SensArray Communication Protocol: Part I

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Revision History

Version	Author	Date	Changes
0.1	Brad Gaiser	2017-02-07	First Draft
0.2	Brad Gaiser	2017-02-16	Added query for SensArray Firmware ID
0.3	Brad Gaiser	2017-09-28	Added documentation of Heartbeat Name function. Documented limits for values to various commands.
0.4	Brad Gaiser	2017-11-16	Documented Get Reader Serial Number command. Rewrote the Introduction. Documented error codes that can be reported by the Get Error List command.
1.0	Brad Gaiser	2018-03-27	Cleaned up formatting. Added documentation for . . .
1.1	Brad Gaiser	2019-02-12	Corrected 4.34, 4.35, 4.36 for maximum elements A12; corrected Length (various)
1.2	N. Mitchell	2021-11-15	Updated copyright
1.3	N. Mitchell	2022-03-10	Updated copyright

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1 Introduction

This document describes the various commands in the low-level binary protocol used to communicate with the SensArray Integrated RFID Reader. There are three sets of commands that are part of the communication protocol:

- Networking and configuration commands that are handled by the SensArray reader's command processor.
- Commands that are handled by the embedded RFID reader module.
- Commands where the underlying functionality is handled by the embedded RFID module but where the command processor provides some additional oversight and extended functionality.

1.1 Reader Command Processor

The SensArray command processor provides the communication conduit between applications communicating with the reader through the Ethernet interface and the internal reader module that controls the module's radio and provides the basic functionality of reading and writing tag data. The command format for the commands that are handled by this processor is detailed below in section 2, Data Transmission Frame Format.

The specific command codes and the details of the data content of the commands and responses are described in section 4, Commands for Controlling Top-Level Controller Functionality. Most of these commands aid in the setup, querying and saving of the network communications configuration. In addition, there are commands related to device management as well as for setting up the time periods and sequences for reading each of the antennas connected to the reader.

1.2 Commands Handled by the Embedded RFID Module

The embedded RFID module is based on the Impinj R2000 platform. It also communicates through a binary protocol with the same basic structure as the binary commands handled by the reader's command processor. It has an independent set of commands prefixed by a two-byte header consisting of the byte values 0xA5/0x5A to distinguish that command set from the reader controller commands where the header bytes are 0xB9/0x9B.

The details of the commands in this category are documented in the "*SensArray Communication Protocol, Part II*" document.

In the text below, the embedded module will be referred to as the "reader module" or just the "module".

1.3 Extended Embedded Module Commands

The SensArray reader utilizes the embedded reader module to perform the primary function of reading and writing of tags. However, this module is a single port device, so the reader's command processor performs additional tasks to provide the full functionality of a multi-antenna RFID reader. The full functionality of the SensArray Reader is achieved by having some of the embedded module's commands partially managed by the reader's command processor. Section 3, Modified Reader Module Commands, describes the extensions the SensArray reader provides relative to the baseline functionality as described in the embedded reader's communication protocol document.

2 Data Transmission Frame Format

The data frame adopted in the SensArray and by the READER MODULE follow the same binary protocol format.

SOF	Length	Command	Data	CRC	EOF
2 Bytes	2 Bytes	1 Byte	N Bytes	1 Byte	1 Byte

2.1 Header (SOF) and Trailer (EOF)

The header (Start Of Frame/SOF) for SensArray specific commands consists of the 2 bytes: 0xB9, 0x9B. The trailer (End Of Frame/EOF) consists of the 2 bytes 0x0D, 0x0A.

2.2 Length

The Length field represents the length of the complete data transmission frame, calculated as follows:

Length = 2+2+1+N+1+2, where N is the number of bytes in the Data field.

2.3 Command

The command codes consist of a single byte and are detailed in the sections below.

2.4 Data

The "Data" field contains either the command parameters (for "Command" frames) or the results from a reader operation (for "Response" frame).

2.5 CRC

The CRC value is calculated using bitwise XOR of the Length, Command, and Data bytes in each frame.

```
Example:
FRAME = 0xA5 0x5A 0x00 0x0A 0x43 0x01 0x25 CRC 0x0D 0x0A
CRC = 0x00 ^ 0x0A ^ 0x43 ^ 0x01 ^ 0x25 = 0x6D
```

3 Modified Reader Module Commands

The reader commands in this section are being handled by the SensArray controller. The following simply describes any differences that might arise because of this.

3.1 Set Transmit Power (Section 3.2.1, Command 0x10)

This command is handled by the SensArray firmware but utilizes the same command structure as the module command. The sensor sets the appropriate value for the read/write power whenever a continuous read cycle is performed. Currently, the Mode bits are ignored. An explicit Save Current Configuration command (section 4.23) needs to be issued to save the power setup. Note that the range of power levels accepted is from 5 dBm to 30 dBm. (Currently, this range is non-compliant for Vietnam.)

3.2 Get Transmit Power (Section 3.2.3, Command 0x12)

This command behaves the same as that documented for the reader module. Since the mode bits are being ignored by the Set Transmit Power command, they will be returned as zero.

3.3 Antenna Setting (Section 3.2.17, Command 0x28)

This is handled by the reader controller firmware. This results in the specified antenna being set as active and any settings that are specific to that antenna – currently only the read and write power – are sent to the READER MODULE during the continuous read process.

3.4 Get Current Antenna Setting (Section 3.2.19, Command 0x2A)

This is handled by the reader controller firmware and returns the currently active antenna.

