GENERATIONS AHEAD IN SONAR & ULTRASONIC TECHNOLOGY

Serial Communications Guide

MassaSonic™ M-5000
Smart Ultrasonic Sensors

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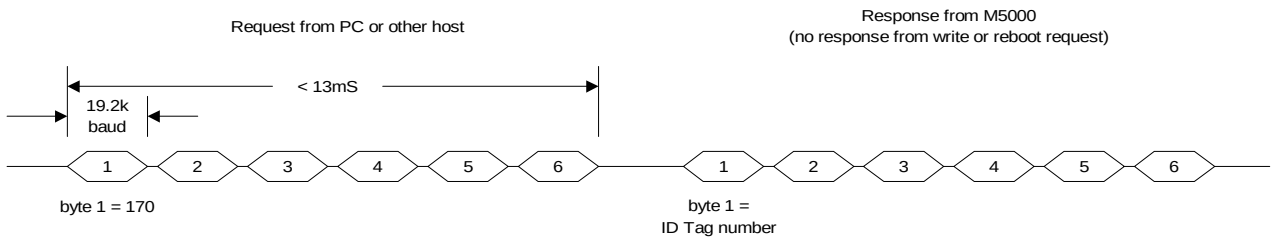
RoHS COMPLIANT

The MassaSonic™ M-5000 Smart Ultrasonic Sensor can be requested to output status, range distance, and temperature information digitally using the M-5000's RS-485 communications bus. Also included in this guide is the ability to read and reprogram the data parameters that will tailor the operation of the sensor. This data memory is non-volatile, thus retaining its value even when power is lost.

The flow charts in the latter part of this guide will aid the developer in properly accessing the data memory.

Communications Protocol

The data rate is set at 19.2 kbaud. Each byte contains 10 bits that include a start bit, 8 bit data, and 1 stop bit. There are a total of 6 bytes required to access the M-5000 and all 6 bytes must be sent within 13 mS or it will not be accepted. The M-5000 will respond back with 6 bytes for either status, data memory read requests, and system error messages on the RS-485 bus.



Request Status from the M-5000 Smart Sensor

There are a total of 6 bytes required to retrieve the status information from the M-5000. The data format is as follows:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	2 (status)
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

See pages 4 and 9 for the data format of the response from the M-5000 Smart Sensor to this request.

Request to READ from the M-5000 Smart Sensor's data memory

There are a total of 6 bytes required to access and read the data memory from the M-5000. The data format is as follows:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	104 (read)
4	Address of data memory	45 to 124
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

See page 4 for the data format of the response from the M-5000 Smart Sensor to this request. Included in this guide is the description of each data memory location (see pages 6-8).

Request to WRITE to the M-5000 Smart Sensor's data memory

There are a total of 6 bytes required to access and write data to the M-5000. The data format is as follows:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	103 (write)
4	Address of data memory	45 to 124
5	Data to be stored in memory	0 – 255 (see note below)
6	Checksum	sum of bytes 1 to 5, modulo 256

Request to Software Trigger the M-5000 Smart Sensor

If the M-5000's trigger mode is programmed for software trigger (memory location 101 = 4), the M-5000 will wait for a software trigger request before it transmits the next sample pulse. Page 7 describes the trigger mode options. Shown below is the data format to trigger the M-5000:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	1 (trigger sensor to transmit)
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

Note:
Included in this guide is the description of each data memory location (see pages 6-8). Note that there is no response from the M-5000 after a write request. You must read back from the data memory location for verification of acceptance of data by the M-5000 Smart Sensor. Also, each data memory location is limited to specific values as described in data memory description section. Any invalid data is replaced with default data upon reboot command or power up.

