see Section 11.3)

Response Data Bytes

Byte	Format	Description
0	Enum	Display Mode (see Section 11.3)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 21. Command #144 Specification Format

10.7 Command #145: Read Split Range

Gets the Split Range.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Split Range Span [mA]
4-7	Float	Split Range Zero [mA]

Command-Specific Response Codes

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

Figure 22. Command #145 Specification Format

10.8 Command #146: Write Split Range

Set the Split Range Span and Zero.

Request Data Bytes

Byte	Format	Description
0-3	Float	Split Range Span [mA]
4-7	Float	Split Range Zero [mA]

Response Data Bytes

Byte	Format	Description
0-3	Float	Split Range Span [mA]
4-7	Float	Split Range Zero [mA]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8		Undefined
9	Error	Split Range Zero > 16.00
10	Error	Split Range Zero < 4.00

Code	Class	Description
11	Error	Split Range Span > 20.00
12	Error	Split Range Span < 8.00
13		Undefined
14	Error	Split Range of Span - Zero > 4.00
15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 23. Command #146 Specification Format

10.9 Command #147: Calibrate Zero/Span Range

Set current position as Zero or Span range.

Request Data Bytes

Byte	Format	Description
0	Enum	Zero/Span selection (see Section 11.4)

Response Data Bytes

Byte	Format	Description
0	Enum	Zero/Span selection (see Section 11.4)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8		Undefined
9	Error	Position Zero is too high
10	Error	Position Zero is too low
11	Error	Position Span is too high
12	Error	Position Span is too low
13-15		Undefined
16	Error	Manual operation is in active

Code	Class	Description
17-127		Undefined

Figure 24. Command #147 Specification Format

10.10 Command #148: Write Span Range as Relative Update

Updates Span range to relative percentage.

Request Data Bytes

Byte	Format	Description
0-3	Float	Relative percentage [%] (100% means no change.)

Response Data Bytes

Byte	Format	Description
0-3	Float	Relative percentage [%]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Relative percentage > 110.0
4	Error	Relative percentage < 65.0
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8		Undefined
9	Error	Updated Span Range is too high
10	Error	Updated Span Range is too low
11-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 25. Command #148 Specification Format

10.11 Command #149: Read CW or CCW of Position Sensor

Gets the Position Sensor Direction to shut valve.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	CW or CCW (see Section 11.4)

Command-Specific Response Codes

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

Figure 26. Command #149 Specification Format

10.12 Command #150: Write CW or CCW of Position Sensor

Set the Position Sensor Direction to shut valve.

Request Data Bytes

Byte	Format	Description
0	Enum	CW or CCW (see Section 11.4)

Response Data Bytes

Byte	Format	Description
0	Enum	CW or CCW (see Section 11.4)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 27. Command #150 Specification Format

10.13 Command #151: Read Position Sensor Angle

Gets current and min/max Position Sensor raw Angle.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Position Sensor raw Angle [deg]
4-7	Float	Position Set-min raw Angle [deg]
8-11	Float	Position Set-max raw Angle [deg]
12-15	Float	Adjustment value of half position [%] *

Those marked with * is not supported in device revision 1.

Command-Specific Response Codes

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

Figure 28. Command #151 Specification Format

10.14 Command #153: Read PID Parameters

Gets PID Parameters.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	P-Gain
4-7	Float	I-Gain
8-11	Float	D-Gain
12-15	Float	TF-Time

Command-Specific Response Codes

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

Figure 29. Command #153 Specification Format

10.15 Command #154: Write PID Parameter

Set each PID Parameter.

Request Data Bytes

Byte	Format	Description
0	Enum	PID Parameter Selection (see Section 11.6)
1-4	Float	Parameter Value

Response Data Bytes

Byte	Format	Description
0	Enum	PID Parameter Selection (see Section 11.6)
1-4	Float	Parameter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Parameter Value is too high
4	Error	Parameter Value is too low
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8	Warning	Modified to appropriate value
9-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 30. Command #154 Specification Format

Each parameter's appropriate Range and Step are shown as follows.
Less than Step is truncated. For example, if you set TF-Time to 2.5, 2.0 will be set.

Parameter	Range	Step
P-Gain	1 – 100	1
I-Gain	0.01 – 1.00 or "-10" specially means "OFF"	0.01
D-Gain	0.1 – 25.0 or "-100" specially means "OFF"	0.1

Parameter	Range	Step
TF-Time	1 – 20 or "-1000" specially means "OFF"	1

10.16 Command #157: Read Threshold of Forced Full Opening/Closing

Gets the Threshold of Position of Forced Full Opening/Closing drive.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Threshold of Forced Full Opening [%]
4-7	Float	Threshold of Forced Full Closing [%]

Command-Specific Response Codes

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

Figure 31. Command #157 Specification Format

10.17 Command #158: Write Threshold of Forced Full Opening/Closing

Set the Threshold of Position of Forced Full Opening/Closing drive.

