

Communication Protocol Specification

UAM-05LP



Revision History

Symbol	Revision Detail	Rev. Page	Rev. Date	Drafted	DWG. No
-	First release (2015-10-06)	-	-	-	-
1	Modifications of AR, VR command specification	7 – 9	2015.12.3	Santosh	RS-00666
	Modification of status codes	10			
	Modification of SCIP compatible commands	11, 15 - 17			
2	Continuous data output commands (AR, MD and ME) added.	10, 11, 20	2016.03.02	Santosh	RS-00702
	SCIP commands (QT, RS and RT) added.	23			
	Grammar Correction	All			
3	Notes related to scan skip function added	6, 16	2016.12.27	Santosh	RS-00844
	Laser off status added in AR commands	8			
	Status Command Added	12			
	Area Command and status details added	13, 14			
4	Warning message added	4	2017.06.29	Santosh	RS-00959
	New parameter added in sensing commands and status command	9, 14			
	Detection log commands added	15-17			
5	Notes related to firmware version modified	4	2018.04.06	Santosh	RS-01059
	Notes related to scan skip function modified	7			
	New commands (AR06, AR07, AR08) added	8,9, 14, 15			
	Unified the word “byte” in detection log commands to “char” as in other commands	17			
	Information related to step number is added and detection log time stamp unit is corrected in DL command.	18			
6	Notes related to firmware version modified	4	2020.02.18	Santosh	RS-01406
	Serial number size modified in VR command	9			
	Encoder input pattern number added in AR and XR commands.	9, 12, 13, 14, 15, 17			
	Max area number is changed to 128 in AR and YR command details table	10, 18			
	Information regarding start and end steps in YR command is added for 32, 64 and 128 areas	18			
	New ID command added	21			
	Details added	4			



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1. Introduction

This document describes the communication protocol specification for the safety laser scanner, UAM-05LP (henceforth UAM).

Communication protocol is a predefined format of ASCII strings used for data transmission between host computer and UAM referred as, "Command" and "Reply". Commands are sent from the host computer to UAM which will then reply with the data corresponding to the type of command. Protocol should be strictly followed in order to obtain the appropriate data. Set of such commands and their responses are explained in this document.

This specification is compatible with firmware version 2.4.0 (and later) of UAM. 1, 2, 3, 4, 5, 6.

Note:

- This specification is intended for the developers who have sufficient knowledge on the product and software programming.
- Read this document carefully before programming the communication software.
- Read user's manual of UAM before programming the communication software.

Danger!

- Sending commands other than those specified in this document can permanently damage the UAM.
- Sending commands other than those specified in this document can lead to unintended performance of UAM causing critical injury or death.
- Sending commands in sequence other than those specified in this document can lead to unintended performance of UAM causing critical injury or death.
- Data integrity (size, CRC, status etc.) shall be sufficiently checked before using the data for the intended purpose.
- Data obtained through communication should not be used for controlling the safety device.
- Verification shall be done to ensure that the data output does not hamper the safety operation of either UAM or the controlled device.
- Do not perform Ethernet and USB communication simultaneously. If Ethernet is connected, stop the Ethernet transmission when configuring the UAM with USB device or SD card. 4.
- As a measure to avoid the effect of electric noise, UAM resets the Ethernet PHY every 10 seconds when it is not connected to the host. Connection fails to establish during the reset process. Therefore, try to connect multiple times with the sufficient timeout when connecting with the UAM. 6.
- When UAM detects error, it saves the information in the ROM. During this period communication may stop briefly. Therefore, try to connect multiple times with the sufficient



timeout when connecting with the UAM. 6.

2. Abbreviations and Descriptions

CRC: Cyclic Redundancy Check

STX: Start of Text

ETX: End of Text

OSSD: Output Signal Switching Device



3. Communication Format

General communication format and terms used in it are explained below.

Command

Host » UAM

STX 1 char	Command Size 4 char	Header 2 char	Sub Header 2 chars	CRC 4 char	ETX 1 char
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Reply

Host « UAM

STX 1 char	Reply Size 4 char	Header 2 char	Sub Header 2 chars	Data* N char	Status 2 char	CRC 4 char	ETX 1 char
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*Some of the replies may not contain this field.

Command:

It is the data transmitted from the host computer to UAM. It is enclosed between STX and ETX and contains Command Size, Header, Sub-Header and CRC.

Command Size:

It is the total length of ASCII characters in a command. Command size is encoded to hexadecimal strings (refer to section 4).

Header:

It is a unique code to differentiate the type of command.

Sub-Header:

It is an additional parameter to differentiate the same command having multiple replies.

CRC:

It is a 16-Bit code for checking the data integrity. Command size, header, sub-header and data are included in CRC calculation (refer to section 5). CRC is encoded to hexadecimal strings (refer to section 4)

Reply:

It is the data transmitted from UAM to host computer upon receiving a command. It is enclosed between STX and ETX and contains Reply size, Header, Sub-Header, Data, Status and CRC. Reply is unique for each command.

Reply Size:

It is the total length of ASCII characters in a reply. Reply size is encoded to hexadecimal strings (refer to section 4).

Data:

Data is UAM's internal state and/or measurement values. It is encoded in ASCII strings and transmitted from UAM. Some of the replies may not contain the data.

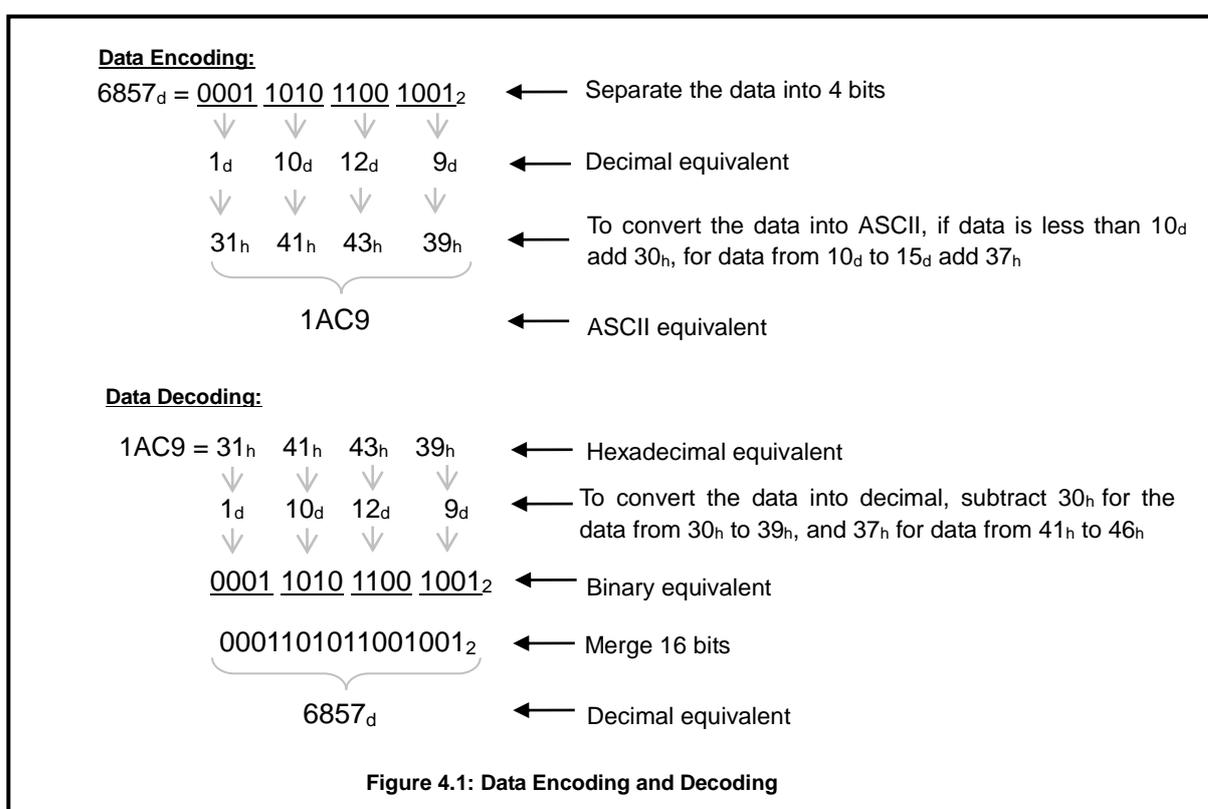
Status:



It is a code to inform the success or failure of the command execution. Status other than “00” is error code. Refer to section 7 for details.

4. Data Encoding and Decoding

Data encoding is applied in the communication protocol. Host computer should convert all the numerical values into ASCII characters before transmitting them to UAM. For encoding, the data should be first divided into 4 bits, and then depending on its value, either 30_h or 37_h is added to convert into ASCII characters (Figure 4.1). Values received from UAM are also in the same format therefore, program on the host computer should decode it before using. Decoding is exactly the opposite of encoding process where, depending on the value of each received ASCII characters, either 30_h or 37_h is subtracted and merged to generate the original value.