3.5 Set GPIO (Section 3.2.41, Command 0x46)

This command functions as specified in the reader module command protocol document. If any bits in the mask or the state bytes are set other than the 4 least significant bits, the command will return as failed.

3.6 Get GPIO (Section 3.2.43, Command 0x48)

This command functions as specified in the reader module command protocol document.

3.7 Start Continuous Read (Section 3.3.3, Command 0x82)

This command activates continuous read in much the same way the command would operate if reader module was a 4-port device. Reads are performed cycling through the antennas as specified in the Set Antenna Sequence command 0x66 (Section 4.35) with Read and Gap times set by command 0x62 (Section 4.31). Read power (and write power) are set based on the values established by the Set Antenna Power Levels command 0x6A (Section 4.39) for each antenna as the reader cycles through.

3.8 Stop Continuous Read (Section 3.3.5, Command 0x8C)

This command stops a continuous read process. As per the reader module protocol, no command should be sent to the SensArray device between the issuing of the Start Continuous Read command and the Stop Continuous Read command (and returned response.)

4 Commands for Controlling Top-Level Controller Functionality

The SensArray device is an Ethernet networked POE device. This introduces the need to provision the network settings and examine and control the internal state of the device. The following define these commands and the expected responses.

4.1 Get SensArray Hardware ID

Command: 0x00

Function: Request the hardware version of the reader.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x00	0xNN	0x0D	0x0A

4.2 Get SensArray Hardware ID Response

Response Code: 0x01

Function: Response to the request for the hardware version of the reader.

SOF		Length		Response	Reader Hardware Version			CRC	EOF	
0xB9	0x9B	0x00	0x0B	0x01	Major	Minor	Update	0xNN	0x0D	0x0A

4.3 Get Reader Firmware ID

Command: 0x02

Function: Request the firmware version of the reader.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x02	0xNN	0x0D	0x0A

4.4 Get Reader Firmware ID Response

Response Code: 0x03

Function: Response to the request for the hardware version of the reader.

SOF		Length		Response	Reader Firmware Version			CRC	EOF	
0xB9	0x9B	0x00	0x0B	0x03	Major	Minor	Update	0xNN	0x0D	0x0A

4.5 Get Reader Locator Indicator State

Command: 0x06

Function: Request the current state of the locator indicator.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x06	0xNN	0x0D	0x0A

4.6 Get Reader Locator Indicator State Response

Response Code: 0x07

Function: Response to the request to return the current state of the locator indicator.

SOF		Length		Response	Locator State	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x07	0/1	0xNN	0x0D	0x0A

Comments: When the Locator State is 1, the LED on the sensor will alternate flashing red and green. In normal operating mode, when the Locator State is 0, the LED on the sensor will simply flash green on and off.

4.7 Set Reader Locator Indicator State

Command: 0x08

Function: Set the current state of the locator indicator for the sensor. The purpose of this command is to change the flash pattern of the sensor's LED so that the device can be located. Turning the locator on changes the flash pattern from the normal green flashing light to alternating between green and red to make identifying the deployed sensor easier to spot.

SOF		Length		Command	Locator State	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x08	0/1	0xNN	0x0D	0x0A

Comments: When the Locator State is set to 1, the LED on the sensor will alternate flashing red and green. When returned to normal operating mode, i.e., the Locator State is set to 0, the LED on the sensor will simply flash green on and off.

4.8 Set Reader Locator Indicator State Response

Response Code: 0x09

Function: Response to the request to set the current state of the locator indicator.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x09	0/1	0xNN	0x0D	0x0A

Comments: The response to this function will be 1 if it succeeds and 0 otherwise. In general, this command will only fail if the Locator State field in the Set command has a value other than 0 or 1.

4.9 Get Reader Serial Number

Command: 0x0A

Function: Request the serial number of the reader.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x0A	0xNN	0x0D	0x0A

4.10 Get Reader Serial Number Response

Response Code: 0x0B

Function: Response to the request for the serial number of the reader.

SOF		Length		Response	Reader Serial Number								CRC	EOF	
0xB9	0x9B	0x00	0x0A	0x0B	C1	C2	C3	C4	C5	C6	C7	C8	0xNN	0x0D	0x0A

The returned 8 data bytes are the UTF-8 character codes that form the string value of the reader's serial number. In C, a 9th byte with value 0x00 would need to be added after C8 to form a standard null terminated string.

4.11 Get IPv4 Network Configuration

Command: 0x10

Function: Request the current Ethernet IPv4 configuration of the reader.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x10	0xNN	0x0D	0x0A

4.12 Get IPv4 Network Configuration Response

Response Code: 0x11

Function: Response to the request to return the current Ethernet IPv4 configuration of the reader.

SOF		Length		Response	IP Address			
0xB9	0x9B	0x00	0x19	0x11	192	168	1	150

Netmask				Gateway			
255	255	255	0	192	168	1	1

DNS Server				DHCP Active	Comm. Port		CRC	EOF	
192	168	1	1	1/0	Port MSB	Port LSB	0xNN	0x0D	0x0A

Comments: The values shown in the columns for the IP Address, Netmask, Gateway, and DNS Server are examples of the type of values that would be returned as the response to this request. Also, note that this corresponds to the default setup for the SensArray device.

If the IP address was obtained through DHCP, the various values returned will be the ones obtained from the DHCP server.

4.13 Set IPv4 Network Configuration

Command: 0x12

Function: Set the Ethernet IPv4 configuration of the SensArray device.