Response from M-5000 Smart Sensor when Status information is requested

Upon the M-5000 receiving the Status request, the M-5000 will respond back with 6 bytes of Status data with the format defined below if no error is active:

Byte	Description	Value
1	Sensor ID Tag No.	1 to 32
2	Response Code	8 bits parsed, see definition below
3	Range data byte (MSB)	xxxx xxxx 8 bit integer, no radix point
4	Range data byte (LSB)	x.xxx xxxx 8 bits, radix point after most significant bit
5	Temperature data	50 to 250, see note 4 below
6	Checksum byte	Sum of bytes 1 to 5, modulo 256

Status data byte parsed:

bit	7 6 5 4	Description	bit	Description	
	0 0 0 0	0% target strength	3	Echo Status Output	0=OFF 1=ON
	0 0 0 1	25% target strength	2	Setpoint Output A	0=OFF 1=ON
	0 0 1 0	50% target strength	1	Setpoint Output B	0=OFF 1=ON
	0 0 1 1	75% target strength	0	bit=1 if temperature out of range	
	0 1 0 0	100% target strength		(-25°C ≤ specified sensor temp. range ≤ +75°C)	
	0 1 1 1	System Error, see page 9			

Notes:
1. Range distance is defined in inches = xxxx xxxx x.xxx xxxx
2. Combining MSB & LSB as a 16 bit-integer, range distance in inches = xxxx xxxx xxxx xxxx / 128
3. After a timeout for no echo, MSB & LSB values = 0
4. Temperature data is defined in °C = (Value / 2) - 50
5. See Page 9 for the response if there is a sensor error

Response from the M-5000 Smart Sensor when requested a read from data memory

Upon the M-5000 receiving the read request, the M-5000 will respond back with 6 bytes of data with the format defined below:

Byte	Description	Value
1	Sensor ID Tag No.	1 to 32
2	Response Code	128 (read)
3	Address	address of data memory
4	Data memory	data from address in byte 3
5	Data memory	data from next higher address
6	Checksum	sum of bytes 1 to 5, modulo 256

Request for M5000 Smart Sensor Firmware Revision Level

There are a total of 6 bytes required to access the sensor's firmware revision level. Shown below is the data format required to receive this information:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	122
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

Response from the M-5000 Smart Sensor when requesting the Firmware Revision Level

Upon the M-5000 receiving the Firmware Revision Level request, the M-5000 will respond back with 6 bytes of data with the format defined below:

Byte	Description	Value
1	Sensor ID Tag No.	1 to 32
2	Response Code	130 (firmware revision level response code)
3	Firmware Revision	data
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

Request for M5000 Smart Sensor Model Code

There are a total of 6 bytes required to access the sensor's model type. Shown below is the data format required to receive this information:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	123
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

Response from the M-5000 Smart Sensor when requesting the Sensor Model Code

Upon the M-5000 receiving the Model Code request, the M-5000 will respond back with 6 bytes of data with the format defined below:

Byte	Description	Value
1	Sensor ID Tag No.	1 to 32
2	Response Code	131 (sensor model response code)
3	Sensor Model Code	0 = M5000/220, 1 = M5000/95
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

Addresses of data memory in the M-5000 Smart Sensor

You may read and write to the sensor locations described below. The M-5000 sensor will verify that you stay within product limits. If you write invalid data to any location, the M-5000 sensor will replace the invalid data with the product default values after a re-boot command or next power up. Do not write data to locations other than the ones listed here or the sensor may reload ALL locations to the product default values or operate unpredictably. Indication of an error or reload of defaults is only determined by requesting for status information. Values take effect only after power up or the reboot command.

ID Tag is address **45**. Values in this location must be between 1 and 32.

User Description Field is address **46** thru **77**. These values must be ASCII codes from 32 through 126.

Current Loop Span is address **78**. A "0" in this location will force the current loop to a 0 to 20mA output. A "1" will force the current loop output to 4 to 20 mA.

0/4 mA Distance is address **79** and **80**. Location 79 is the most significant byte. The distance is in inches and the radix point is placed as follows:

location 79 80
bbbb bbbb b.bbb bbbb (value limited to product specification)

20 mA Distance is address **81** and **82**. Location 81 is the most significant byte. The distance is in inches and the radix point is placed as follows:

location 79 80
bbbb bbbb b.bbb bbbb (value limited to product specification)

Loss of Echo Current is address **83**. Values allowed in this location are from 0 thru 4 and is defined as follows: 0 = 0mA, 1 = 3.5mA, 2 = 4.0mA, 3 = 20.0mA, and 4=20.5mA.