5. CRC Calculation

CRC is a 16 bit code to check the data integrity at the receiving end. It serves as a mean to detect corruption or loss during transmission that may occur due noise in the communication channel. When UAM receives data from the host computer, it recalculates the CRC and compares it with the CRC value in the command. UAM will reply with the requested data only if both CRCs match otherwise, it will reply with an error code in the status. Data integrity check should be also applied on the host computer before using the received data. Discard the data if verification fails data and try again by resending the command.

CRC is calculated using the polynomial $X^{16} + X^{12} + X^5 + 1$. CRC value is encoded into 4 ASCII

characters (see section 4) before the transmission. STX and ETX are not included when calculating the CRC value.

CRC Standard: Kermit
Polynomial: 0x1021
Shift Direction: Right
Initial Value: 0x0000
Byte Swap: Yes
Reverse CRC Result: Yes

CRC Example:

Data → "000EVR00" : 0x3492 ← CRC

6. Commands

Commands recognized by UAM are described in this section. UAM will respond with the corresponding data when it receives these commands. Format should be strictly followed in order to obtain the appropriate data. UAM will reply with error status (refer to section 7) if length, CRC or header string validation fails.

UAM performs communication routine once in every sensing cycle (one sensing cycle of UAM is 29 to 30ms) and sends the reply to any command received during this period. Therefore, if commands are not received completely in once cycle it will take another cycle to send the reply. Further, reply can be delayed depending on the communication speed of the host system. Allow sufficient timeout period by considering all possible delays that can occur in the system before resending the command when reply is not received from UAM. Avoid continuously sending the commands to UAM without waiting for the reply. It will affect the performance and becomes a cause of error.

Some of the commands can set UAM to supply the measurement data continuously. When UAM is in continuous transmission mode, it will supply the data at every 30ms (approx.). Continuous mode can be terminated by sending the appropriate stop commands. In continuous transmission mode, avoid sending additional commands to acquire the same data. However, commands to request other information such as, sensor version can be sent to UAM.

Important Note:

When the scan skip function is active, device will reply only during the measurement cycles. For example, if the scan skip function is configured as 2, reply of AR02, AR04 and AR07 (refer to sections 6.2.3, 6.2.4, 6.2.8) commands will be provided at every 90msec. However, if the device is in the error state, the reply will be sent at every cycle. In such case, the values of measurement data when the sensor is skipping the measurement will be 0xFFFE. Further, scan skip function is temporarily suspended when the device is in setting mode and the communication cycle is 30msec.



6.1 Version Details (VR Command)

When UAM receives this command, it replies with its version details. Version details include serial number, firmware version among other information. Data in the version command are not encoded except the length and CRC.

Before acquiring sensing data using AR commands, send the VR command to confirm the connection with intended UAM.

Host » UAM

STX	Length	V	R	0	0	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	V	R	0	0	Status
1 char	4 char	1 char	1 char	1 char	1 char	2 char
Sensor model 29 char		,				
		1 char				
Firmware version 29 char		,				
		1 char				
Reserved 37 char		,				
		1 char				
Serial Number n* char	,		CRC	ETX		
	1 char		4 char	1 char		

*Length of the serial number can be 8 to 16 ascii characters

6.2 Sensing Data (AR Commands)

There are 9 variations of this command differentiated by sub-header. Function of commands will vary depending on it (Table 6.2.1). When UAM receives this command, it replies with its sensing data (Table 6.2.2).

After sending a command to acquire data in continuous transmission mode, avoid sending additional commands to get the same data. However, commands to request other information such as, sensor version, can be sent to UAM even in continuous mode.

UAM will supply the data at every 30ms (approx.) in continuous transmission mode. Even if UAM can not perform the measurement due to internal error or goes to lockout state, it will continue to send the reply but the measurement values are not updated.

Important: Before acquiring sensing data using AR commands, send the VR command to check the serial number for verifying the connection with an intended UAM.



Table 6.2.1: Function of AR Commands Based on Sub-header Parameter

Command	Function
“AR00”	Acquire sensing data with measured distance
“AR01”	Acquire sensing data with measured distance and intensity
“AR02”	Acquire sensing data with measured distance in continuous mode
“AR03”	Stop continuous mode initiated by “AR02”
“AR04”	Acquire sensing data with measured distance and intensity in continuous mode
“AR05”	Stop continuous mode initiated by “AR04”
“AR06”	Acquire sensing data with high resolution measured distance
“AR07”	Acquire sensing data with high resolution measured distance in continuous mode
“AR08”	Stop continuous mode initiated by “AR07”

Table 6.2.2: Details of Sensing Data

Item	Data	Remarks
Operating Mode	0: Normal 1: Setting	OSSDs are always off in setting mode.
Area Number	00 ~ 7F	Offset the number by 1 to match with 7-seg display of UAM
Error State	0: No error 1: Error is detected	Use this information with Error Code to show the error status. Also check the Lockout State.
Error Code	1 ~ BF	Use this information with Error Status to show the error number. Offset the number by 0x40 to match with 7-seg display of UAM. Refer to UAM user’s manual for error details.
Lockout State	0: Normal 1: Lockout	Use this information with Error Code to show the error status. Also check the Error State.
OSSD 1 State	0: Off (No detection) 1: On (Detection)	Always 1 in setting mode
OSSD 2 State	0: Off (No detection) 1: On (Detection)	Always 1 in setting mode
Warning 1 State	0: Off (No detection) 1: On (Detection)	Always 0 when UAM is operating without warning zone1. Always 1 in setting mode when operating with warning zone1.
Warning 2 State	0: Off (No detection) 1: On (Detection)	Always 0 when UAM is operating without warning zone2. Always 1 in setting mode when operating with warning zone2.
OSSD 3 State	0: Off (No detection) 1: On (Detection)	Always 0 when UAM is operating without protection zone2. Always 1 in setting mode when operating with protection zone2.
OSSD 4 State	0: Off (No detection) 1: On (Detection)	Always 0 when UAM is operating without protection zone2. Always 1 in setting mode when operating with protection zone2.
Muting/override State1	0: Not Active 1: Active	Always 0 when UAM is operating without muting function.
Muting/override State2	0: Not active 1: Active	Always 0 when UAM is operating without muting function and/or without protection zone2.
Reset Request1	0: Off 1: On	Always 0 when UAM is operating without interlock1 function.
Reset Request2	0: Off 1: On	Always 0 when UAM is operating without interlock2 function and/or without protection zone2.
Encoder Speed	0~FFFF	Always 0 when UAM is operating without encoder Input function.
Time Stamp	0 ~ FFFFFFFF	Unit is millisecond.
Laser off State	0: Laser is emitted 1: Laser is stopped	Always 0 when operating without Laser off function Always 0 in setting mode
Optical Window contamination warning	0: Off (Not contaminated) 1: On (Contaminated)	Data will be 1 when optical window starts to accumulate dust. Use this information to clean the optical window before it becomes severe leading the device to error state (error 85, b1 ~ c1).
Encoder Input Pattern	0~7	Always 0 when operating without encoder input function.

Number ⑥		
Distance Data	0000 ~ FFFF	1081 Steps data Note: 1. Values more than 40000 are error code (0xFFFF). 2. If object is not detected value will be 65534 (0xFFFE) 3. If object is at a very close range the value will be 65533 (0xFFFD). 4. When the device is in laser off state the value will be 65532 (0xFFFC) ③
Distance Data – High resolution ⑤	0000 ~ FFFF	2161 Steps data Note: 1. Values more than 40000 are error code (0xFFFF). 2. If object is not detected value will be 65534 (0xFFFE) 3. If object is at a very close range the value will be 65533 (0xFFFD). 4. When the device is in laser off state the value will be 65532 (0xFFFC)
Intensity Data	0000 ~ FFFF	1081 Steps data Note: 1. If object is not detected the value will be 0. 2. Do not use the value if distance of the corresponding step has error. 3. When the device is in laser off state the value will be 65532 (0xFFFC) ③

6.2.1 AR00 Command

When UAM receives this command, it provides sensing data with measured distance. Refer to Table 6.2.2 for details on the data.

Host » UAM

STX	Length	A	R	0	0	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	A	R	0	0	Status
1 char	4 char	1 char	1 char	1 char	1 char	2 char
Operating Mode		Area Number		Error State	Error Code	Lockout State
1 char		2 char		1 char	2 char	1 char
OSSD 1 State	OSSD 2 State		Warning 1 State		Warning 2 State	
1 char	1 char		1 char		1 char	
OSSD 3 State	OSSD 4 State		Reserved (0)		Reserved (0)	
1 char	1 char		1 char		1 char	
Muting/Override State 1			Muting/Override State 2			
1 char			1 char			
Reset Request 1		Reset Request 2		Encoder Speed		
1 char		1 char		4 char		
Time Stamp		Laser off Status		Optical Window Contamination Warning		Encoder Input Pattern Number
8 char		1 char		1 char		1 char
Distance Data		CRC	ETX		Reserved (0)	
4324 char		4 char	1 char		5 char	

6.2.2 AR01 Command

When UAM receives this command, it provides sensing data with measured distance and intensity. Refer to Table 6.2.2 for details on the data.