Request Data Bytes

Byte	Format	Description
0-3	Float	Threshold of Forced Full Opening [%] or "-100 %" specially means "OFF"
4-7	Float	Threshold of Forced Full Closing [%] or "-100 %" specially means "OFF"

Response Data Bytes

Byte	Format	Description
0-3	Float	Threshold of Forced Full Opening [%]
4-7	Float	Threshold of Forced Full Closing [%]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8		Undefined
9	Error	Threshold of Forced Full Closing > 10.0 %
10	Error	Threshold of Forced Full Closing < -5.00 %
11	Error	Threshold of Forced Full Opening > 105.0 %
12	Error	Threshold of Forced Full Opening < 90.0 %
13-15		Undefined
16	Error	Manual operation is in active
11-127		Undefined

Figure 32. Command #158 Specification Format

10.18 Command #159: Read User Defined Characteristic Map

Gets the User Defined Characteristic Map for Input conversion.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Characteristic Map Type (see Section 11.7)
1-4	Float	User Defined Characteristic Map at 0.00% Input
5-8	Float	User Defined Characteristic Map at 6.25% Input
9-12	Float	User Defined Characteristic Map at 12.50% Input
13-16	Float	User Defined Characteristic Map at 18.75% Input
17-20	Float	User Defined Characteristic Map at 25.00% Input
21-24	Float	User Defined Characteristic Map at 31.25% Input
25-28	Float	User Defined Characteristic Map at 37.50% Input
29-32	Float	User Defined Characteristic Map at 43.75% Input
33-36	Float	User Defined Characteristic Map at 50.00% Input

27-40	Float	User Defined Characteristic Map at 56.25% Input
41-44	Float	User Defined Characteristic Map at 62.50% Input
45-48	Float	User Defined Characteristic Map at 68.75% Input
49-52	Float	User Defined Characteristic Map at 75.00% Input
53-56	Float	User Defined Characteristic Map at 81.25% Input
57-60	Float	User Defined Characteristic Map at 87.50% Input
61-64	Float	User Defined Characteristic Map at 93.75% Input
65-68	Float	User Defined Characteristic Map at 100.00% Input

Command-Specific Response Codes

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

Figure 33. Command #159 Specification Format

10.19 Command #160: Write User Defined Characteristic Map

Set the User Defined Characteristic Map for Input conversion.

Request Data Bytes

Byte	Format	Description
0	Enum	Characteristic Map Type (see Section 11.7)
1-4	Float	User Defined Characteristic Map at 0.00% Input
5-8	Float	User Defined Characteristic Map at 6.25% Input
9-12	Float	User Defined Characteristic Map at 12.50% Input
13-16	Float	User Defined Characteristic Map at 18.75% Input
17-20	Float	User Defined Characteristic Map at 25.00% Input
21-24	Float	User Defined Characteristic Map at 31.25% Input
25-28	Float	User Defined Characteristic Map at 37.50% Input
29-32	Float	User Defined Characteristic Map at 43.75% Input
33-36	Float	User Defined Characteristic Map at 50.00% Input
27-40	Float	User Defined Characteristic Map at 56.25% Input
41-44	Float	User Defined Characteristic Map at 62.50% Input
45-48	Float	User Defined Characteristic Map at 68.75% Input
49-52	Float	User Defined Characteristic Map at 75.00% Input

53-56	Float	User Defined Characteristic Map at 81.25% Input
57-60	Float	User Defined Characteristic Map at 87.50% Input
61-64	Float	User Defined Characteristic Map at 93.75% Input
65-68	Float	User Defined Characteristic Map at 100.00% Input

When Byte 0 is not '3' (=User Defined Map), Byte 1 - 68 are ignored. Request data size can be one.

Response Data Bytes

Byte	Format	Description
0	Enum	Characteristic Map Type (see Section 11.7)
1-4	Float	User Defined Characteristic Map at 0.00% Input
5-8	Float	User Defined Characteristic Map at 6.25% Input
9-12	Float	User Defined Characteristic Map at 12.50% Input
13-16	Float	User Defined Characteristic Map at 18.75% Input
17-20	Float	User Defined Characteristic Map at 25.00% Input
21-24	Float	User Defined Characteristic Map at 31.25% Input
25-28	Float	User Defined Characteristic Map at 37.50% Input
29-32	Float	User Defined Characteristic Map at 43.75% Input
33-36	Float	User Defined Characteristic Map at 50.00% Input
27-40	Float	User Defined Characteristic Map at 56.25% Input
41-44	Float	User Defined Characteristic Map at 62.50% Input
45-48	Float	User Defined Characteristic Map at 68.75% Input
49-52	Float	User Defined Characteristic Map at 75.00% Input
53-56	Float	User Defined Characteristic Map at 81.25% Input
57-60	Float	User Defined Characteristic Map at 87.50% Input
61-64	Float	User Defined Characteristic Map at 93.75% Input
65-68	Float	User Defined Characteristic Map at 100.00% Input

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Map Value > 100.00 %
4	Error	Map Value < 0.00 %

Code	Class	Description
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-12		Undefined
13	Warning	Modified to appropriate value
14-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 34. Command #160 Specification Format

10.20 Command #161: Read Dead-band Width

Gets the Dead-band Width.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Dead-band Width [%]

Command-Specific Response Codes

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

Figure 35. Command #161 Specification Format

10.21 Command #162: Write Dead-band Width

Set the Dead-band Width.

