INTERFACE DESIGN SPECIFICATION

THRUSTER MOTOR CONTROLLER

RS485

28 December 2007

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1. INTRODUCTION

1.1 PURPOSE

This document specifies the RS485 interface for the Gen 2 SeaBotix Thruster Motor Controllers.

1.2 RESPONSIBILITY

The responsibility for preparation and maintenance of this document belongs to SeaBotix Inc. Engineering Department. Changes to this document shall be in accordance with established procedures.

1.3 SCOPE

This Interface Design Specification (IDS) provides the information required for the design of the computer programs which control the exchange of data across the interface, and for configuration control of Thruster Motor Controller interface. As such, it is a record of the agreed upon and approved interface control techniques, message format and contents, timing requirements, and disposition of exchanged data.

2. APPLICABLE DOCUMENTS

2.1 GENERAL

The documents applicable to this IDS are listed in Table I.

TABLE I. APPLICABLE DOCUMENTS

Document	Title
PIC18F4431 Data Sheet	**PIC18F2331/2431/4331/4431 Data Sheet** 28/40/44-Pin Enhanced Flash Microcontrollers with nanoWatt Technology, High Performance PWM and A/D

3. INTERFACE MESSAGE SUMMARY CROSS INDEX

3.1 GENERAL

This section is not needed in this IDS.

4. FIELD DEFINITION LIST

4.1 GENERAL

This section is not needed in this IDS.

5. NARRATIVE MESSAGE FLOW TABLE

5.1 GENERAL

This section is not needed in this IDS.

6. INTERCOMPUTER COMMUNICATIONS

6.1 General

This section describes the Thruster Motor Controller interface. It describes the hardware and software of the system interface, as well as supported protocols.

6.2 Hardware

The Thruster Motor Controller may use any processor that conforms to the RS485 interface specification.

The Thruster Motor Controller shall be capable of setting 102 discreet speed settings into the motor in both the forward and reverse directions. The forward direction shall turn the motor shaft in the counter-clockwise direction as viewed from shaft end. The reverse direction shall turn the motor shaft in the clockwise direction as viewed from shaft end.

The Thruster Motor Controller shall be capable of detecting water, ground fault, overtemp, stalled motor, or hall sensor (if applicable) errors.

6.3 Communication Protocols

The hardware and software employed in the support of this interface must support the industry standard RS485 mode of operation. Baud rate is 115200bps.

6.4 Interface Initialization

6.4.1 Thruster Motor Controller Application

Upon power-up, the Thruster Motor Controller shall configure the RS485 interface and enable receive operation.

6.5 Interface Shutdown

6.5.1 Thruster Motor Controller Application

No special processing is necessary.

6.6 Software

The following subsection specifies the conventions, data transfer procedures and timing requirements which shall be observed during communications between the LBV Motherboard and Thruster Motor Controller.

6.6.1 Normal Data Exchange

After power-up, the Thruster Motor Controller shall be ready to receive data and respond with the appropriate data as described in Section 8.

Upon receipt of the slave address write command, the Thruster Motor Controller shall configure to read the remaining bytes in the LBV message described in Section 8. In the event of an invalid checksum being received, the incoming message shall be discarded.

Upon receipt of slave address read command, the Thruster Motor Controller shall send the motor controller status as described in Section 8.

6.6.2 Error Recovery Procedures

In the event of an error, the Thruster Motor Controller shall ensure that their respective applications do not lock up the RS485 bus.

7. UNIQUE DATA UNIT DESCRIPTION

7.1 General

This section has been purposely left out due to the redundancy of this section to that provided in Section 8.

8. MESSAGE DESCRIPTIONS

8.1 GENERAL

This section provides a description of the format and content of each message transmitted across the Thruster Motor Controller RS485 interface. The technical data of each message is contained in the message format chart. The format and description conventions are as follows:

1. Message Format Chart - shows the position of each field carried by the message (by word and bit location).
    a) The message format is a visual representation of the data fields which comprise the message, arranged in word number sequence and by field (bit location) within each word. Bit numbers (locations) are presented in decimal at the top of the format. Word numbers, starting with word zero, are presented in decimal at the left side of the format. Field locations are indicated by abbreviated names (letters) within the format. A field that represents a constant will show the value in decimal unless otherwise stated. A field that is not used in the message is designated by an elongated dash. These fields must be set to zero by the sending program, however the receiving program must not assume these fields are zero. This allows the fields to be used for future interface updates. In sending and receiving programs, the elongated dash indicates that the field is available for other use. The size of the field is determined by the location of a field separator. The number of bits from either the beginning of a word or a field separator to either another field separator or ending of a word defines the field size. The Least Significant Bit (LSB) of a field is always the lowest bit number of a field in a word.
    b) Additional information, such as message identification, name, source, destination, purpose, timing constraints and remarks, are provided. The interdependency of fields within the message (if any) will be discussed in the message Remarks.
2. Message Description Tables – The message description tables describe each message, in word number and field location sequence, down to the bit level with a tabular representation of all data fields contained in the message as follows:
    a) Field Name/Symbol - The assigned functional name, symbolic representation (mnemonic), and unique data unit (if applicable) of the data field. When it is necessary to make some comment about an unnamed field (constant or unused), the field will be identified by bit position.
    b) Word - Positional information concerning the data field is identified by referencing the word number. By knowing the number of the word containing the data field, the Message Format Chart can be examined to determine the location and size of the data field.

c) Data Type - The terminology used to identify the specific data type is presented in the following table.