Host » UAM

STX	Length	A	R	0	1	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	A	R	0	1	Status
1 char	4 char	1 char	1 char	1 char	1 char	2 char
Operating Mode		Area Number		Error State	Error Code	Lockout State
1 char		2 char		1 char	2 char	1 char
OSSD 1 State	OSSD 2 State		Warning 1 State		Warning 2 State	
1 char	1 char		1 char		1 char	
OSSD 3 State	OSSD 4 State		Reserved (0)		Reserved (0)	
1 char	1 char		1 char		1 char	
Muting/Override State 1			Muting/Override State 2			
1 char			1 char			
Reset Request 1		Reset Request 2		Encoder Speed		
1 char		1 char		4 char		



Time Stamp 8 char	Laser off Status 1 char	Optical window Contamination Warning 1 char		Encoder Input Pattern Number 1 char	Reserved (0) 5 char
Distance Data 4324 char	Intensity Data 4324 char	CRC 4 char	ETX 1 char		

6.2.3 AR02 Command

When UAM receives this command, it provides sensing data with measured distance in continuous mode. Data is supplied at every 30ms (approx.) after completing the scan. Send “AR03 Command” (refer to section 6.2.4) to stop the continuous data output.

Host » UAM

STX 1 char	Length 4 char	A 1 char	R 1 char	0 1 char	2 1 char	CRC 4 char	ETX 1 char
---------------	------------------	-------------	-------------	-------------	-------------	---------------	---------------

Host « UAM

*First response of UAM (contains only the status without any data)

STX 1 char	Length 4 char	A 1 char	R 1 char	0 1 char	2 1 char	Status 2 char	CRC 4 char	ETX 1 char
---------------	------------------	-------------	-------------	-------------	-------------	------------------	---------------	---------------

* Scan data response of UAM (provides the same data as in “AR00 command” (refer to section 6.2.1) with continuous mode)

STX 1 char	Length 4 char	A 1 char	R 1 char	0 1 char	2 1 char	Status 2 char		
Operating Mode 1 char		Area Number 2 char		Error State 1 char		Error Code 2 char		Lockout State 1 char
OSSD 1 State 1 char		OSSD 2 State 1 char		Warning 1 State 1 char		Warning 2 State 1 char		
OSSD 3 State 1 char		OSSD 4 State 1 char		Reserved (0) 1 char		Reserved (0) 1 char		
Muting/Override State 1 1 char			Muting/Override State 2 1 char					
Reset Request 1 1 char		Reset Request 2 1 char		Encoder Speed 4 char				
Time Stamp 8 char	Laser off Status 1 char	Optical Window Contamination Warning 1 char		Encoder Input Pattern Number 1 char	Reserved (0) 5 char			
Distance Data 4324 char	CRC 4 char	ETX 1 char						

6.2.4 AR03 Command

UAM stops the continuous data output initiated by “AR02 Command” (refer to section 6.2.3) on receiving this command.

Host » UAM

STX	Length	A	R	0	3	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	A	R	0	3	Status	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	2 char	4 char	1 char

6.2.5 AR04 Command

When UAM receives this command, it provides sensing data with measured distance and intensity in continuous mode. Data is supplied at every 30ms (approx.) after completing the scan. Send “AR04 Command” (refer to section 6.2.6) to stop the continuous data output.

Host » UAM

STX	Length	A	R	0	4	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

*First response of UAM (contains only the status without any data)

STX	Length	A	R	0	4	Status	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	2 char	4 char	1 char

* Scan data response of UAM (provides the same data as in “AR01 command” (refer to section 6.2.2) with continuous mode)

STX	Length	A	R	0	4	Status			
1 char	4 char	1 char	1 char	1 char	1 char	2 char			
Operating Mode		Area Number		Error State		Error Code		Lockout State	
1 char		2 char		1 char		2 char		1 char	
OSSD 1 State		OSSD 2 State		Warning 1 State		Warning 2 State			
1 char		1 char		1 char		1 char			
OSSD 3 State		OSSD 4 State		Reserved (0)		Reserved (0)			
1 char		1 char		1 char		1 char			
Muting/Override State 1			Muting/Override State 2						
1 char			1 char						
Reset Request 1		Reset Request 2		Encoder Speed					
1 char		1 char		4 char					
Time Stamp		Laser off Status		Optical window Contamination Warning		Encoder Input Pattern Number		Reserved (0)	
8 char		1 char		1 char		1 char		5 char	
Distance Data		Intensity Data		CRC		ETX			
4324 char		4324 char		4 char		1 char			



6.2.6 AR05 Command

UAM stops the continuous data output initiated by “AR04 Command” (refer to section 6.2.5) on receiving this command.

Host » UAM

STX	Length	A	R	0	5	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	A	R	0	5	Status	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	2 char	4 char	1 char

6.2.7 AR06 Command

When UAM receives this command, it provides sensing data with high resolution measured distance. Refer to Table 6.2.2 for details on the data.

Host » UAM

STX	Length	A	R	0	6	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	A	R	0	6	Status
1 char	4 char	1 char	1 char	1 char	1 char	2 char
Operating Mode	Area Number	Error Status	Error Code	Lockout Status		
1 char	2 char	1 char	2 char	1 char		
OSSD 1 State	OSSD 2 State	Warning 1 State	Warning 2 State			
1 char	1 char	1 char	1 char			
OSSD 3 State	OSSD 4 State	Reserved (0)	Reserved (0)			
1 char	1 char	1 char	1 char			
Muting/Override State 1	Muting/Override State 2					
1 char	1 char					
Reset Request 1	Reset Request 2	Encoder Speed				
1 char	1 char	4 char				
Time Stamp	Laser off Status	Optical window contamination warning	Encoder Input Pattern Number	Reserved (0)		
8 char	1 char	1 char	1 char	5 char		
Distance Data – High Resolution	CRC	ETX				
8644 char	4 char	1 char				

6.2.8 AR07 Command

When UAM receives this command, it provides sensing data with high definition measured distance in continuous mode. Data is supplied at every 30ms (approx.) after completing the scan. Send “AR08 Command” (refer to section 6.2.6) to stop the continuous data output.

Host » UAM

STX	Length	A	R	0	7	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

*First response of UAM (contains only the status without any data)

STX	Length	A	R	0	7	Status	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	2 char	4 char	1 char

* Scan data response of UAM (provides the same data as in "AR06 command" (refer to section 6.2.2) with continuous mode)

STX	Length	A	R	0	7	Status			
1 char	4 char	1 char	1 char	1 char	1 char	2 char			
Operating Mode		Area Number		Error Status		Error Code		Lockout Status	
1 char		2 char		1 char		2 char		1 char	
OSSD 1 State		OSSD 2 State		Warning 1 State		Warning 2 State			
1 char		1 char		1 char		1 char			
OSSD 3 State		OSSD 4 State		Reserved (0)		Reserved (0)			
1 char		1 char		1 char		1 char			
Muting/Override State 1			Muting/Override State 2						
1 char			1 char						
Reset Request 1		Reset Request 2		Encoder Speed					
1 char		1 char		4 char					
Time Stamp		Laser off Status		Optical window contamination warning		Encoder Input Pattern Number		Reserved (0)	
8 char		1 char		1 char		1 char		5 char	
Distance Data – High resolution				CRC		ETX			
8644 char				4 char		1 char			

6.2.9 AR08 Command

UAM stops the continuous data output initiated by "AR07 Command" (refer to section 6.2.5) on receiving this command.

Host » UAM

STX	Length	A	R	0	8	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	A	R	0	8	Status	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	2 char	4 char	1 char

6.3 Status Data (XR Commands)

When UAM receives this command, it provides the status data. Refer to Table 6.2.2 for details on the data.

Host » UAM

STX	Length	X	R	0	0	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	X	R	0	0	Status
1 char	4 char	1 char	1 char	1 char	1 char	2 char
Operating Mode	Area Number	Error State	Error Code	Lockout Status		
1 char	2 char	1 char	2 char	1 char		
OSSD 1 State	OSSD 2 State	Warning 1 State	Warning 2 State			
1 char	1 char	1 char	1 char			
OSSD 3 State	OSSD 4 State	Reserved (0)	Reserved (0)			
1 char	1 char	1 char	1 char			
Muting/Override State 1	Muting/Override State 2					
1 char	1 char					
Reset Request 1	Reset Request 2	Encoder Speed	Laser Off State			
1 char	1 char	4 char	1 char			
Slave1 OSSD1,2 State	Slave2 OSSD1,2 State	Slave3 OSSD1,2 State				
1 char	1 char	1 char				
Slave1 OSSD3,4 State	Slave2 OSSD3,4 State	Slave3 OSSD3,4 State				
1 char	1 char	1 char				
Slave1 Warning1 State	Slave2 Warning1 State	Slave3 Warning1 State				
1 char	1 char	1 char				
Slave1 Warning2 State	Slave2 Warning2 State	Slave3 Warning2 State				
1 char	1 char	1 char				
Slave1 Error State	Slave2 Error State	Slave3 Error State				
1 char	1 char	1 char				
Slave1 Laser Off State	Slave2 Laser Off State	Slave3 Laser Off State				
1 char	1 char	1 char				
Time Stamp	Optical window contamination Warning	Encoder Input Pattern Number	Reserved	CRC	ETX	
8 char	1 char	1 char	38 char	4 char	1 char	

Note:

- Slave status data are obtained only when the device is configured to operate in master-slave mode
- When the command is transmitted to master device, status of the master will be provided on the first part of the reply followed by the status of the slaves in the second part.
- When the command is transmitted to slave device, its own status will be provided on the first part of the reply and second part will be all 0.