Request Data Bytes

Byte	Format	Description
0-3	Float	Dead-band Width [%]

Response Data Bytes

Byte	Format	Description
0-3	Float	Dead-band Width [%]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-2		Undefined
3	Error	Dead-band Width > 10.00
4	Error	Dead-band Width < 0.00
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 36. Command #162 Specification Format

10.22 Command #163: Read DA/RA Setting

Gets the DA/RA Setting.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	DA/RA Setting (see Section 11.8)

Command-Specific Response Codes

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

Figure 37. Command #163 Specification Format

10.23 Command #164: Write DA/RA Setting

Set the DA/RA Setting.

Request Data Bytes

Byte	Format	Description
0	Enum	DA/RA Setting (see Section 11.8)

Response Data Bytes

Byte	Format	Description
0	Enum	DA/RA Setting (see Section 11.8)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 38. Command #164 Specification Format

10.24 Command #165: Read Linear/Rotary Setting

Gets the Linear/Rotary Setting.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Linear/Rotary Setting (see Section 11.9)

Command-Specific Response Codes

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

Figure 39. Command #165 Specification Format

10.25 Command #166: Write Linear/Rotary Setting

Set the Linear/Rotary Setting.

Request Data Bytes

Byte	Format	Description
0	Enum	Linear/Rotary Setting (see Section 11.9)

Response Data Bytes

Byte	Format	Description
0	Enum	Linear/Rotary Setting (see Section 11.9)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 40. Command #166 Specification Format

10.26 Command #167: Read Single/Double Setting

Gets the Single/Double Setting.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Single/Double Setting (see Section 11.10)

Command-Specific Response Codes

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

Figure 41. Command #167 Specification Format

10.27 Command #168: Write Single/Double Setting

Set the Single/Double Setting.

Request Data Bytes

Byte	Format	Description
0	Enum	Single/Double Setting (see Section 11.10)

Response Data Bytes

Byte	Format	Description
0	Enum	Single/Double Setting (see Section 11.10)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 42. Command #168 Specification Format

10.28 Command #169: Read Feed Forward Value

Gets the Feed Forward Value.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8bit	Feed Forward Value
1-2	Unsigned-16bit	Full-stroke time on charge-up
3-4	Unsigned-16bit	Full-stroke time on discharge
5-6	Unsigned-16bit	Motion delay time on charge-up

7-8	Unsigned-16bit	Motion delay time on discharge

Command-Specific Response Codes

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

Figure 43. Command #169 Specification Format

10.29 Command #170: Write Feed Forward Value

Set the Feed Forward Value.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8bit	Feed Forward Value (0-255)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8bit	Feed Forward Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 44. Command #170 Specification Format

10.30 Command #171: Read Torque Min/Max

Gets Torque Min and Max value.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-1	Unsigned-16bit	Torque Max value
2-3	Unsigned-16bit	Torque Min value

Command-Specific Response Codes

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

Figure 45. Command #171 Specification Format

10.31 Command #172: Write Torque Min/Max

Set Torque Min or Max value.

Request Data Bytes

Byte	Format	Description
0	Enum	Torque Min/Max Code (see Section 11.11)
1-2	Unsigned-16bit	Torque value

Response Data Bytes

Byte	Format	Description
0	Enum	Torque Min/Max Code (see Section 11.11)
1-2	Unsigned-16bit	Torque value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Request Data Value is too High
4	Error	Request Data Value is too Low
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 46. Command #172 Specification Format

Each Data's appropriate Range is shown as follows.

Selection	Range
Torque Max value	40 – 480
Torque Min value	30 – 470

10.32 Command #182: Calibrate Input Signal

Set current input signal value as 4mA or 20mA.

Request Data Bytes

Byte	Format	Description
0	Enum	4mA/20mA selection (see Section 11.12)

Response Data Bytes

Byte	Format	Description
0	Enum	4mA/20mA selection (see Section 11.12)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 47. Command #182 Specification Format

10.33 Command #183: Read Input Signal Alarm

Gets the Input Signal Alarm Setting.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Input Signal Max Alarm [mA] or "-10.00mA" specially means "OFF"
4-7	Float	Input Signal Min Alarm [mA] or "-10.00mA" specially means "OFF"

Command-Specific Response Codes

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

Figure 48. Command #183 Specification Format

10.34 Command #184: Write Input Signal Alarm

Set the Input Signal Alarm.