SOF		Length		Command	IP Address			
0xB9	0x9B	0x00	0x19	0x12	192	168	1	150

Netmask				Gateway			
255	255	255	0	192	168	1	1

DNS Server				DHCP Active	Comm. Port		CRC	EOF	
192	168	1	1	1/0	Port MSB	Port LSB	0xNN	0x0D	0x0A

Comments:

The values shown in the tables are simply examples. The various values that can be configured follow the standard dotted octet notation for specifying addresses and netmasks. The Communication Port field corresponds to the TCP/IP port that is utilized by application software to send commands to the sensor. Its default value is 5000 which corresponds to Port MSB = 0x13, Port LSB = 0x88.

The change in IPv4 information will be put into effect immediately, so if this is on a different subnet, you may lose communications with the device. The default heartbeat setup for the SensArray, does, however, broadcast to 255.255.255.255, so you should still be able to see the heartbeat messages detailing the current configuration.

Also, this configuration is not saved to the device automatically. You will need to reestablish communications and subsequently issue the Save Current Configuration (0x1E) command documented below to get the new configuration written to the non-volatile memory of the SensArray device. Until the configuration is saved, power cycling or rebooting the SensArray device will reset to the prior saved configuration. ***As with any networked device, if you set up a network configuration with a given IP address and subnet, then move the sensor to a different network, you may not be able to communicate with the device.***

4.14 Set IPv4 Network Configuration Response

Response Code: 0x13

Function: Returned response to the request to set the current Ethernet IPv4 configuration of the SensArray device.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x13	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status value will return 0x01 on success, 0x00 if it fails. The Set IPv4 Network Configuration command will fail if the port number is less than 1024 and if the DHCP Active byte has a value other than 0 or 1.

4.15 Get Heartbeat Configuration

Command: 0x14

Function: Request the current Heartbeat network configuration of the SensArray device.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x14	0xNN	0x0D	0x0A

4.16 Get Heartbeat Configuration Response

Response Code: 0x15

Function: Response to the request to return the current Heartbeat network configuration of the SensArray device.

SOF		Length		Response	UDP Listener IP Address			
0xB9	0x9B	0x00	0x14	0x15	Octet 1	Octet 2	Octet 3	Octet 4

Port Number				Interval (seconds)			
Byte 1 (MSB)	Byte 2	Byte 3	Byte 4 (LSB)	Byte 1 (MSB)	Byte 2	Byte 3	Byte 4 (LSB)

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

The default Heartbeat setup is a UDP broadcast (UDP Listener IP Address: 255.255.255.255) on port 3988 every 30 seconds.

4.17 Set Heartbeat Configuration

Command: 0x16

Function: Request a change to the current Heartbeat network configuration of the SensArray device.

SOF		Length		Command	UDP Listener IP Address			
0xB9	0x9B	0x00	0x14	0x16	Octet 1	Octet 2	Octet 3	Octet 4

Port Number				Interval (seconds)			
Byte 1 (MSB)	Byte 2	Byte 3	Byte 4 (LSB)	Byte 1 (MSB)	Byte 2	Byte 3	Byte 4 (LSB)

Count				CRC	EOF	
Byte 1 (MSB)	Byte 2	Byte 3	Byte 4 (LSB)	0xNN	0x0D	0x0A

Comments:

The default Heartbeat setup is a UDP broadcast (Recipient IP Address: 255.255.255.255) on port 3988 every 30 seconds that never turns off.

If the UDP Listener needs to be a specific computer or the port number needs to be changed to reduce broadcast traffic, this command would be used for this purpose. Similarly, the default heartbeat period has been set so that newly added devices can be identified and commissioned quickly.

Even though 4 bytes are allocated for the Port Number, only Byte 3 and Byte 4 are valid. Byte 1 and Byte 2 must be set to 0x00. Valid port numbers represented by the 4-byte Port Number range from 1024 to 65535

The Interval field sets the periodicity of the heartbeat in seconds. The default value is 30 indicating that the heartbeat will be repeated every 30 seconds. This can be reduced if needed during initial deployment to be sure the sensor can be seen on the network. Once deployed, this interval can be set to a higher value to reduce network traffic and can even be set to 0 to indicate that no heartbeat messages are sent. Note that this field is treated as a 32-bit unsigned number giving it a range from 0 to 4,294,967,295 seconds or just over 136 years.

The Count field has been provided to turn the heartbeat off after a set number of heartbeats have been sent out after the device boots. Again, this is used to reduce network traffic. The count field is treated as an unsigned 32-bit integer by the sensor. Although, 0xFFFFFFFF would indicate a very large number of intervals, it represents

the special case of never stopping. The default value for the Count field is 0xFFFFFFFF indicating that the heartbeat will continue indefinitely.

This configuration information is not saved to the device automatically. You need to issue the Save Current Configuration (0x1E) command documented below to get the new configuration written to the non-volatile memory of the SensArray device. Until the configuration is saved, power cycling or rebooting the SensArray device will reset this to the prior saved configuration allowing you to confirm the configuration before committing it.

4.18 Set Heartbeat Configuration Response

Response Code: 0x17

Function: Returned response to the request to set the current Heartbeat configuration of the SensArray device.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x17	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status value will return 0x01 on success, 0x00 if it fails. This command will fail if the 4 bytes comprising the Port Number field fall outside the range from 0 to 65535.