6.4 Area Data (YR Commands)

When UAM receives this command, it provides the area configuration data. Refer to Table 6.4.1 for details on the parameters to be provided on the command. Parameters should be sent in the hexadecimal equivalent characters. Status codes for YR command are shown in Table 7.2.



Table 6.4.1 Parameter details in YR command

Parameter	Size	Details	Note
Area type	2	00: Protection Zone 1 01: Protection Zone 2 02: Warning Zone 1 03: Warning Zone 2 04: Muting Area 1 05: Muting Area 2 06: Reference Area (Centre) 07: Reference Area (Max value) 08: Reference Area (Min Value)	- Device should be configured with the corresponding function to obtain the correct data.
Area Number	2	00: Area 1 01: Area 2 7F: Area 128 ⁶	- Provide the area numbers in hexadecimal equivalent characters (0 to 7F). ⁶ - Area number should not exceed the configured active area count
Start Step	4	0000: Step 1 0001: Step 2 0438: Step 1081	- Provide the step values in hexadecimal equivalent characters - Step values should not exceed the maximum range 0438 (1081 in decimal). - Start step should not be greater than the end step.
End Step	4	0000: Step 1 0001: Step 2 0438: Step 1081	- Start and End Step of protection and warning areas will change with the active area configuration as follows, Active area up to 32: 0 to 1081 Active area up to 64: 0 to 541 Active area up to 128: 0 to 271 ⁶
Grouping	2	00/01: No grouping 02: Grouping two data 03: Group three data 09: Group nine data	- Parameter 00 and 01 are treated in the same way (no grouping). - Steps with the specified count are treated as one group and a single value is supplied from each group in order to reduce the data volume. - Data with the maximum value in the group is provided when the grouping is more than 2.
Area Data	4	0 ~ 7FFF (15 bit data)	- Uppermost bit of the area data is reserved. If the data exceeds 7FFF, ignore the first bit and only use the remaining 15 bit data.

Host » UAM

STX	Length	Y	R	Area Type	Area Number
1 char	4 char	1 char	1 char	2 char	2 char
Start Step	End Step	Resolution	CRC	ETX	
4 char	4 char	2 char	4 char	1 char	

Host « UAM

STX	Length	Y	R	Area Type	Area Number
1 char	4 char	1 char	1 char	2 char	2 char
Start Step	End Step	Resolution	Status		
4 char	4 char	2 char	2 char		
Area Data	CRC	ETX			
n* char	4 char	1 char			

$$*n = ((\text{End Step} - \text{Start Step}) / \text{Resolution}) \times 4$$

If n is not a whole number, one data (4 char) from the remaining steps will be supplied.



6.5 Detection Log Command

When UAM detects obstacle in the protection area it records the information such as, operating area number, distance and step (position) of the obstacle. If obstacles are present at multiple steps, UAM records the data of the step having the shortest range. In master-slave mode, master unit records the detection log of all the slaves however, slave units don't record the master or other slave's detection information. There are two commands related to detection log function, one to obtain the log and the other to clear it.

6.5.1 Detection Log Read (DL00 Command)

When UAM receives this command, it provides detection log data. UAM stores maximum 29 sets of log information in a ring buffer in its RAM. Contents of the log data is given in Table 6.5.1.1. When log count exceeds 29, old records are overwritten by the new ones in the ring buffer. A set of log data is 64 characters long (Figure 6.5.1.1). Value "FFFF" of the first 4 data, indicates the end position of the ring buffer therefore, ignore the 64 characters in this line. Data above the indicator are new and below it are the old logs. Since the data are stored in the RAM, they are erased whenever the device is switched off.

Table 6.5.1.1: Details of Detection Log

Item	Data	Remarks
Input/Output*1	0 ~ FFFF	Input and output states of the connected device. Bit15 ~ Bit8 represents the operating area number when the log was recorded. Value is from 0x00 to 0x1F which represents area 1 to area 32. Bit1 represents detection state of Protection zone 1. Bit0 represents detection state of Protection zone 2. Note: 1. Value FFFF of this data indicates the end position of the ring buffer therefore, ignore 64 characters in this set. Data above the indicator are new and below it are the old logs (Figure 6.5.1.1). 2. Bit 0 is always 0 when UAM is operating without protection zone2.
Protection1 Min dist	0 ~ FFFF	Minimum distance measured inside the protection zone1.
Protection1 Min dist step	0 ~ FFFF	Position where the minimum distance was detected inside the protection zone1. Note: Data is provided in high resolution (0.125°/step) step number (0 to 2160). Divide the number by 2 to match with lower resolution (0.25°/step) step number (0 to 1080). 
Protection2 Min dist	0 ~ FFFF	Minimum distance measured inside the protection zone2 Note: Always 0 when UAM is operating without protection zone2.
Protection2 Min dist step	0 ~ FFFF	Position where the minimum distance was detected inside the protection zone2. Note: 1. Data is provided in high resolution (0.125°/step) step number (0 to 2160). Divide the number by 2 to match with lower resolution (0.25°/step) step number (0 to 1080).  2. Always 0 when UAM is operating without protection zone2.
Slave1 Input/Output	0 ~ FFFF	If UAM is operating in Master-Slave mode and connected unit is Master, this is an input and output states of Slave unit 1.



		Note: 1. Details are same as input output states (see *1) of connected device. 2. Always 0 when the device is slave unit.
Slave2 Input/Output	0 ~ FFFF	If UAM is operating in Master-Slave mode and connected unit is Master, this is an input and output states Slave unit 2. Note: 1. Details are same as input output states (see *1) of connected device. 2. Always 0 when the device is slave unit.
Slave3 Input/Output	0 ~ FFFF	If UAM is operating in Master-Slave mode and connected unit is Master, this is an input and output states Slave unit 3. Note: 1. Details are same as input output states (see *1) of connected device. 2. Always 0 when the device is slave unit.
Log Lapsed time	0 ~ FFFFFFFF	It is the duration that has lapsed since the data was recorded and the log command was received. Unit is second. For example, if the vale is 0000007A, then the log was recorded 122 seconds ago. $\frac{7}{16}$
Reserved	0 ~ FFFF	Note: Ignore the data.

Host » UAM

STX	Length	D	L	0	0	CRC	ETX
1 char	4 char	1 char	1 char	1 char	1 char	4 char	1 char

Host « UAM

STX	Length	D	L	0	0	Status
1 char	4 char	1 char	1 char	1 char	1 char	2 char
Log Data	CRC	ETX				
1920 char	4 char	1 char				

Log details:

	Input /Output*	Protection1 Min dist.	Protection1 Min dist step	Protection2 Min dist	Protection2 Min dist step
	4 char	4 char	4 char	4 char	4 char
Log1	Slave1 Input /Output*	Reserved	Reserved		
	4 char	4 char	4 char		
	Slave2 Input /Output*	Reserved	Reserved		
	4 char	4 char	4 char		
	Slave3 Input /Output*	Reserved	Reserved	Log lapsed time	
	4 char	4 char	4 char	8 char	
..	..				
	Input /Output	Protection1 Min dist.	Protection1 Min dist step	Protection2 Min dist	Protection2 Min dist step
	4 char	4 char	4 char	4 char	4 char
Log30	Slave1 Input /Output	Reserved	Reserved		
	4 char	4 char	4 char		
	Slave2 Input /Output	Reserved	Reserved		
	4 char	4 char	4 char		
	Slave3 Input /Output	Reserved	Reserved	Log lapsed time	
	4 char	4 char	4 char	8 char	

*Input/Output bit details

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Area number								Reserved				Protection1 state	Protection2 state		

7. Reply Status

UAM validates the received command by conducting number of checks. If they are successful UAM replies with the corresponding data with the status code "00". On the other hand, it will reply with error status if verification fails. Details of status codes are shown in table 7.1.