Request Data Bytes

Byte	Format	Description
0-3	Float	Input Signal Max Alarm [mA] or "-10.00mA" specially means "OFF"
4-7	Float	Input Signal Min Alarm [mA] or "-10.00mA" specially means "OFF"

Response Data Bytes

Byte	Format	Description
0-3	Float	Input Signal Max Alarm [mA]
4-7	Float	Input Signal Min Alarm [mA]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8		Undefined
9	Error	Input Signal Min Alarm > 20.00
10	Error	Input Signal Min Alarm < 3.71
11	Error	Input Signal Max Alarm > 22.00

Code	Class	Description
12	Error	Input Signal Max Alarm < 4.00
13-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 49. Command #184 Specification Format

10.35 Command #185: Read Shutdown Cycle Counter

Gets the Shutdown Cycle Counter Value.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Unsigned-32bit	Shutdown Cycle Counter Value

Command-Specific Response Codes

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

Figure 50. Command #185 Specification Format

10.36 Command #186: Reset Shutdown Cycle Counter

Reset the Shutdown Cycle Counter.

Request Data Bytes

Byte	Format	Description
0	Enum	0xfe

Response Data Bytes

Byte	Format	Description
0	Enum	0xfe

Command-Specific Response Codes

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

Code	Class	Description
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 51. Command #186 Specification Format

10.37 Command #187: Read Operating Time

Gets the Operating Time or the setting.

Request Data Bytes

Byte	Format	Description
0	Enum	Operating Time Selection (see Section 11.13)

Response Data Bytes

Byte	Format	Description
0	Enum	Operating Time Selection (see Section 11.13)
1	Unsigned-8bit	Seconds, or 0 for Maintenance Timer
2	Unsigned-8bit	Minutes, or 0 for Maintenance Timer
3	Unsigned-8bit	Hours
4-5	Signed-16bit	Days, or “-1000” specially means “Alarm OFF”

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6-127		Undefined

Figure 52. Command #187 Specification Format

10.38 Command #188: Write Operating Time

Set the Alarm of Operating Time.

Request Data Bytes

Byte	Format	Description
0	Enum	Operating Time Selection (see Section 11.13)
1-2	Signed-16bit	Days

Response Data Bytes

Byte	Format	Description
0	Enum	Operating Time Selection (see Section 11.13)
1-2	Signed-16bit	Days

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Request Data Value is too High
4	Error	Request Data Value is too Low
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 53. Command #188 Specification Format

Each Data's appropriate Range is shown as follows.

Selection	Range
Total Operating Timer	Any value will be error.
Alarm Time for Maintenance	1 – 9999 [day] or "-1000" specially means "OFF"
Maintenance Timer	Only 0xfffe is allowed and does Reset

10.39 Command #189: Read Position Sensor Alarm

Gets the Position Sensor Alarm Setting.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Position Sensor Max Alarm [%] or "-100.0%" specially means "OFF"
4-7	Float	Position Sensor Min Alarm [%] or "-100.0%" specially means "OFF"

Command-Specific Response Codes

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

Figure 54. Command #189 Specification Format

10.40 Command #190: Write Position Sensor Alarm

Set the Position Sensor Alarm.

Request Data Bytes

Byte	Format	Description
0-3	Float	Position Sensor Max Alarm [%] or "-100.0%" specially means "OFF"
4-7	Float	Position Sensor Min Alarm [%] or "-100.0%" specially means "OFF"

Response Data Bytes

Byte	Format	Description
0-3	Float	Position Sensor Max Alarm [%]
4-7	Float	Position Sensor Min Alarm [%]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power

Code	Class	Description
8		Undefined
9	Error	Position Sensor Min Alarm > 100.00
10	Error	Position Sensor Min Alarm < -25.00
11	Error	Position Sensor Max Alarm > 125.00
12	Error	Position Sensor Max Alarm < 0.00
13-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 55. Command #190 Specification Format

10.41 Command #191: Read Stroke Counter

Gets the Stroke Counter or the relevant parameter.

Request Data Bytes

Byte	Format	Description
0	Enum	Counter or Parameter Selection (see Section 11.14)

Response Data Bytes

Byte	Format	Description
0	Enum	Counter or Parameter Selection (see Section 11.14)
Byte 0 = ‘0’ Stroke Counter		
1-4	Unsigned-32bit	Stroke Counter Value
Byte 0 = ‘1’ Minimum Stroke judged to count		
1-4	Float	Minimum Stroke judged to count [%]
Byte 0 = ‘2’ Alarm Setting Count for Maintenance		
1-2	Signed-16bit	Alarm Setting Stroke Count for Maintenance [*1000] or “-1000” specially means “Alarm OFF”
Byte 0 = ‘3’ Maintenance Counter		
1-4	Unsigned-32bit	Maintenance Counter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined

Code	Class	Description
5	Error	Too Few Data Byte Received
6-127		Undefined

Figure 56. Command #191 Specification Format

10.42 Command #192: Write Stroke Counter

Set the Stroke Counter or the relevant parameter.