Note that, any value can be set for both the Interval and the Count fields allowing for very large values for either field. ***It is the responsibility of the person configuring the sensor to ensure that the IP address is correct, and the port number does not interfere with any port that may already be in use on his/her network.***

4.19 Reset to Default Configuration

Command: 0x1A

Function: Request all device configuration be reset to the factory defaults.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x1A	0xNN	0x0D	0x0A

Comments:

This will reset the main Ethernet communications IPv4 configuration, the Heartbeat configuration, the Power settings for each antenna, the antenna read sequence, and the 24V power on state back to their default values. You can find the default values

for each of these values in the section at the end of this document, as well as, in each of the sections corresponding to the request for these various items.

Note that this will set the primary networking values back to their initial state, so you will need to treat this as an initial deployment and set the sensor up to operate properly on your network.

Also, these configuration values do not automatically become the new power-on default values. You need to issue the Save Current Configuration (0x1E) command documented below to get the new configuration written to the non-volatile memory of the SensArray device. Until the configuration is saved, power cycling or rebooting the SensArray device will reset these values to the prior saved configuration allowing you to confirm the configuration before committing it.

4.20 Reset to Default Configuration Response

Response Code: 0x1B

Function: Response to the request to reset the device configuration to the factory defaults.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x1B	0/1	0xNN	0x0D	0x0A

Comments:

The status returned will be 1 on success and 0 if the command fails. This command should generally succeed with failure most likely occurring due to a hardware failure. If this should happen, please follow the SensArray Troubleshooting Guide before contacting your technical support team.

4.21 Restore Saved Configuration

Command: 0x1C

Function: Request all device configuration be reset to the configuration saved in flash memory.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x1C	0xNN	0x0D	0x0A

Comments:

This will read the main Ethernet communications IPv4 configuration, the Heartbeat configuration, the Power settings for each antenna, the antenna read sequence, and

the 24V power-on configuration saved in flash memory and start the device operating with those parameters. This command can be used to reset the configuration of the device without needing to power cycle it.

Since this will restore the saved configuration, you will not need to reissue the save command (0x1E) for this configuration to be in effect on the next power cycle.

4.22 Restore Saved Configuration Response

Response Code: 0x1D

Function: Response to the request to restore the device configuration from the values saved in flash memory.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x1D	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 0x01 on success and 0x00 if the command fails. This command should generally succeed with failure most likely occurring due to a hardware failure. If this should happen, please follow the SensArray Troubleshooting Guide before contacting your technical support team.

4.23 Save Current Configuration

Command: 0x1E

Function: Request all device configuration be reset to the configuration saved in flash memory.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x1E	0xNN	0x0D	0x0A

Comments:

This will write the main Ethernet communications IPv4 configuration, the Heartbeat configuration, the Power settings for each antenna, the antenna read sequence, and the 24V power-on configuration to flash memory so that these parameters will become the working configuration of the SensArray device after it power cycles.

4.24 Save Current Configuration Response

Response Code: 0x1F

Function: Response to the request to restore the device configuration from the values saved in flash memory.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x1F	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 0x01 on success and 0x00 if the command fails. This command should generally succeed with failure most likely occurring due to a hardware failure. If this should happen, please follow the SensArray Troubleshooting Guide before contacting your technical support team.

4.25 Get 24V Output Status

Command: 0x20

Function: Request the current state of the 24V DC output and the configured startup state.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x20	0xNN	0x0D	0x0A

Comments:

This command retrieves the current state of the 24V output (on or off) and whether the voltage is applied on startup.

4.26 Get 24V Output Status Response

Response Code: 0x21

Function: Response to the request for the current state and startup state of the 24V DC output supply.

SOF		Length		Response	Current State	Startup State	CRC	EOF	
0xB9	0x9B	0x00	0x0A	0x21	0x00/0x01	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The Current State value returned will be 0 if the 24V DC output power is off and 1 if it is on. The Startup State indicates whether the power is to be applied to the 24V DC output during the startup process or whether it is to be left off.

4.27 Set 24V Output Status

Command: 0x22

Function: Request for the current state and the configured startup state of the 24V DC output be set.

SOF		Length		Command	Current State	Startup State	CRC	EOF	
0xB9	0x9B	0x00	0x0A	0x22	0x00/0x01	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The 24V DC output will be turned on if Current State is set to 1 or off if it is set to 0. On reboot or power cycle, the 24V DC output will be turned on automatically if the Startup State is set to 1 and left off if it is set to 0.

Note that a subsequent Save Current Configuration (0x1E) command needs to be issued for the Startup State to take effect on the next reboot or power cycle. This is required because all the device configuration information is saved together allowing you to confirm all of the settings before committing to the new configuration.

4.28 Set 24V Output Status Response

Response Code: 0x23

Function: Response to the request to set a new configuration for the current state and startup state of the 24V DC output.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x23	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 1 if the command succeeds and 0 if it fails. This command fails if the Current Status and/or the Startup Status values are something other than 0 or 1.

4.29 Get Antenna Read and Gap Times

Command: 0x60

Function: Request the Read Time and the Gap Time for cycling through the antennas during a continuous tag inventory command.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x60	0xNN	0x0D	0x0A

Comments:

This command requests current setup for the Read Time (ms), the time during which tags are continuously being read by the reader, and the Gap Time (ms), the time when no tags are being read when switching from one antenna to the next.

4.30 Get Antenna Read and Gap Times Response

Response Code: 0x61

Function: Response to the request for the current values for the Read Time and the Gap time of the antenna read cycle.