Table 7.1 Detail of Status Code 

Status	Detail
0x00	No Error
0x12	Received command does not contain the minimum required fields or received data size exceeds the maximum size of internal buffer.
0x31	Command is received without STX
0x34	Command header contains unspecified characters
0x35	Data contains unspecified characters
0x36	Data size is not equal to the size mentioned in the command
0x37	CRC of received data is not equal to CRC in the command
0x41, 0x42	Unspecified command is received
0x44	Sub header is out-of-range
0x45	Sub header is not a number
0x66,	Configuration of UAM is incomplete
0x73	Unable to process commands (AR02 and AR04) as the device is in setting mode (Continuous data output mode can not be started when the device is in setting mode).
Others	Internal error (See table 7.2 if the transmitted command is status command YR)

Table 7.2 Detail of Status Code for YR command 

Status	Detail
0x00	No Error
0x44	- Grouping count exceed the maximum value - Area type exceeds the maximum value.
0x52	- Start and/or end step exceeds the maximum value - Start step is greater than end step
0x54	Area number exceeds the maximum value
0x55	Area number exceeds the active area count in the sensor
0x81	Protection2 data is requested (YR01) without activating the Protection2 area.
0x82	Warning1 data is requested (YR02) without activating the Warning1 area.
0x83	Warning2 data is requested (YR03) without activating the Warning2 area.
0x84	Muting1 data is requested (YR04) without activating the muting1 area.
0x85	Muting2 data is requested (YR05) without activating the muting2 area.
0x86	Reference data is requested (YR06) without activating the reference area.
0x87	Reference max data is requested (YR07) without activating the reference area.
0x88	Reference min data is requested (YR08) without activating the reference area.



8. SCIP Mode Communication

UAM also supports commands of Sensor Communication Interface Protocol (SCIP). List of supported SCIP commands are shown in Table 8.1.

Table 8.1 SCIP Commands Supported by UAM

Command	Function
BM*	Switch on the laser for measurement.
GD	Acquire measured distance
GE	Acquire measured distance and intensity.
MD	Acquire measured distance in continuous mode
ME	Acquire measured distance and intensity in continuous mode
QT	Stop the continuous mode
RS	Stop the continuous mode
RT	Stop the continuous mode
VV	Acquire version detail of UAM
PP	Acquire parameters of UAM
II	Acquire state of UAM

*: Laser is always emitted in UAM therefore, it is not necessary to send the “BM Command” to switch-on the laser before starting the measurement. It is supported for maintaining the compatibility with the SCIP protocol and SCIP library.

For more details on SCIP commands refer to SCIP specification.

8.1 SCIP Format

8.1.1 Request Message

Request Message is sent from the host computer to UAM. It contains command code, parameters, user specified strings and request terminator (Figure 8.1.1.1).

Command code is expressed in two upper case alphabets. UAM uses this code to differentiate the command and provides the corresponding response.

Parameters are command specific values expressed in integers. Values should be filled with zero if integer digits are less than parameter’s size, for example, if the value is 4, it must be represented as 4, 04 or 004 respectively if parameter size is one, two or three. Encoding is not applied for the parameters.

User specified string is sequence of characters starting with a semicolon (Figure 8.1.1.2). Characters that can be used are all the alphabets and numbers along with special characters ‘ ’, ‘:’, ‘_’, ‘+’, ‘-’ and ‘@’. Avoid using any other characters in the string and limit the size to maximum 16 characters. User specified string is an optional field therefore it can be excluded from the request message. However, when same request is issued in succession with separate strings it can serve as a means to differentiate the response message from UAM.

Request terminator can be a Line feed (LF) character, a Carriage Return (CR) character or both CR and LF in succession.



Request Message

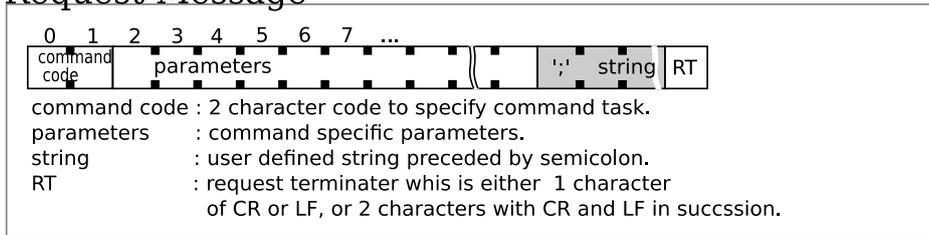


Figure 8.1.1.1: SCIP Request Message Format

User String

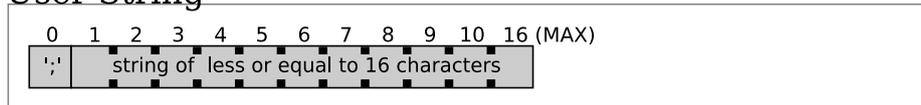


Figure 8.1.1.2: User String format

8.1.2 Response Message

Response Message is sent from UAM to host computer after receiving a request. It contains echo back of request message, status, check code, data corresponding to the command code and response delimiter (Figure 8.1.2.1).

Echo back is the retransmission of request message by UAM excluding the request terminator.

Status is a two-character alpha-numeric code to inform the success or failure of the command execution.

Check code is a one-character code generated for the data enclosed between response delimiter (refer to section 8.3).

Data is UAM's internal state or measurement values. Some of the data are encoded before transmission. See the corresponding commands in section 8.7 for the type of data sent by UAM and encoding applied to them.

Response delimiter is a line feed character inserted between the data and at the end of the response message. Check the two consecutive RD in the response message or empty line to confirm the response termination.

Important Note:

When the scan skip function is active, device will reply only during the measurement cycles. For example, if the scan skip function is configured as 2, reply of commands will be provided at every 90msec. However, if the device is in the error state, the reply will be sent at every cycle. In such case, the values of measurement data when the sensor is skipping the measurement will be 0xFFFE. Further, scan skip function is temporarily suspended when the device is in setting mode and the communication cycle is 30msec.

Response Message

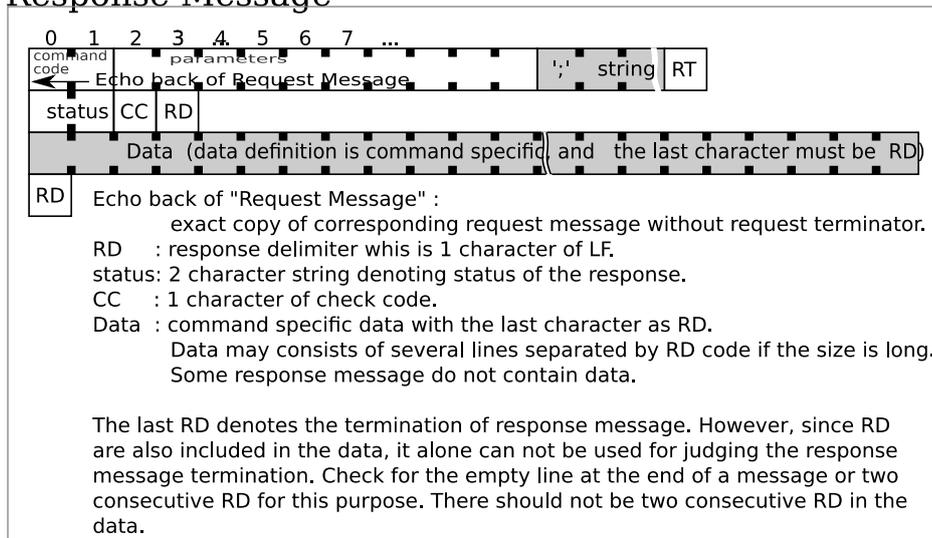


Figure 8.1.2.1: Response Message Format

8.1.3 Scan Response Message

Apart from general response format (refer to section 8.1.2), UAM provides the data in an additional format called, scan response message, when request message is sent to obtain data in continuous mode (Figure 8.1.3.1). Echo back in such message is not exactly the same as request message. They are partially changed. Further, status of such response reflects the current state of UAM.

Scan Response Message

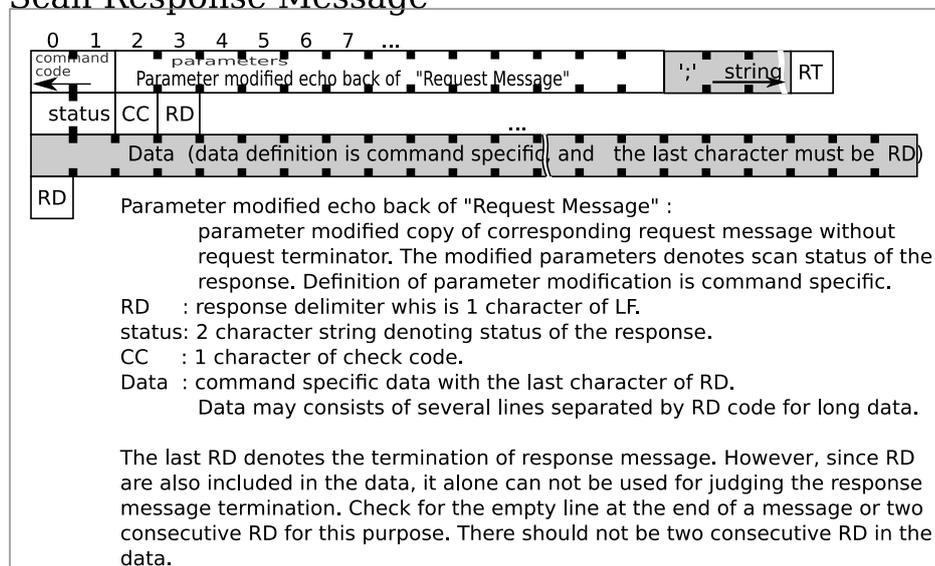


Figure 8.1.3.1: Scan Response Message Format

8.2 SCIP Encoding and Decoding

SCIP protocol encodes the decimal values into ASCII characters in order to compress the data and reduce the transmission time.