Request Data Bytes

Byte	Format	Description
0	Enum	Counter or Parameter Selection (see Section 11.14)
Byte 0 = '1' Minimum Stroke judged to count		
1-4	Float	Minimum Stroke judged to count [%]
Byte 0 = '2' Alarm Setting Stroke Count for Maintenance		
1-2	Signed-16bit	Alarm Setting Count for Maintenance [*1000] or "-1000" specially means "OFF"
Byte 0 = '3' Maintenance Counter		
1-4	Unsigned-32bit	0xfffffffe for Maintenance Counter Reset

Response Data Bytes

Byte	Format	Description
0	Enum	Counter or Parameter Selection (see Section 11.14)
Byte 0 = '1' Minimum Stroke judged to count		
1-4	Float	Minimum Stroke judged to count [%]
Byte 0 = '2' Alarm Setting Count for Maintenance		
1-2	Signed-16bit	Alarm Setting Stroke Count for Maintenance [*1000]
Byte 0 = '3' Maintenance Counter		
1-4	Unsigned-32bit	0xfffffffe

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Request Data Value is too High
4	Error	Request Data Value is too Low

Code	Class	Description
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 57. Command #192 Specification Format

Each Data's appropriate Range is shown as follows.

Selection	Range
Stroke Counter	Any value will be error.
Minimum Stroke judged to count	1.0 – 25.0 [%]
Alarm Count for Maintenance	1 – 9999 or "-1000" specially means "OFF"
Maintenance Counter	Only 0xfffffffe is allowed and does Reset

10.43 Command #193: Read Sum of Valve Travel Odometer

Gets the Sum of Valve Travel Odometer or the relevant parameter.

Request Data Bytes

Byte	Format	Description
0	Enum	Odometer or Parameter Selection (see Section 11.15)

Response Data Bytes

Byte	Format	Description
0	Enum	Odometer or Parameter Selection (see Section 11.15)
Byte 0 = '0' Valve Travel Odometer		
1-8	Unsigned-64bit	Valve Travel Odometer Value [mm]
Byte 0 = '1' Alarm Setting Distance for Maintenance		
1-2	Signed-16bit	Alarm Setting Distance for Maintenance Trip-meter [km] or "-1000" specially means "Alarm OFF"
Byte 0 = '2' Minimum Movement judged to increase meter		
1-2	Unsigned-16bit	Minimum Movement judged to increase meter [mm]
Byte 0 = '3' Distance of a Full Stroke		

1-2	Unsigned-16bit	Distance of a Full Stroke of the Valve
Byte 0 = ‘4’ Maintenance Trip-meter		
1-8	Unsigned-64bit	Maintenance Trip-meter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6-127		Undefined

Figure 58. Command #193 Specification Format

10.44 Command #194: Write Sum of Valve Travel Odometer

Set the Sum of Valve Travel Odometer or the relevant parameter.

Request Data Bytes

Byte	Format	Description
0	Enum	Odometer or Parameter Selection (see Section 11.15)
Byte 0 = ‘1’ Alarm Setting Distance for Maintenance		
1-2	Signed-16bit	Alarm Setting Distance for Maintenance Trip-meter [km]
Byte 0 = ‘2’ Minimum Movement judged to increase meter		
1-2	Unsigned-16bit	Minimum Movement judged to increase meter [mm]
Byte 0 = ‘3’ Distance of a Full Stroke		
1-2	Unsigned-16bit	Distance of a Full Stroke of the Valve
Byte 0 = ‘4’ Maintenance Trip-meter		
1-8	Unsigned-64bit	Maintenance Trip-meter Value

Response Data Bytes

Byte	Format	Description
0	Enum	Odometer or Parameter Selection (see Section 11.15)
Byte 0 = ‘1’ Alarm Setting Distance for Maintenance		
1-2	Signed-16bit	Alarm Setting Distance for Maintenance Trip-meter [km]
Byte 0 = ‘2’ Minimum Movement judged to increase meter		
1-2	Unsigned-16bit	Minimum Movement judged to increase meter [mm]

Byte 0 = ‘3’ Distance of a Full Stroke		
1-2	Unsigned-16bit	Distance of a Full Stroke of the Valve
Byte 0 = ‘4’ Maintenance Trip-meter		
1-8	Unsigned-64bit	Maintenance Trip-meter Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Request Data Value is too High
4	Error	Request Data Value is too Low
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 59. Command #194 Specification Format

Each Data’s appropriate Range is shown as follows.