SOF		Length		Response	Read Time		Gap Time		CRC	EOF	
0xB9	0x9B	0x00	0x0C	0x61	MSB	LSB	MSB	LSB	0xNN	0x0D	0x0A

Comments:

The current 16 bit values for the Read Time and the Gap Time are returned. Note that these are in milliseconds. A Read Time of ½ second would be 500 ms and would be returned as 0x01 (MSB) and 0xF4 (LSB). Similarly, for the Gap Time.

4.31 Set Antenna Read and Gap Times

Command: 0x62

Function: Request that the current values of the Read Time and the Gap Time of the antenna read cycle be updated.

SOF		Length		Command	Read Time		Gap Time		CRC	EOF	
0xB9	0x9B	0x00	0x0C	0x62	MSB	LSB	MSB	LSB	0xNN	0x0D	0x0A

Comments:

The current 16-bit values for the Read Time and the Gap Time are updated. Note that these are in milliseconds. A Read Time of ½ second would be 500 ms and would be sent as 0x01 for the MSB and 0xF4 for the LSB. Similarly, for the Gap Time.

As with the other configuration parameters for the SensArray, the values are not saved to flash memory until the Save Current Configuration command (0x1E) is sent. These values can be tested but will revert to the saved configuration unless the Save command is issued.

4.32 Set Antenna Read and Gap Times Response

Response Code: 0x63

Function: Response to the request to set the Read Time and Gap Time to be used during continuous tag reads.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x63	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 1 if the command succeeds and 0 if it fails. This command fails if an attempt is made to set the gap time to less than 10 milliseconds.

Note that this command does not check gap and read times to verify that the duty cycle will not result in excessive heating of the sensor if run for an extended time period. Please refer to the SensThys whitepaper, "Thermal Performance of the SensArray Product Family", for guidance on appropriate values.

4.33 Get Antenna Sequence

Command: 0x64

Function: Request the sequence of antenna ids through which the SensArray will cycle during a continuous tag read process.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x64	0xNN	0x0D	0x0A

Comments:

During a continuous tag read process, the SensArray can automatically sequence through the internal antenna as well as externally attached antennas. This command

requests the current setup. Note that the factory default for the sequence is to only read from the internal antenna.

4.34 Get Antenna Sequence Response

Response Code: 0x65

Function: Response to the request for the current values of the antenna read sequence.

SOF		Length		Response
0xB9	0x9B	0x00	0x15	0x65

Seq. Length	Antenna Sequence											
0xMM	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

This response returns the number of elements in the antenna sequence and the antenna id for each of those elements. Note that the Sequence Length will be between 1 and 12 and each of the Antenna Sequence elements A1 through A12 will have values between 0 and 3. Note that antenna id 0 corresponds to the internal antenna of the SensArray and ids 1 through 3 correspond to the external ports with 1 being the one toward the middle and 3 the one nearest the corner where the antenna SMA connectors are located. Also, the antenna id will be 0 for any elements in the sequence where the element number is larger than the Sequence Length. So, for example, for a Sequence Length of 9, A10 through A12 will all be 0.

4.35 Set Antenna Sequence

Command: 0x66

Function: Set the current values of the antenna read sequence.

SOF		Length		Command
0xB9	0x9B	0x00	0x15	0x66

Seq. Length	Antenna Sequence										
0xMM	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

This sets the number of elements in the antenna sequence and the antenna id for each of those elements. During continuous reads, the SensArray will activate each antenna in the sequence one after another based on these input values. When the end of the sequence is reached, it cycles around to the start and repeats until the continuous tag read command is terminated.

Note that the Sequence Length must be between 1 and 12 and each of the Antenna Sequence elements A1 through A12 must have values between 0 and 3. Note that antenna id 0 corresponds to the internal antenna of the SensArray and ids 1 through 3 correspond to the external ports with 1 being the one toward the middle and 3 the one nearest the corner where the antenna SMA connectors are located. Also, the antenna id should be 0 for any elements in the sequence where the element number is larger than the Sequence Length. So, for example, for a Sequence Length of 9, A10 through A12 should all be 0. Also, none of the intermediate values in the sequence should have 0 values.

The antenna sequence is part of the power-up configuration of the SensArray. However, the values are not saved to flash memory until the Save Current Configuration command (0x1E) is sent. These values can be tested, but will revert to the saved configuration unless the Save command is issued.

4.36 Set Antenna Sequence Response

Response Code: 0x67

Function: Response to the request to set the Read Time and Gap Time to be used during continuous tag reads.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x67	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 1 if the command succeeds and 0 if it fails. This command will fail if the Sequence Length is less than 1 or greater than 12, as well as, if any of the element values in the sequence as specified by the Sequence Length are less than 0 or greater than 4. It will also fail if there is a non-zero element after the sequence is finished based on the Sequence Length.

4.37 Get Module Power Level

Command: 0x68

Function: Request the current read and write power levels of the RF module.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x68	0xNN	0x0D	0x0A

4.38 Get Antenna Power Levels Response

Response Code: 0x69

Function: Response to the request for the current values of the power levels of each antenna.

SOF		Length		Response	Reserved
0xB9	0x9B	0x00	0x1D	0x69	0x00

Read/Write Module Power					Unused				
0x00	R1(MSB)	R1(LSB)	W1(MSB)	W1(LSB)	B1	B2	B3	B4	B5

Unused	Unused

B6	B7	B8	B9	B10	B11	B12	B13	B14	B15

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

This response returns the values of the configured read power and write power in dBm multiplied by 100. If either value is negative, a two's complement value is returned. For example, a read power of -7 dBm would be returned as 0xFD, 0x44 while a write power of 19.5 dBm would be represented as 0x07, 0x9E.