Encoding process involve dividing a number into groups of 6 bits. For each 6 bit data, 0x30 is added to convert them into ASCII characters.

Example of encoding 1234 (0x4d2) in SCIP protocol:

Step 1: Expressing the data in binary with incomplete upper bits padded with zero.

1234: 00 0000 0100 1101 0010

Step 2: Separate into three groups with 6 bits each

000000 010011 010010

0x00 0x13 0x12

Step 3: Add 0x30 to convert them into ASCII

0x00 + 0x30 = 0x30 = '0'

0x13 + 0x30 = 0x43 = 'C'

0x12 + 0x30 = 0x42 = 'B'

Data are encoded to either three or four characters. Host computer should appropriately decode the data before using them. Figure 8.2.1 shows the general expression of encoded data.

Character Encoded Data

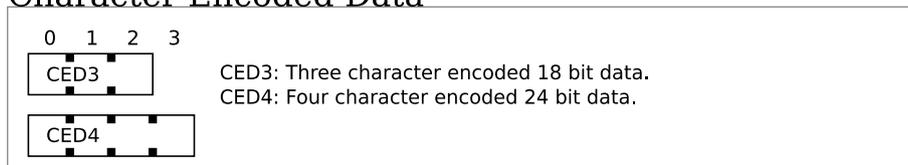


Figure 8.2.1: Representation of Encoded Data

8.3 Check Code

Check code is a value obtained by adding all character in a target string. Size of the check code is reduced to 6 bits and applied SCIP encoding (refer to section 8.2) to convert into ASCII character. Check code should be used for validating the received data by the host computer.

Example of obtaining check code for string "ABC01" in SCIP protocol:

Step 1: Calculate the sum of all characters in the string

'A' 'B' 'C' '0' '1' '2'

0x41 + 0x42 + 0x43 + 0x30 + 0x31 + 0x32 = 0x159

Step 2: Truncate the value to lower 6 bits and add 0x30 to convert into ASCII character.



$$0x19 + 0x30 = 0x49 = 'I'$$

8.4 Timestamp

Timestamp is a 24 bit counter value of internal timer. It is included in the response message of data request commands. 24 bit data is converted into 4 ASCII characters by SCIP encoding (refer to section 8.2) before transmission. Value will reset to 0 when counter overflows therefore, host computer should handle this with appropriate measure. Timestamp comes as a set with timer value, check code and response delimiter called as, Time Data (Figure 8.4.1).

Time Data

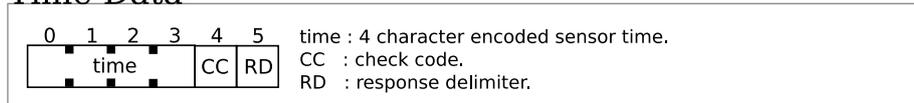


Figure 8.4.1: Representation of Timestamp

8.5 Data Splitting

When response message contains a large volume of data they are split into number of blocks each containing 64 characters with its check code and response delimiter (Figure 8.5.1). However, as data may not be always in exact multiple of 64, the last block may contain less than 64 characters with its check code and response delimiter.

Dividing into Blocks

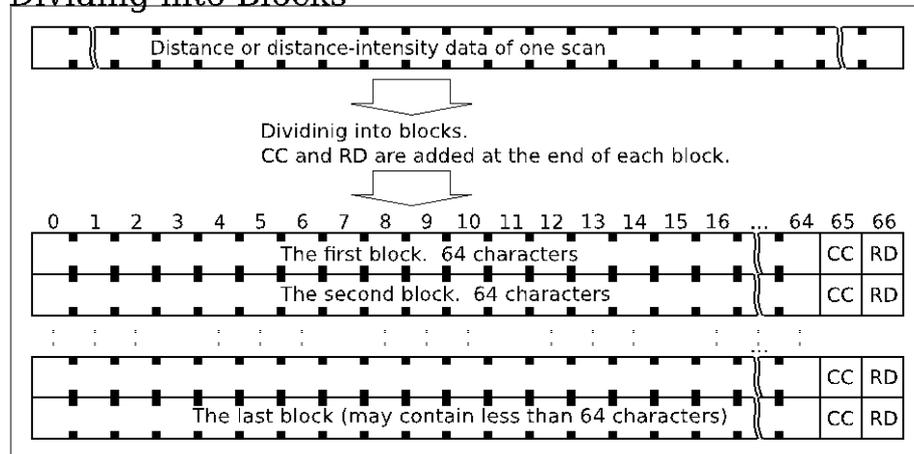


Figure 8.5.1: Separation of Measurement Data into Blocks

8.6 Common SCIP Status Codes

When request message format is wrong or when device is unable to send the desired response due to internal errors, it sends the reply with error status. Status that is common for all commands are shown in Table 8.6.1. Command specific status codes are explained in the respective command in section 8.7.

Table 8.6.1 Common SCIP Status Codes

Code	Detail
00	No error
01 ~ 07	Error in the command parameter
0D	Request message is longer than specified
0E	Undefined command
0G	User specified string is longer than allowed.
0H	User specified string has error
0N	UAM is in lockout state due to error

8.7 SCIP Commands

8.7.1 BM Command

In SCIP specification, it is required to send BM command to switch-on the laser to start the measurement before sending the GD or GE command. However, in UAM laser is always on therefore, sending this command is unnecessary. This command is supported to maintain the compatibility with the SCIP protocol and the SCIP library.

Request and response messages of BM command are shown in Figure 8.7.1.1 and Table 8.7.1.1 shows the status code detail. Generally, the status is always 02, but when the device is in the lockout state due to error or if it is switched to laser off mode, the status will be 01 .

Table 8.7.1.1 Details of Status Code

Code	Detail
01	Laser emission is stopped due to internal error or the device is switched to laser off mode 
02	Laser is on

BM request message



BM response message



Figure 8.7.1.1: BM command Request and Response



8.7.2 Measurement Data (GD and GE Command)▲

When UAM receives this command, it replies with measurement data. There are 2 variations of this command. GD Command provides only the distance and GE command provides both the distance and intensity. Parameters in the request message are listed in Table 8.7.2.1. UAM's response depends on these parameters. Measurement data in the response message are encoded to 3 ASCII characters with SCIP encoding technique (refer to section 8.2). Further, the data is also split into number of blocks during transmission (refer to section 8.5). Format of request and response message are respectively shown in Figure 8.7.2.1, and 8.7.2.2.

If parameters are not received in the correct format, UAM will send the reply with error status (refer to Table 8.7.2.2). Refer to section 8.1 for details on terminology used in the message.

Important: Before acquiring sensing data using GD, GE command, send the VV command to check the serial number for verifying the connection with an intended UAM.

Table 8.7.2.1 Parameters of GD and GE request message

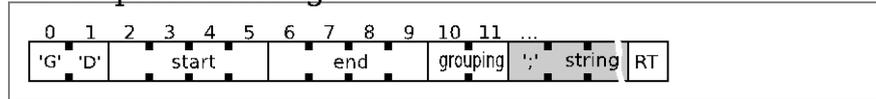
Parameters	Size	Detail	Remarks
Start	4	Position of first measurement data to send	UAM has a total of 1081 steps (numbered from 0 to 1080). Value should not exceed this range.
End	4	Position of the last measurement data to send	
Grouping	2	Number of adjacent steps among which UAM is requested to send only the minimum measurement value	Grouping parameter 0 is treated as 1.