Close Setpoint Distance is address **84** and **85**. Location 84 is the most significant byte. The distance is in inches and the radix point is placed as follows:

location 79 80
bbbb bbbb b.bbb bbbb (value limited to product specification)

Far Setpoint Distance is address **86** and **87**. Location 86 is the most significant byte. The distance is in inches and the radix point is placed as follows:

location 79 80
bbbb bbbb b.bbb bbbb (value limited to product specification)

Setpoint Output A is address **88**. This location is defined to drive the state of Setpoint Output A. Zones set up by the "Close Setpoint Distance" and "Far Setpoint Distance" will drive the output, based on the average target distance and optionally hysteresis, by the following defined bit settings:
bit 3= "< Close Setpoint", bit 2= "Mid Zone", bit 1= "> Far Setpoint", and bit 0= "No Echo". A "0" in the bit location will turn the switch OFF and a "1" will turn the switch ON.

Setpoint Output B is address **89**. This location is defined to drive the state of Setpoint Output B. Zones set up by the "Close Setpoint Distance" and "Far Setpoint Distance" will drive the output, based on the average target distance and optionally hysteresis, by the following defined bit settings:
bit 3= "< Close Setpoint", bit 2= "Mid Zone", bit 1= "> Far Setpoint", and bit 0= "No Echo". A "0" in the bit location will turn the switch OFF and a "1" will turn the switch ON.

Addresses of data memory in the M-5000 Smart Sensor (continued)

Setpoint Output Hysteresis is address **90**. This location specifies the amount of hysterisis in %. The Close Setpoint Distance, Far Setpoint Distance, and Hysteresis must be chosen so that the Far Setpoint Distance with hysteresis applied is greater than the Close Setpoint Distance.

Echo Status Output with No Echo is location **91**. "0" is defined as "ON" and "1" is "OFF

Average is address **93**. This location is defined as follows: "0" = no average, "1" = ave. of 2, "2" = ave. of 4, "3" = ave. of 8, "4" = ave. of 16, "5" = ave. of 32, "6" = ave. of 64, "7" = ave. of 128, "8" = ave. of 256, "9" = ave. of 512, and "10" = ave. of 1024. The maximum average for the "Rolling" average type is 64.

Average type is address **94**. This location is defined as follows: "1" = rolling and "2" = boxcar.

No Echo Time Out is address **95**. This location is programmable from 1 to 255 representing the amount of consecutive missing echoes required before the sensor states a loss of echo condition.

Trigger Mode is address **101**. This location is defined as follows: "0" = normal, "1" = normal w/trig out, "2" = external trig in, "3" = external w/trig delay, and "4" = software trigger.

Trigger Delay is address **102**. This location is programmable from 1 to 255 representing the amount of delay in milliseconds (after an external trigger) for the sensor to start its transmit pulse. This is only used in the "External w/delay" mode.

Temperature Compensation is address **103**. This location is defined as follows: "0" = internal probe and "1" = manual (see location 104)

Manual Temperature Override is address **104**. This location is defined as follows: "50" = -25°C to "250" = 75°C (0.5°C/bit).

Setpoint Output "Mid Zone NO CHANGE" is address **105**. This location is defined as follows:
Bit 0 is will be used to operate Setpoint Output A. If bit 0 is a "0", then the operation of the Mid Zone for Setpoint Output A will be defined by bit 2 on location 88 (see **Setpoint Output A**). If bit 0 is a "1", then the operation of the Mid Zone for Setpoint Output A is "NO CHANGE".
Bit 1 is will be used to operate Setpoint Output B. If bit 1 is a "0", then the operation of the Mid Zone for Setpoint Output B will be defined by bit 2 on location 89 (see **Setpoint Output B**). If bit 1 is a "1", then the operation of the Mid Zone for Setpoint Output B is "NO CHANGE".