Note that this command is complementary to the module command 0x12. This command, however, retrieves the current power settings for the reader module. Since the module has a single RF output port, the module's power is reported for only the first block of power settings.

4.39 Set Module Power Level

Command: 0x6A

Function: Set the configured read and write power in the module.

SOF		Length		Command	Reserved
0xB9	0x9B	0x00	0x0D	0x6A	0x00

Antenna ID	Read/Write Power			
0x00	R1(MSB)	R1(LSB)	W1(MSB)	W1(LSB)

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

This command sets the configured read power and write power multiplied by 100 for the module. If either value is negative, a two's complement value should be sent. For example, a read power of -7 dBm would be sent as 0xFD, 0x44 while a write power of 19.5 dBm would be represented as 0x07, 0x9E.

Note that this command is complementary to the module's Set Transmit Power command 0x10. The 0x10 command sets the power levels for each of the individual antennas. This command (0x6A) sets the read and write power that the module will

use during single-tag inventory reads. These read/write values will be overwritten during a continuous tag read cycle by the values specified through the module's 0x10 command.

4.40 Set Antenna Power Levels Response

Response Code: 0x6B

Function: Response to the request to set the read and write power for the specified antenna.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x6B	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 1 if the command succeeds and 0 if it fails. Currently, the command will fail only if the antenna id is not set to 0.

4.41 Get Temperature Notifications

Command: 0x70

Function: Request the temperature notification settings.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0x70	0xNN	0x0D	0x0A

4.42 Set Temperature Notifications Response

Response Code: 0x71

Function: Return the temperature warning and alert levels, as well as, the time interval at which these checks are performed.

SOF		Length		Response	Reserved
0xB9	0x9B	0x00	0x11	0x71	0x00

Temp. Notice Interval		Temp. Alert Interval		Temp. Warning Threshold		Temp. Alarm Threshold	
TNI (MSB)	TNI (LSB)	TAI (MSB)	TAI (LSB)	TWT (MSB)	TWT (LSB)	TAT (MSB)	TAT(LSB)

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

The two bytes of the Temperature Notice Interval form a time interval in seconds specifying how often the module's temperature is reported when continuous tag reads are being performed. The default value for this interval is 30 seconds. A zero value indicates that these notices have been turned off.

The two bytes of the Temperature Alert Interval specify the time interval in seconds at which the sensor checks the warning and alarm temperature thresholds. The two bytes of the Temperature Warning Threshold specify the level at which warnings are issued by the sensor. The two bytes of the Temperature Alarm Threshold specify the level at which alarms are issued. The temperatures represented by the two bytes are 100 * Temp in degrees C.

More details about these values can be found in the next section (4.43 Set Temperature Notifications).

4.43 Set Temperature Notifications

Command: 0x72

Function: Set the temperature warning and alert levels as well as the time interval at which these checks are performed.

SOF		Length		Command	Reserved
0xB9	0x9B	0x00	0x11	0x72	0x00

Temp. Notice Interval		Temp. Alert Interval		Temp. Warning Threshold		Temp. Alarm Threshold	
TNI (MSB)	TNI (LSB)	TAI (MSB)	TAI (LSB)	TWT (MSB)	TWT (LSB)	TAT (MSB)	TAT(LSB)

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

This command sets the intervals for sending temperature reading notifications to the controlling application. It also sets a warning and an alarm threshold along with the time interval at which the sensor checks to see if these levels have been exceeded or not.

The two bytes of the Temperature Notice Interval form a time interval in seconds specifying how often the module's temperature is reported when continuous tag reads are being performed. This allows the controlling application to track the reader module's temperature. The default value for this interval is 30 seconds. These notices can be turned off by setting this value to 0.

Temperature Notices are sent out as event code 0x20. The details of the message sent are documented in section 5.2.4 below.

The two bytes of the Temperature Alert Interval specify the time interval in seconds at which the sensor checks the warning and alarm temperature thresholds. Note that the minimum interval is 10 seconds. The two bytes of the Temperature Warning Threshold specify the level at which warnings are issued by the sensor. The two bytes of the Temperature Alarm Threshold specify the level at which alarms are issued. The temperatures represented by the two bytes are 100 * Temp in degrees C.

A temperature warning is issued once whenever the temperature exceeds the Temperature Warning Threshold. If the temperature drops 2 degrees below this threshold, the warning is reset and will be issued again if it should rise above the threshold. The 2 degrees is used to be sure that if the temperature is hovering around

the threshold that notices aren't continually being sent to the controller. A similar logic applies to the Temperature Alarms.

Temperature Warnings are sent as notification event code 0xA0 and alarms as event code 0xA1. These are documented in Section 5.2.5 and Section 5.2.6 respectively.

Warnings are intended to inform the controller when it is getting warm, but is not in any serious danger of overheating. The default value is set to 60 degrees C. The alarm threshold should be used to inform the application when the module is in danger of overheating to the point where its internal logic will shut it down. The default value for this threshold is 75 degrees C. The warning threshold can be turned off by setting it very high. The alarm threshold cannot be set higher than 85 degrees C. ***Although it is not recommended,*** *the warnings and alarms can effectively be turned off by setting the Temperature Alert Interval to a very large number.*

4.44 Set Temperature Notification Response

Response Code: 0x73

Function: Response to the request to set the read and write power for the specified antenna.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0x73	0x00/0x01	0xNN	0x0D	0x0A

Comments:

The status returned will be 1 if the command succeeds and 0 if it fails due to values being out of range.