Table 8.7.2.2 Details of Status Code

Code	Detail
00	No error
01	Start parameter contains non numeric character
02	End parameter contains non numeric character
03	Grouping parameter contains non numeric character
04	End parameter exceeds the measurement step
05	End parameter is smaller than start parameter
06	Skips parameter contains non numeric character



GD request message



GD response message

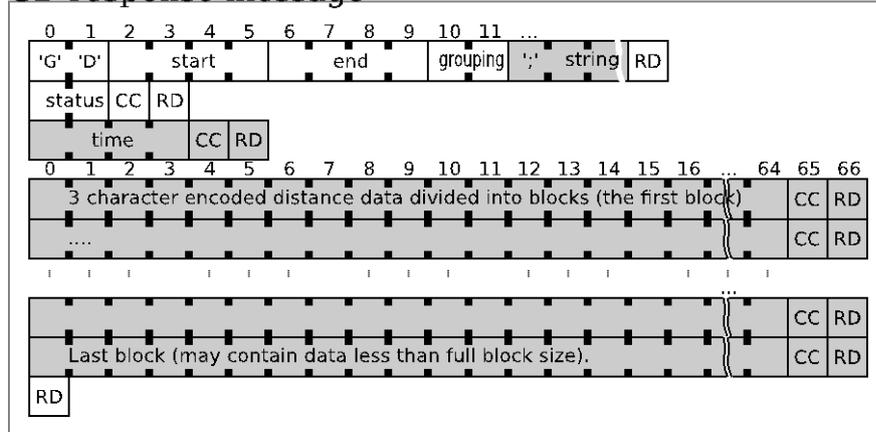
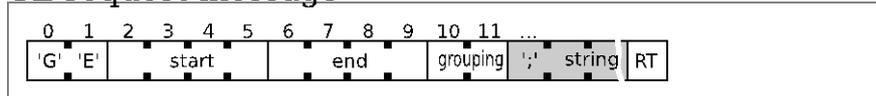


Figure 8.7.2.1: GD command Request and Response

GE request message



GE response message

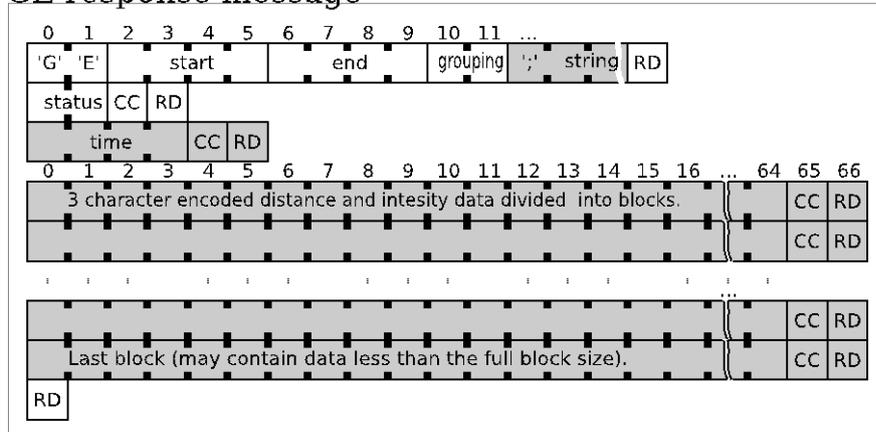


Figure 8.7.2.2: GE command Request and Response

8.7.3 Measurement Data (MD and ME Command)

When UAM receives this command, it replies with measurement data. There are 2 variations of this command. MD Command provides the distance only and ME command provides both the distance and intensity. Parameters in the request message are listed in Table 8.7.3.1. UAM's response depends on these parameters. Measurement data in the response message are encoded to 3 ASCII characters with SCIP encoding technique (refer to section 8.2). Further, the data is also split into number of blocks during transmission (refer to section 8.5). Format of request and response message are respectively shown in Figure 8.7.3.1, and 8.7.3.2.

If parameters are not received in the correct format, UAM will send the reply with error status (refer to Table 8.7.3.2). Refer to section 8.1 for details on terminology used in the message.

Important:

- Before acquiring sensing data using MD, ME command, send the VV command to check the serial number for verifying the connection with an intended UAM.
- Continuous data transmission initiated using the MD, ME command will be terminated if UAM detects error and goes to lockout state.

Table 8.7.3.1 Parameters of MD and ME request message

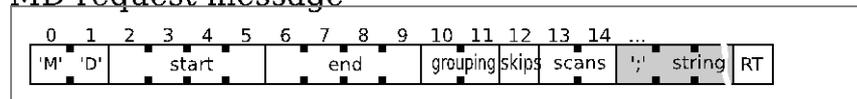
Parameters	Size	Detail	Remarks
Start	4	Position of first measurement data to send	UAM has a total of 1081 steps (numbered from 0 to 1080). Value should not exceed this range.
End	4	Position of the last measurement data to send	
Grouping	2	Number of adjacent steps among which UAM is requested to send only the minimum measurement value	Grouping parameter 0 is treated as 1.
Skips	1	Interval to send the data	UAM skips sending the data for number of cycles provided in this field when it is in continuous transmission mode. One measurement cycle of UAM is 29 ~ 30ms.
Scans	2	Number of scan cycles UAM is requested to provide the data continuously	In the echo back from UAM, original value in this field is replaced by number of remaining scans. If the parameter is set to "00", UAM will continue to send the data until it is stopped by sending stop commands. Status in the response message in such case will be "99". Continuous transmission will stop if connection between host computer and UAM is lost.

Table 8.7.3.2 Details of Status Code

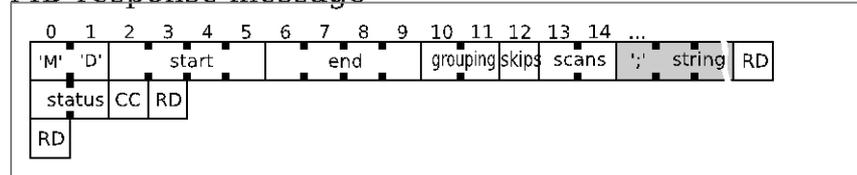
Code	Detail
00	No error
01	Start parameter contains non numeric character
02	End parameter contains non numeric character
03	Grouping parameter contains non numeric character
04	End parameter exceeds the measurement step
05	End parameter is smaller than start parameter
06	Skips parameter contains non numeric character
07	Scan parameter contains non numeric character



MD request message



MD response message



MD scan response message

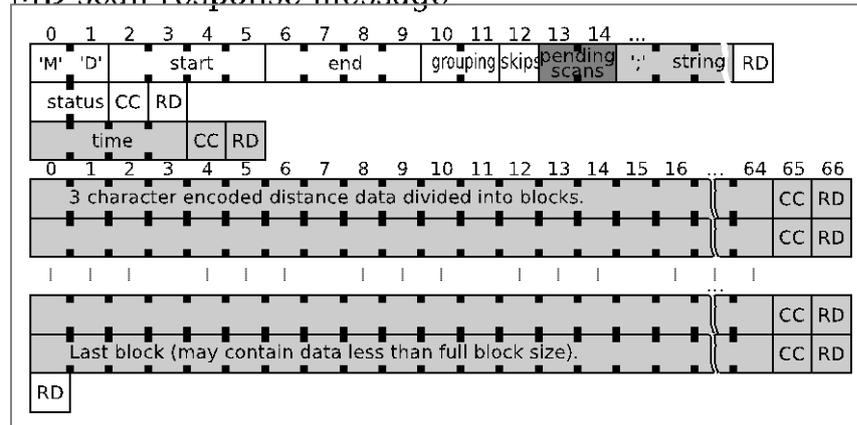
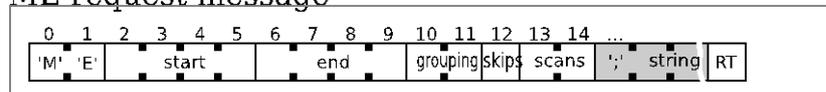
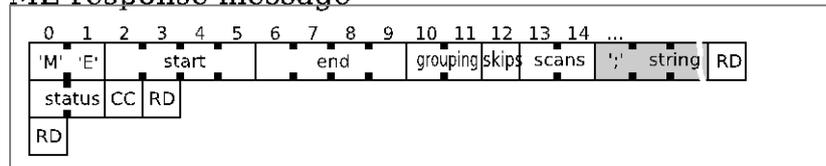


Figure 8.7.3.1: MD command Request and Response

ME request message



ME response message



ME scan response message

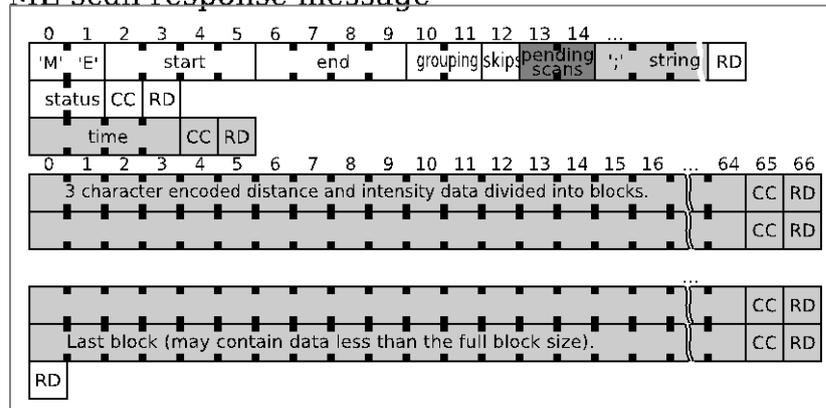


Figure 8.7.3.2: ME command Request and Response

8.7.4 Continuous Transmission Terminate (QT, RS and RT Command)

These commands stop the continuous transmission mode initiated by MD or ME command. Request message has no command specific parameter and response does not contain any data. Format of request and response message are respectively shown in Figure 8.7.4.1, 8.7.4.2 and 8.7.4.3 for QT, RS and RT commands.