Sample Rate is address **117** and **118**. Location 117 is the most significant byte. The value represents the sample rate times 10. Thus the values in locations 117=0 and 118=1 will represent a sample rate of 0.1Hz.

Addresses of data memory in the M-5000 Smart Sensor (continued)

Error Code is address **124**.

Error Code byte parsed:

bit 7 6 5 4 3 2 1 0	Description
0 0 0 0 0 0 0 1	Unable to program M-5000
0 0 0 0 0 0 1 0	Reload default because a value was out of range
0 0 0 0 0 1 0 0	Not used
0 0 0 0 1 0 0 0	Signal fault – possible noise on line
0 0 0 1 0 0 0 0	Signal fault – Echo monitor Output line is under load.
0 0 1 0 0 0 0 0	Temperature probe fault
0 1 0 0 0 0 0 0	Sensor reset itself (watchdog)
1 0 0 0 0 0 0 0	Sensor reset do to low supply voltage (brown-out)

Note:
1. It is possible for more than one error to occur.

For more details on the description and operation of the M-5000 Smart Sensor, please review the MassaSonic™ M-5000 Smart Ultrasonic Sensor Installation and Operation Guide or access “Help” from the M-5000 software.

Response from the M-5000 Smart Sensor on a System Error

The M-5000 will indicate an error only when requesting for Status information. Upon the M-5000 receiving the Status request, the M-5000 will respond back with 6 bytes of Status data with the error format defined below:

Byte	Description	Value
1	Sensor ID Tag No.	1 to 32
2	Response Code	112 to 127
3	Error Code	8 bits parsed, see definition below
4	Placeholder byte	0
5	Temperature data	50 to 250
6	Checksum	sum of bytes 1 to 5, modulo 256

Error Code byte parsed:

bit 7 6 5 4 3 2 1 0	Description
0 0 0 0 0 0 0 1	Unable to program M-5000
0 0 0 0 0 0 1 0	Reload default because a value was out of range
0 0 0 0 0 1 0 0	not used
0 0 0 0 1 0 0 0	Signal fault – possible noise on line
0 0 0 1 0 0 0 0	Signal fault – Echo monitor Output line is under load.
0 0 1 0 0 0 0 0	Temperature probe fault
0 1 0 0 0 0 0 0	Sensor reset itself (watchdog)
1 0 0 0 0 0 0 0	Sensor reset because of low supply voltage (brown-out)

Notes:
1. It is possible for more than one error to occur.
2. Temperature data is defined in ºC = (Value / 2) – 50.

Resetting an M-5000 error

To reset all the errors in the M-5000 sensor you must clear both the non-volatile memory and RAM error bytes. First WRITE a "0" to location 124 to clear the error byte in non-volatile memory. Next send command code 125 to clear the error byte in RAM. Finally, restart the M-5000 Sensor by sending the Reboot command. See below for both the how to clear RAM and Reboot commands.

Request to clear the RAM Error Byte in the M-5000 Smart Sensor

There are a total of 6 bytes required to clear the RAM error in the M-5000. This command must be used after you WRITE a "0" to location 124 that cleared the error in the non-volatile memory. The resetting of the M-5000 will not take effect until the unit receives the Reboot command (see description on page 10). The data structure is as follows:

Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	125 (clear RAM error byte)
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