4.45 Get Error List

Command: 0xE0

Function: Requests that the internal error list be returned.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0xE0	0xNN	0x0D	0x0A

Comments:

Note that the SensArray maintains a list of error codes and extended data for debugging internal errors. In a properly functional device, this list should be empty. This list may need to be queried when attempting to diagnose various errors. Note

that this list is persistent through a reset cycle if it is not due to the device losing power.

4.46 Get Error List Response

Response Code: 0xE1

Function: This response returns the list of internal errors.

SOF		Length		Response	Number of Errors
0xB9	0x9B	0x00	0x13	0xE1	N

When				Error Code		Data Word 1		Data Word 2	
Byte 1	Byte 2	Byte 3	Byte 4	Error Code (MSB)	Error Code (LSB)	DW1 (MSB)	DW1 (LSB)	DW2 (MSB)	DW2 (LSB)

. . .

CRC	EOF	
0xNN	0x0D	0x0A

Comments:

This response returns the internal errors that have been recorded since the SensArray was powered up or since the last time the error list was cleared. The number of errors recorded (up to a maximum of 32) will be returned. There will be one set of records (the second part of the table) returned for each error. The first 4 bytes provide the system uptime in seconds at which the error occurred. Note that the system uptime starts at zero after the initialization on first power up.

The next 2 bytes comprise the error code and the subsequent 2 pairs of bytes provide extended error information. The error codes are documented in the Appendix at the end of this document. Also, this will typically only be used during a problem diagnostic session. If you think you need to diagnose a malfunctioning device, please refer to the SensArray Troubleshooting Guide before contacting your technical support team.

4.47 Clear Error List

Command: 0xE2

Function: Requests that the internal error list be cleared. A subsequent request for the error list will return no errors until another internal error occurs.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0xE2	0xNN	0x0D	0x0A

4.48 Clear Error List Response

Response Code: 0xE3

Function: Response to the request to clear the internal error list.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0xE3	0x00/0x01	0xNN	0x0D	0x0A

Comments:

Note that this command never fails.

4.49 Set Reader Name

Command: 0xE4

Function: Set the name of the reader as reported in the heartbeat <ReaderName> field (see section 5 below).

SOF		Length		Command	Sensor Name			
0xB9	0x9B	0x00	0x08 + name length	0xE4	Char 1	Char 2	…	Char n

CRC	EOF	
0xNN	0x0D	0x0A

Comments: This field can be used as a unique name as it would appear in the heartbeat message to make identifying the sensor with a friendly name.

The length limit on this name is 31 characters.

4.50 Set Reader Name Response

Response Code: 0xE5

Function: Response to the request to set the name of the reader.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0xE5	0x00/0x01	0xNN	0x0D	0x0A

Comments: If the name sent over is between 1 and 31 characters in length, the status code returned will be 1, otherwise, the length is out of range and the status returned will be 0.

4.51 Get Bootloader Configuration

Command: 0xEA

Function: Request the current Bootloader configuration of the SensArray device.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0xEA	0xNN	0x0D	0x0A

4.52 Get Bootloader Configuration Response

Response Code: 0xEB

Function: Response to the request to return the current Bootloader configuration of the SensArray device.

SOF		Length		Response	Bootloader Port #	
0xB9	0x9B	0x00	0x0A	0xEB	Port MSB	Port LSB

CRC	EOF	
0xNN	0x0D	0x0A

Comments: The default bootloader port number is 3986. In hex, the Port MSB field would contain 0x0F and the Port LSB field would contain 0x92.

4.53 Set Bootloader Configuration

Command: 0xEC

Function: Set the Bootloader configuration of the SensArray device.

SOF		Length		Command	Bootloader Port #	
0xB9	0x9B	0x00	0x0A	0xEC	Port MSB	Port LSB

CRC	EOF	
0xNN	0x0D	0x0A

Comments: The allowed values for the bootloader port number are from 1024 to 65535. The default value is 3986. For this default value, the Port MSB field would be sent as 0x0F and the Port LSB field would be sent as 0x92. Use this command when port 3986 is already in use by another application running on your network.

4.54 Set Bootloader Configuration Response

Response Code: 0xED

Function: Returned response to the request to set the current Ethernet IPv4 configuration of the SensArray device.

SOF		Length		Response	Status	CRC	EOF	
0xB9	0x9B	0x00	0x09	0xED	0/1	0xNN	0x0D	0x0A

Comments:

The status value will return 1 on success, 0 if it fails. This command fails if the port number passed in is less than 1024. (Note that with 2 bytes, a value greater than 65535 cannot be passed in.)

4.55 Reboot

Command: 0xF0

Function: Reboot the sensor.

SOF		Length		Command	CRC	EOF	
0xB9	0x9B	0x00	0x08	0xF0	0xNN	0x0D	0x0A

Comments: The sensor is immediately rebooted when this command is received. Consequently, there is no response that is returned from the sensor back to the controlling application.