Selection	Range
Valve Travel Odometer	Any value will be error.
Alarm Distance for Maintenance	1 – 9999 or “-1000” specially means “OFF”
Minimum Movement judged to increase	1 – 100
Distance of a Full Stroke	5 – 999
Maintenance Trip-meter	Only 0xfffffffffffffffe is allowed and does Reset

10.45 Command #195: Read PST

Gets the PST (automatic partial stroke) Setting.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-1	Signed-16bit	PST Interval Hours , or “-1000” specially means “OFF”
2-5	Float	PST Offset Value [%]
6-7	Unsigned-16bit	PST Offset Keeping Duration [sec]
8-9	Unsigned-16bit	PST execution monitor

Command-Specific Response Codes

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

Figure 60. Command #195 Specification Format

10.46 Command #196: Write PST

Set the PST (automatic partial stroke) or the relevant parameter.

Request Data Bytes

Byte	Format	Description
0	Enum	PST or Parameter Selection (see Section 11.16)
Byte 0 = ‘0’ Interval Hours		
1-2	Signed-16bit	PST Interval Hours
Byte 0 = ‘1’ Offset Value		
1-4	Float	PST Offset Value [%]
Byte 0 = ‘2’ Offset Keeping Duration		
1-2	Unsigned-16bit	PST Offset Keeping Duration [sec]

Response Data Bytes

Byte	Format	Description
0	Enum	PST or Parameter Selection (see Section 11.16)
Byte 0 = ‘0’ Interval Hours		
1-2	Signed-16bit	Interval Hours
Byte 0 = ‘1’ Offset Value		
1-4	Float	Offset Value [%]
Byte 0 = ‘2’ Offset Keeping Duration		
1-2	Unsigned-16bit	Offset Keeping Duration [sec]

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3	Error	Request Data Value is too High
4	Error	Request Data Value is too Low
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 61. Command #196 Specification Format

Each Data's appropriate Range is shown as follows.

Selection	Range
PST Interval Hours	1 – 9999 [hour] or "-1000" specially means "OFF"
PST Offset Value	-10.0 – 10.0 [%]
PST Offset Keeping Duration	1 – 1800 [sec]

10.47 Command #197: Read Temperature Unit on LCD

Gets the Temperature Unit on LCD.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Enum	Temperature Unit on LCD (see Section 11.17)

Command-Specific Response Codes

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

Figure 62. Command #197 Specification Format

10.48 Command #198: Write Temperature Unit on LCD

Set the Temperature Unit on LCD.

Request Data Bytes

Byte	Format	Description
0	Enum	Temperature Unit on LCD (see Section 11.17)

Response Data Bytes

Byte	Format	Description
0	Enum	Temperature Unit on LCD (see Section 11.17)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Request Data Code is Wrong
3-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8-15		Undefined
16	Error	Manual operation is in active
17-127		Undefined

Figure 63. Command #198 Specification Format

10.49 Command #199: Read Temperature Alarm

Gets the Temperature Alarm.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0-3	Float	Statistical Maximum Temperature [Unit is the same as LCD]
4-7	Float	Statistical Minimum Temperature [Unit is the same as LCD]

8-11	Float	Maximum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”
12-15	Float	Minimum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”

Command-Specific Response Codes

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

Figure 64. Command #199 Specification Format

10.50 Command #200: Write Temperature Alarm

Set the Temperature Alarm.

Request Data Bytes

Byte	Format	Description
8-11	Float	Maximum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”
12-15	Float	Minimum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”

Response Data Bytes

Byte	Format	Description
8-11	Float	Maximum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”
12-15	Float	Minimum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too Few Data Byte Received
6		Undefined
7	Error	EEPROM disabled because of low loop-power
8		Undefined
9	Error	Minimum Alarm Temperature > 0.0 degC or 32.0 degF
10	Error	Minimum Alarm Temperature < -40.0 degC or -40.0 degF
11	Error	Maximum Alarm Temperature > 80.0 degC or 176.0 degF

Code	Class	Description
12	Error	Maximum Alarm Temperature < 40.0 degC or 104.0 degF
13-15		Undefined
16	Error	Manual operation is in active
11-127		Undefined

Figure 65. Command #200 Specification Format

11. TABLES

11.1 Distribution Map Codes

0	Reserved (Don't Use)
1	Temperature Distribution Map

Figure 66. Distribution Map

11.2 Auto-tuning Level

0	Do All (Level 1, 2 and 3)
1	Do Level 1 only
2	Do Level 2 only
3	Do Level 3 only
4	Do Self-test pattern
5	Stop self motion