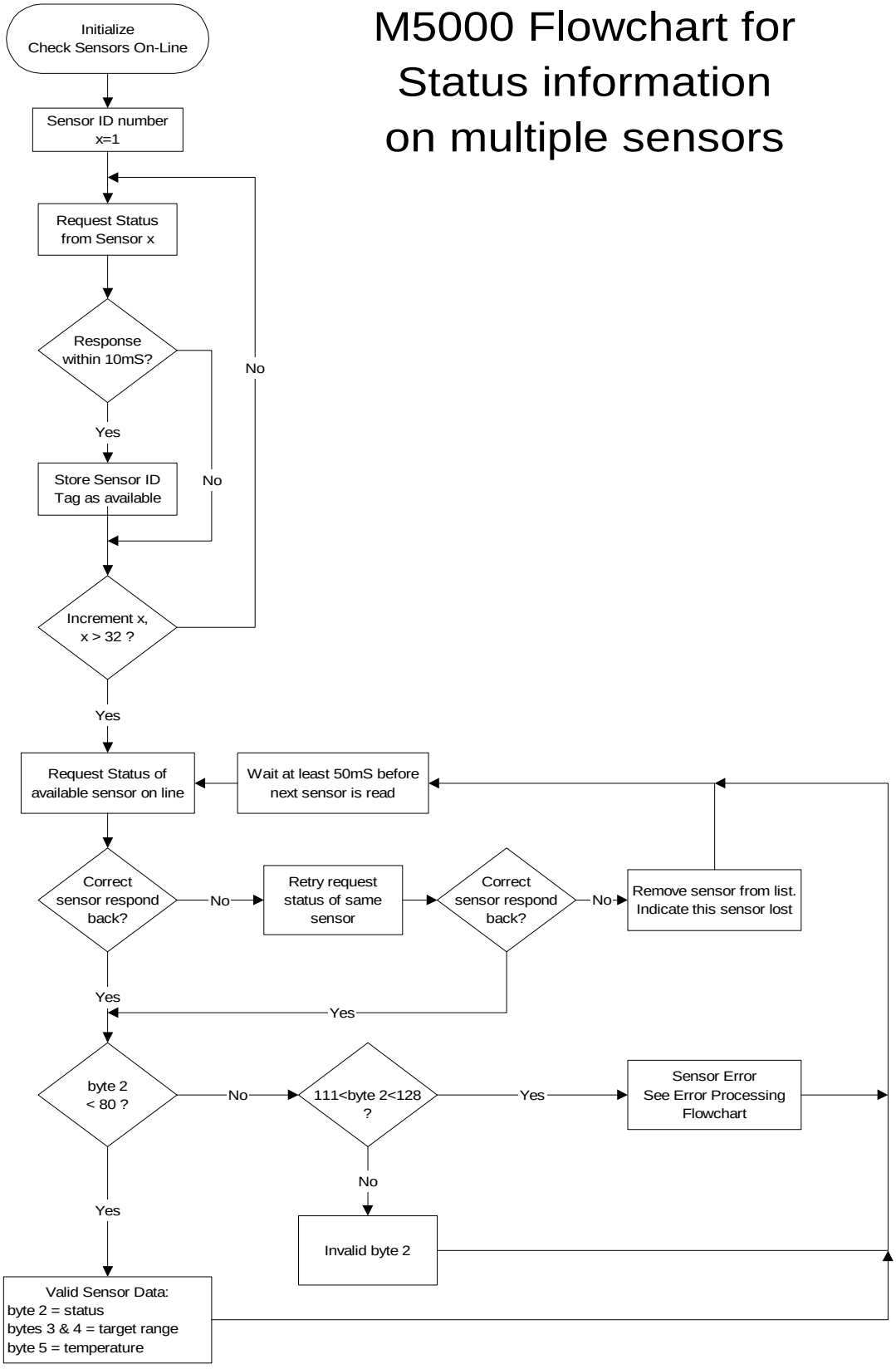
Request to Reboot the M-5000 Smart Sensor

There are a total of 6 bytes required to reboot the M-5000. This command must be used after you have completed writing to all M-5000 data memory locations. This reboot command will activate the changes implemented in data memory. Memory changes will not affect operation until the unit is re-booted, or after the next power up. The data structure is as follows:

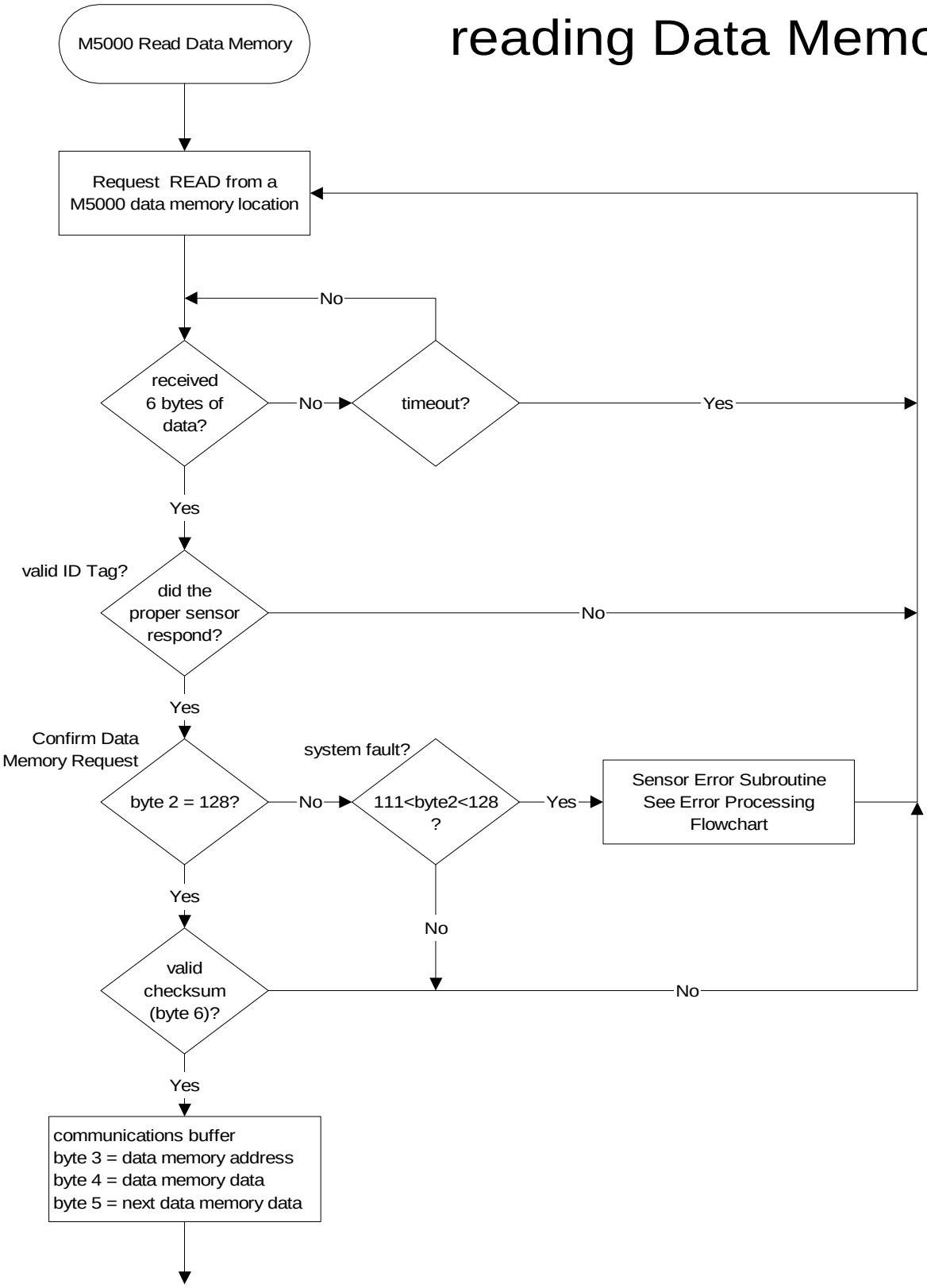
Byte	Description	Value
1	System Request	170
2	Sensor ID Tag No.	1 to 32
3	Request Code	119 (reboot)
4	Placeholder byte	0
5	Placeholder byte	0
6	Checksum	sum of bytes 1 to 5, modulo 256

The following pages contain flowcharts to be used as guides in developing your code.