5 Broadcast Messages

5.1 Heartbeat

The heartbeat from the SensArray device is set up by default as a UDP broadcast (255.255.255.255) on port 3988. This can be reconfigured using command id 0x16 documented above. The following shows an example of the content of the heartbeat message.

```
<?xml version="1.0" encoding="UTF-8"?>
<Alien-RFID-Reader-Heartbeat>
  <HBCount>15</HBCount>
  <ReaderName>SensArray</ReaderName>
  <ReaderType>SensArray, Model: S33111-FCC</ReaderType>
  <IPAddress>192.168.1.150</IPAddress>
  <IPv6Address>fe80:0:0:0:5610:ecff:fe55:4f08</IPv6Address>
  <CommandPort>5000</CommandPort>
  <HeartbeatTime>30</HeartbeatTime>
  <MACAddress>54:10:ec:55:4f:08</MACAddress>
  <ReaderVersion>A.17.11.08.01</ReaderVersion>
  <OpMode>APP</OpMode>
</Alien-RFID-Reader-Heartbeat>
```

Note that the HBCount item is simply a counter that is incremented with each heartbeat message sent. One estimate of uptime can be gotten by multiplying this value by the HeartbeatTime item.

The default heartbeat interval (HeartbeatTime) is set to 30 seconds.

5.2 Events and Notifications

The SensArray can provides notifications for various events and faults. These are roughly modelled around SNMP traps. In the current version of the firmware, these are handled as UDP broadcasts (255.255.255.255) on port 3984. (Currently, these are not configurable, although, this may change in the future.)

5.2.1 Format

Protocol ID		Length	IP Address Type	IP Address of Sender			
0x01	0x01	0xNN	0x01 – IPv4	192	168	1	150

Timestamp ID	Timestamp			
0x10	MSB	Byte 2	Byte 3	LSB

Sequence # ID	Sequence Number			
0x11	MSB	Byte 2	Byte 3	LSB

Event ID	Event Data			
EventId	Byte 1	Byte 2	Byte 3	...

Field definitions:

Length: Total number of bytes in the message. For messages from IPv4 configured SensArray devices, the Length will be 19 plus the number of bytes in the Event Data.

IP Address Type: Currently, only IPv4 addresses are supported. In the future, a second option, 0x02, will be available for IPv6 configured devices.

IP Address of Sender: This is the four octal fields of the IP Address of the SensArray device originating the event or fault notification.

Timestamp: This provides the system uptime in seconds.

Sequence Number: This is a sequence number that is incremented each time a new notification is sent. This can be used to sort out messages that might arrive out of order, act as an indicator of missed messages, or be used to identify messages that are potentially duplicated due to multiple routes from the device to the server.

Event ID: This identifies the event type of the notification. Event IDs for specific notifications are provided below.

Event Data: Some events include data particular to the notification for additional informational or diagnostic purposes.

5.2.2 Device Online

Event ID: 0x01

Event Data: None

Function: Lets the server know that the device has just come online. This device does not keep track of wall clock time, so this provides a baseline event from which the

event timestamp can be used to approximate the wall-clock time of the event. This event will happen on both a power cycle reset and on a soft reset. In the case of a soft reset, this continues to increment, although, this loses accuracy as a total uptime indicator since the internal timer that increments the time is only active when the main application is running.

5.2.3 General Purpose Input(s) Changed

Event ID: 0x10

Event Data: One (1) byte indicating the new state of the general-purpose inputs. The least significant bit (bit 0) corresponds to GPI1, bit 1 corresponds to GPI2, bit 2 to GIP3, and bit 3 to GPI4.

Event Data Byte (7..0) = (0, 0, 0, 0, GPI4, GPI3, GPI2, GPI1)

Function: Notify when a general-purpose input changes. Note that the base state is assumed to be 0 for all 4 inputs. The state is checked when the reader boots, and a notice is sent if any of the inputs is non-zero. No notice is sent at bootup if all inputs are 0. Any other time an input changes, whether from on to off or off to on, a notice is sent.

5.2.4 Temperature Notification

Event ID: 0x20

Event Data: None

5.2.5 Temperature Warning

Event ID: 0xA0

Event Data: None

5.2.6 Temperature Alarm

Event ID: 0xA1

Event Data: None

5.2.7 Hardware Faults

5.2.7.1 Startup Fault

Event ID: 0xF0

Event Data: One (1) byte indicating subsystem where fault occurred.

Function: Provide early detection and diagnostics of hardware failures.

5.3 Error List Error Codes

Several errors can potentially be seen when the error list is queried. Most of these errors are related to hardware problems that are detected during the startup process. We will document the most common ones that occur during normal operation of the device here. If you should happen to see error codes that are not shown below, we would recommend that you write the error codes down and record any operating context that might help us debug the problem. After that, please clear the error list and reboot your reader. If that does not clear the error code, power the reader down and back up. Again, if the error code is still being reported, please contact SensThys technical support for help.

5.3.1 Error code 210

This indicates that the I2C bus that is used to read the status of the chip that provides outgoing PoE power to the Ethernet ports has stalled. Other than some informational monitoring while the reader is up, once the reader has booted and is providing outgoing PoE power, this error can be ignored. If this happens consistently on bootup and PoE output power is not being supplied, please contact technical support for help resolving this issue.

5.3.2 Error code 605

This error code appears when the module reports a problem while reading tags. The main cause of this is operating over the 85C temperature limit. This code will be reported twice with the first occurrence having a supplemental code of 0x82. When this error is reported, the embedded module stops reading tags until its internal temperature drops back below 85C at which point it resumes reading.

5.3.3 Error code 700

This code is reported most often when trying to change the network configuration, when restoring a saved configuration or resetting back to the default configuration. This is primarily associated with communications problems as network sockets are closed, then reopened so that communication can be properly established for the new network setup. If you see this error code and your configuration has not changed, repeat the operation that failed. Generally, with reasonably reliable network communications, the subsequent retry will succeed. Note that this problem will primarily occur during initial deployment and should not be an issue during subsequent operation.