Figure 67. Auto-tuning Level

11.3 Display Mode

0	Input [mA]
1	Input [%]
2	Position [mA]
3	Position [%]
4	Temperature
0xFE	ESC mode

Figure 68. Display Mode

11.4 Zero/Span Selection Code

0	Zero
1	Span

Figure 69. Zero/Span Selection Code

11.5 Position Sensor Direction Code

0	CW
1	CCW

Figure 70. Position Sensor Direction Code

11.6 PID Parameter Selection Code

0	P-Gain
1	I-Gain
2	Reserved (Don't Use)
3	D-Gain
4	Reserved (Don't Use)
5	TF-Time

Figure 71. PID Parameter Selection Code

11.7 Characteristic Map Type Code

0	Linear
1	EQ%
2	Quick Open
3	User Defined Map

Figure 72. Characteristic Map Type

11.8 DA/RA Code

0	DA
1	RA

Figure 73. DA/RA Code

11.9 Linear/Rotary Code

0	Linear (tan lever)
1	Rotary (1:1)
2	Linear (sin lever)

Figure 74. Linear/Rotary Code

11.10 Single/Double Code

0	Single
1	Double

Figure 75. Single/Double Code

11.11 Torque Min/Max Code

0	Torque Max
1	Torque Min

Figure 76. Torque Min/Max Code

11.12 4mA/20mA Selection Code

0	4 mA
1	20 mA

Figure 77. 4mA/20mA Selection Code

11.13 Operating Time Selection Code

0	Total Operating Timer (Unable to Reset)
1	Alarm Setting Time for Maintenance
2	Maintenance Timer

Figure 78. Operating Time Selection

11.14 Stroke Counter or Parameter Selection Code

0	Stroke Counter (Unable to Reset)
1	Minimum Stroke judged to count
2	Alarm Setting Count for Maintenance
3	Maintenance Counter

Figure 79. Stroke Counter or Parameter

11.15 Sum of Valve Travel Odometer or Parameter Selection Code

0	Valve Travel Odometer (Unable to Reset)
1	Alarm Setting Distance for Maintenance
2	Minimum Movement judged to increase meter
3	Distance of a Full Stroke
4	Maintenance Trip-meter

Figure 80. Sum of Valve Travel Odometer or Parameter

11.16 PST Parameter Selection Code

0	PST Interval Hours
1	PST Offset Value
2	PST Offset Keeping Duration

Figure 81. PST Parameter

11.17 Temperature Unit on LCD Selection Code

0	Celsius
1	Fahrenheit

Figure 82. Temperature Unit on LCD

12. PERFORMANCE

12.1 Sampling Rates

Typical sampling rates are shown in the following table.

AD conversion and PID calculation task	50 per second
Key scan task	50 per second
LCD display update task	2 per second
HART waiting task	250 per second

12.2 Power-Up

This device doesn't have any special reason of start-up delay. It should become fully active in less than one second after the input current reaches 4.0 mA.

12.3 Reset

Command 42 ("Device Reset") causes the device to reset its microprocessor. The resulting restart is identical to the normal power up sequence.

12.4 Self-Test

All of the self-test items are always being executed with normal periodical tasks.

- In case if a code execution malfunction occurs, it will be identified by the absence of proper HART communication.
- In case if 4-20 mA input (power source) is too low, it is judged by the normal periodic task, but it will be identified by the absence of proper HART communication.
- In case if the built-in sensor fails, it is judged by the normal periodic task, and is informed as Device Status bit of HART communication.
- In case if the pneumatic output fails, the valve position will be uncontrollable. However, there are many possible reasons why the valve position is uncontrolled, such as the air supply or valve actuator failure, and the true cause of failure cannot be determined by self-test, so a human investigation is required.

Command 41 ("self-test") is implemented for future use. Currently it does only set Device Status Bit 4 (More Status).

12.5 Command Response Times

Throughout whole commands including device-specific commands, there is no reason to spend milliseconds time of preparation before starting to transmit response message. (see Section 12.8)

12.6 Busy and Delayed-Response

Busy and Delayed-Response are not used.

12.7 Long Messages

In Universal and Common Practice commands, the largest data field is used in the response to Command #21. The size is 34 bytes including the two status bytes.
In Device-specific commands, the largest data field is used in the response to Command #159 and #160. The size is 70 bytes including the two status bytes.

12.8 Non-Volatile Memory

External EEPROM chip is used to hold the device's configuration parameters. The microprocessor accesses the chip via UART (serial). The copy of whole EEPROM data is always ready to read from the internal RAM. New data is written to the EEPROM chip via UART at the event after the RAM updated.
Almost all HART 'write' commands update EEPROM, and it needs to spend time of UART access, but such updating jobs are executed as different task from the HART response message transmitting task in order not to delay the response.
In case if input is less than 4 mA, EEPROM update is disabled because loop-power is not enough.

12.9 Modes

No mode is implemented.

12.10 Write Protection

Write protection is not done against HART communication related procedures in this device.