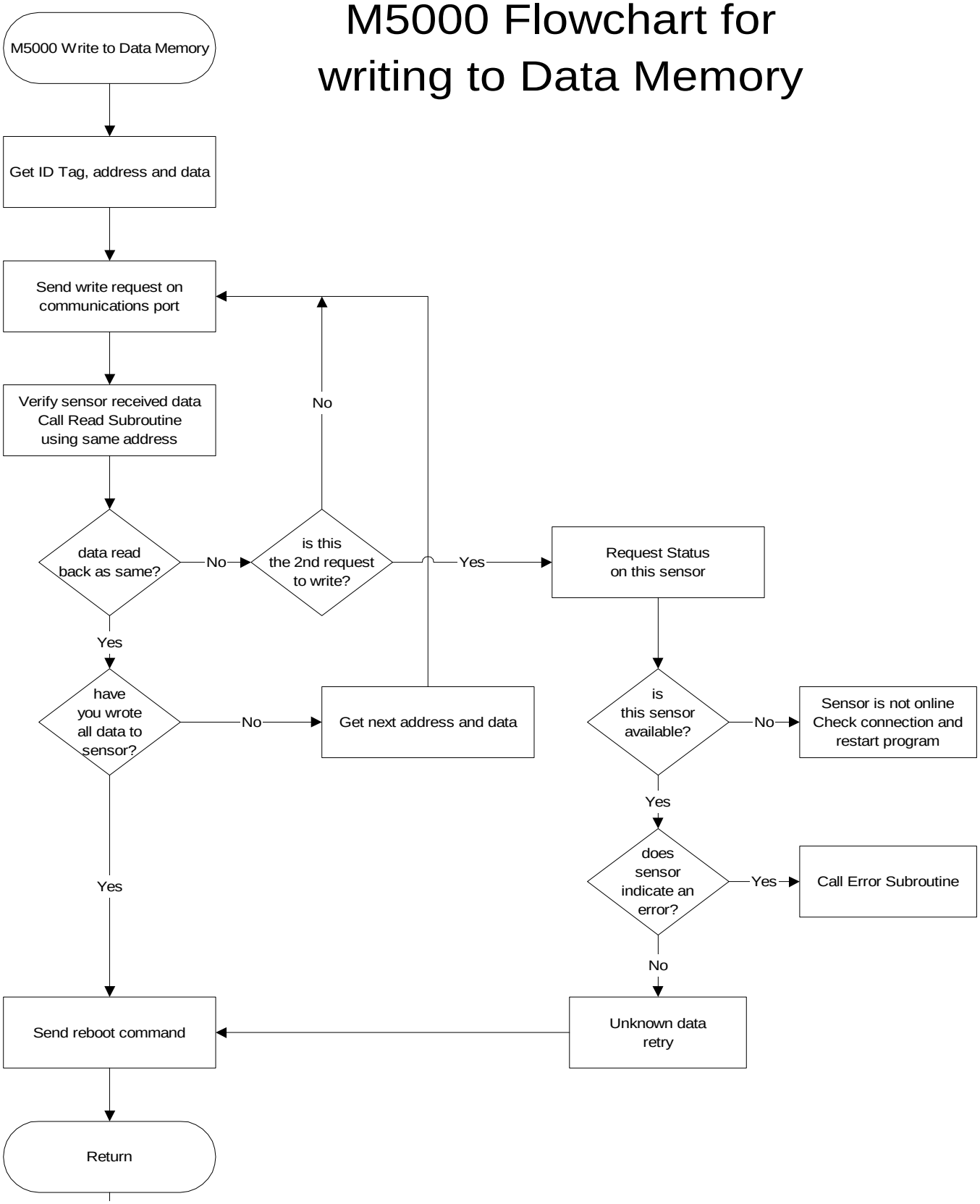
M5000 Flowchart for Status information on multiple sensors



M5000 Flowchart for reading Data Memory



M5000 Flowchart for writing to Data Memory



M5000 Flowchart for Error Processing