Table 8.7.4.1 Details of Status Code

Code	Detail
00	No error. UAM stops the continuous data transmission

QT request message



QT response message

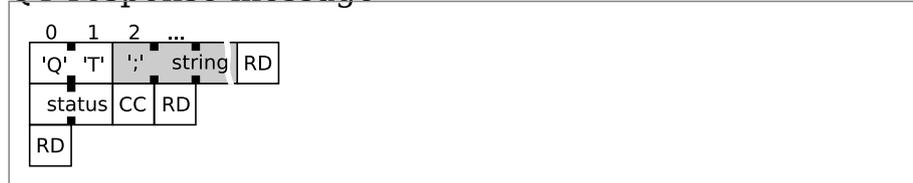


Figure 8.7.4.1: QT command Request and Response

RS request message



RS response message

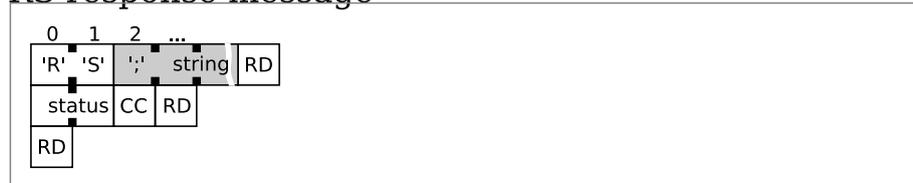


Figure 8.7.4.2: RS command Request and Response

RT request message



RT response message

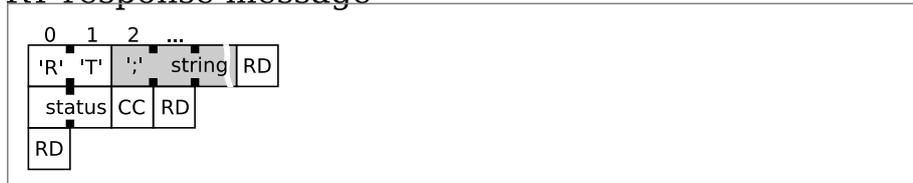


Figure 8.7.4.3: RT command Request and Response

8.7.5 Sensor Information (VV, PP and II Commands)

When UAM receives this command, it replies with sensor information. Request messages have no command specific parameter. Response message contains number of fields separated by a semicolon. Therefore, they should not be treated as a check code. Request and response messages are respectively shown in Figure 8.7.5.1, Figure 8.7.5.2 and Figure 8.7.5.3 for VV, PP and II commands. Information included in response of each command is shown in Table 8.7.5.2, Table 8.7.5.3 and Table 8.7.5.4.

Table 8.7.5.1 Details of Status Code

Code	Detail
00	No error.

Table 8.7.5.2 Information in VV Command

Description	String Sample
Vendor information	VEND:Hokuyo Automatic Co.,Ltd.
Product model	PROD:UAM-05LP
Firmware version	FIRM:01.00.00
SCIP protocol version	PROT: SCIP 2.0 for Safety
Product serial number	SERI:H0123456

Table 8.7.5.3 Information in PP Command

Description	String Sample
Product model	MODL:UAM-05LP
Minimum measurable distance (mm)	DMIN:20
Maximum measurable distance (mm)	DMAX:40000
Angular resolution (Number of divisions in 360°)	ARES:1440
First measurement step	AMIN:0000
Last measurement step	AMAX:1080
Front measurement step	AFRT:0540
Standard scanning speed (rpm)	SCAN:2000

Table 8.7.5.4 Information in II Command

Description	String Sample
Product model	MODL:UAM-05LP
Laser status	LASR:ON
Scanning speed	SCSP: 2000[rpm]<-Fixed
Sensing mode	MESM: Measuring by Sensitive Mode
Communication speed	SBPS: Ethernet 100[Mbps]<- Fixed
Time	TIME:012345
Device status	STAT: Sensor works well.



VV request message



VV response message

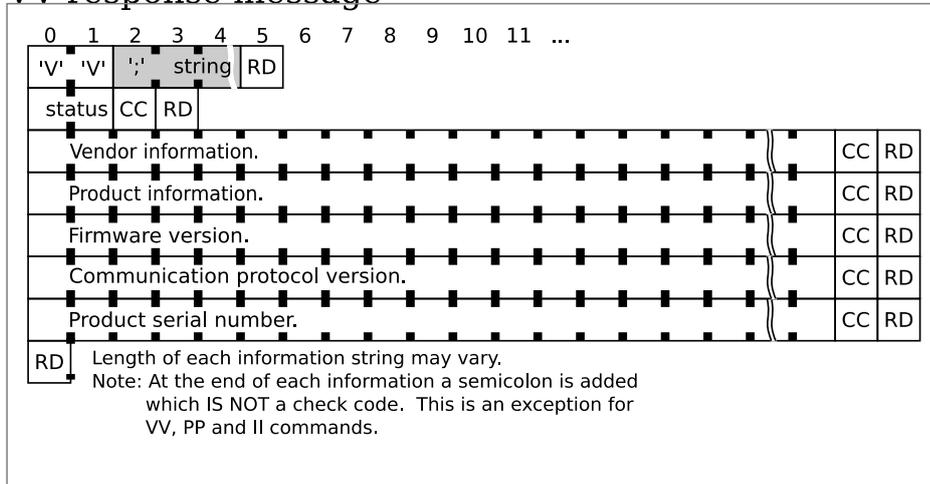


Figure 8.7.5.1: VV command Request and Response

PP request message



PP response message

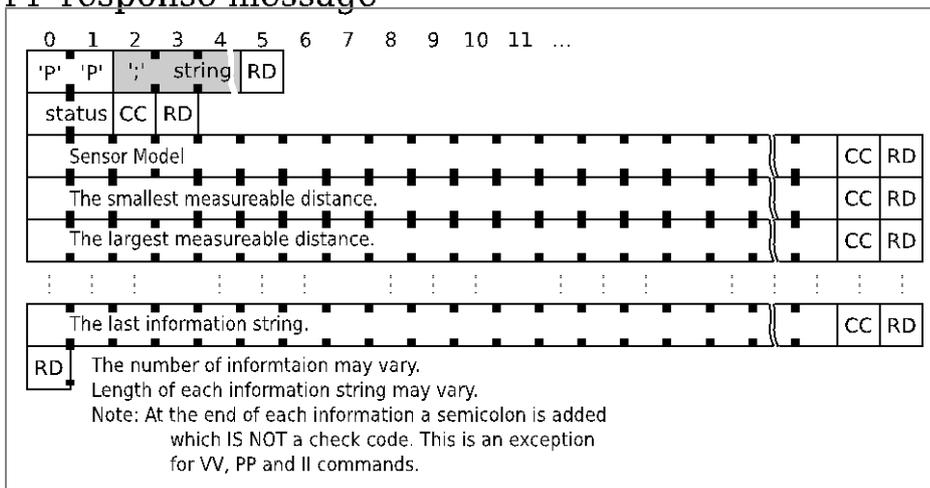


Figure 8.7.5.2: PP command Request and Response

II request message



II response message

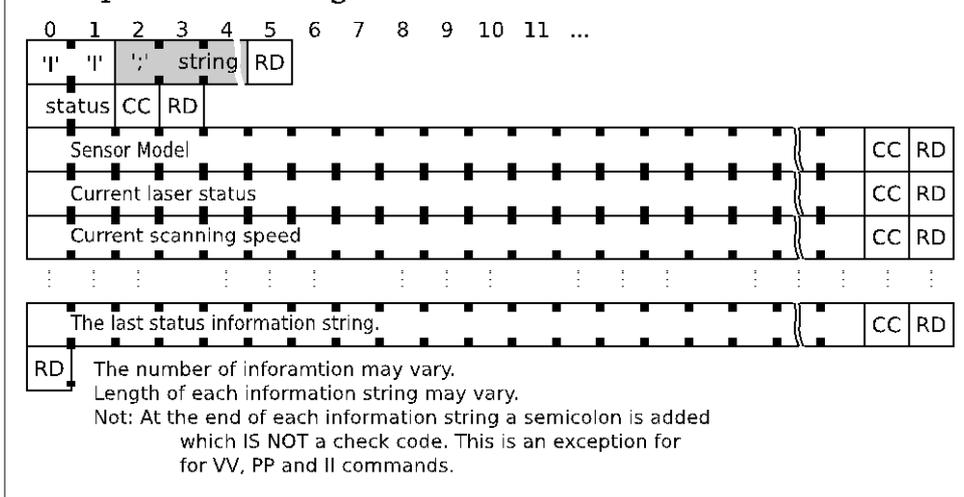


Figure 8.7.5.3: II command Request and Response



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