ANNEX A. CAPABILITY CHECKLIST

Manufacturer, model and revision	3S, MP100, rev. 2 (MP100, MP160, MP300, MP340)
Device type	Actuator
HART revision	7
Device Description available	Yes
Number and type of sensors	3 internal: current, angle, temperature
Number and type of actuators	2 internal: pneumatic
Number and type of host side signals	1: 4 - 20mA analog actuator
Number of Device Variables	4
Number of Dynamic Variables	4
Mappable Dynamic Variables?	No
Number of common-practice commands	9
Number of device-specific commands	53
Bits of additional device status	35
Alternative operating modes?	No
Burst mode?	No
Write-protection?	No

ANNEX B. DEFAULT CONFIGURATION

Parameter	Default value
Distribution Rate of < -20.0 degC [%]	0.0
Distribution Rate of -20.0 – 0.0 degC [%]	0.0
Distribution Rate of 0.0 – 20.0 degC [%]	0.0
Distribution Rate of 20.0 – 40.0 degC [%]	0.0
Distribution Rate of 40.0 – 60.0 degC [%]	0.0
Distribution Rate of > 60.0 degC [%]	0.0
Display Mode (see Section 11.3)	0
Split Range Span [mA]	20.00
Split Range Zero [mA]	4.00
CW or CCW (see Section 11.4)	0
P-Gain	0.2
I-Gain	0.1
D-Gain	10.0
TF-Time [ms] or “-100.0” specially means “OFF”	2.0
Threshold of Forced Full Opening [%] or “-100.0” specially means “OFF”	OFF (-100.0)
Threshold of Forced Full Closing [%] or “-100.0” specially means “OFF”	0.5
Characteristic Map Type (see Section 11.7)	0
User Defined Characteristic Map at 0.00% Input	0.00
User Defined Characteristic Map at 6.25% Input	6.25
User Defined Characteristic Map at 12.50% Input	12.50
User Defined Characteristic Map at 18.75% Input	18.75
User Defined Characteristic Map at 25.00% Input	25.00
User Defined Characteristic Map at 31.25% Input	31.25
User Defined Characteristic Map at 37.50% Input	37.50

User Defined Characteristic Map at 43.75% Input	43.75
User Defined Characteristic Map at 50.00% Input	50.00
User Defined Characteristic Map at 56.25% Input	56.25
User Defined Characteristic Map at 62.50% Input	62.50
User Defined Characteristic Map at 68.75% Input	68.75
User Defined Characteristic Map at 75.00% Input	75.00
User Defined Characteristic Map at 81.25% Input	81.25
User Defined Characteristic Map at 87.50% Input	87.50
User Defined Characteristic Map at 93.75% Input	93.75
User Defined Characteristic Map at 100.00% Input	100.00
Dead-band Width [%]	0.20
DA/RA Setting (see Section 11.8)	1
Linear/Rotary Setting (see Section 11.9)	0
Single/Double Setting (see Section 11.10)	0
Feed Forward Value (0-255)	100
Torque Max value	269
Torque Min value	243
Input Signal Max Alarm [mA] or “-10.00mA” specially means “OFF”	OFF (-10.00)
Input Signal Min Alarm [mA] or “-10.00mA” specially means “OFF”	OFF (-10.00)
Alarm Time for Maintenance or “-1000” specially means “OFF”	OFF (-1000)
Position Sensor Max Alarm [%] or “-100.0%” specially means “OFF”	OFF (-100.0)
Position Sensor Min Alarm [%] or “-100.0%” specially means “OFF”	OFF (-100.0)
Minimum Stroke judged to count [%]	5.0
Alarm Setting Stroke Count for Maintenance [*1000] or “-1000” specially means “OFF”	OFF (-1000)

Alarm Setting Distance for Maintenance Trip-meter [km] or “-1000” specially means “Alarm OFF”	OFF (-1000)
Minimum Movement judged to increase meter [mm]	2
Distance of a Full Stroke of the Valve	20
PST Interval Hours , or “-1000” specially means “OFF”	OFF (-1000)
PST Offset Value [%]	5.0
PST Offset Keeping Duration [sec]	10
Temperature Unit on LCD (see Section 11.17)	0
Maximum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”	OFF (-100.0)
Minimum Alarm Temperature [Unit is the same as LCD] , or “-100.0” specially means “OFF”	OFF (-100.0)
Calibration Value of 4mA side (-500 – 500)	0
Calibration Value of 20mA side (-500 – 500)	0

ANNEX C. REVISION HISTORY

R 2.0: - Correction of typographical errors and improvement of difficult-to-understand text.
- Add undocumented commands #59, #76, #95 and #132
- Revise description at command #147, #148, #151, #154, #169, #195, Figure 67, 68, 74.
- Remove unimplemented command #201-204.

R 1.0: Original revision.