Terminology	Data Type
Character Data	
Char	ASCII Character (8 bits)
Floating Point Data	
Float	Float (32 bits)
Double	Double Precision (64 bits)
Integer Data	
Char	Integer (8 bits) signed
UChar	Integer (8 bits) unsigned
Short	Integer (16 bits) signed
UShort	Integer (16 bits) unsigned
Integer	Integer (32 bits) signed
UInteger	Integer (32 bits) unsigned

d) Range of Value – The data field type and expected upper and lower limits of the data field.

i) The limits, defining valid ranges of values to be transmitted, are expressed in decimal unless otherwise stated. When the number is a hex number, it will be shown with a "16" subscript. Where necessary, the meaning of a number is explained under the Remarks column. Where there is only one value, the word "fixed" appears in the column along with the constant value.

ii) When the range of value is limited only by the capacity of the character, integer, and floating point data types, the terms Float, Double, Integer, UInteger, Long, ULong, Short, and UShort are used rather than repeating the minimum and maximum values for each occurrence.

e) Remarks - Any special considerations or amplification of the data field. When enumerated data is used, the meaning will be explained under the associated remarks column. ON or SET conditions which are indicated by a single bit quantity shall be represented by a 1 unless otherwise indicated. OFF or NOT SET conditions which are indicated by a single bit quantity shall be represented by a 0 unless otherwise indicated. When single bit quantities are utilized for other states or conditions, they are described in the remarks column. Whenever an enumeration is marked "NA" (not applicable) the message transmitter may set the enumeration but the message receiver will not interpret the enumeration.

Units - The increment of metering the parameter, such as degrees, yards, seconds, if applicable will be shown in the remarks column.

Scaling - Applicable to a fixed point binary data field only. The scaling specifies the number of bits before and after the binary point. For example, a one byte temperature measurement with the binary point between bit 0 and 1 would be defined to have a scaling of 7-1. If the units for defining the scaling is other than binary, then the units, such as Octal or Hex, must be identified. Scaling if applicable will be shown in the remarks column.

8.2 Order of Precedence

In the event of a conflict with information within this document the information found in section 8 shall take precedence.

8.3 Messages to Thruster Motor Controller

Message Name: Thruster Motor Controller Speed Order

Destination: Thruster Motor Controller

Message Purpose: This message is used to order the Thruster Motor Controller to the desired speed.

Timing Constraints:

1. This message shall be sent to the Thruster Motor Controller whenever an update to the previously ordered thruster speed is required. This message also needs to be repeated at least every 10s to keep the thruster running at the set speed.

Message Format

ASCII String

Note that values in Range of Values are ASCII characters.
0 – F = 0x30 – 0x39, 0x41-0x46 $ = 0x24, ! = 0x21

Example:

$558000D5!

Message Format Chart

Char	0 7
0	SC
1	A1
2	A2
3	S1
4	S2
5	I1
6	I2
7	CSUM1
8	CSUM2
9	EC

Message Description Table

Field Name/Symbol	Char	Data Type	Range of Values	Remarks
Start Character/SC	0	UChar	$	Indicates the beginning of a message
Address1/A1	1	UChar	0 - F	This is the first character of the address in hex.
Address/A2	2	UChar	0 - F	This is the second character of the address in hex.

Speed1/S1	3	UChar	1 - E	This is the first character of the speed in hex. Indicates the ordered speed of the thruster. $7F_{16}$ and 80_{16} are zero speed. 81_{16} - $E6_{16}$ are forward speeds with $E6_{16}$ being max forward speed. $7E_{16}$ - 19_{16} are reverse speeds with 19_{16} being max reverse speed. Max forward and reverse speeds are currently set to 4500 rpm.
Speed2/S2	4	UChar	0 – F	This is the second character of the speed in hex. Indicates the ordered speed of the thruster. $7F_{16}$ and 80_{16} are zero speed. 81_{16} - $E6_{16}$ are forward speeds with $E6_{16}$ being max forward speed. $7E_{16}$ - 19_{16} are reverse speeds with 19_{16} being max reverse speed. Max forward and reverse speeds are currently set to 4500 rpm.
Additional Info1/I1	5	UChar	0 - F	This is the first character of the additional information byte in hex. Future growth.
Additional Info2/I2	6	UChar	0 - F	This is the second character of the additional information byte in hex. Future growth.
Checksum1 /CSUM1	7	UChar	0 – F	This is the first character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. This does not include the start character. Ex. – 0x55+0x80+0x00 = 0xD5. First character is "D" or 0x43.
Checksum2 /CSUM2	8	UChar	0 - F	This is the second character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. . This does not include the start character. Ex. – 0x55+0x80+0x00 = 0xD5. Second character is "5" or 0x35.
End Character/EC	9	UChar	!	Indicates the end of a message.

Remarks:

1. None.

Message Name: Thruster Motor Controller Read Command

Destination: Thruster Motor Controller

Message Purpose: This message is used to read the status of the Thruster Motor Controller.

Timing Constraints:

This message shall be sent to the Thruster Motor Controller whenever the user requires an update of thruster status information.

Message Format

ASCII String

Note that values in Range of Values are ASCII characters.
0 – F = 0x30 – 0x39, 0x41-0x46 $ = 0x24, ! = 0x21

Example:

$5555!

Message Format Chart

Char	0 7
0	SC
1	A1
2	A2
3	CSUM1
4	CSUM2
5	EC

Message Description Table

Field Name/Symbol	Char	Data Type	Range of Values	Remarks
Start Character/SC	0	UChar	$	Indicates the beginning of a message
Address1/A1	1	UChar	0 - F	This is the first character of the address in hex.
Address/A2	2	UChar	0 - F	This is the second character of the address in hex.
Checksum1 /CSUM1	3	UChar	0 – F	This is the first character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. For this message, this equals the first character of the address.
Checksum2 /CSUM2	4	UChar	0 - F	This is the second character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. For this message, this equals the second character of the address.
End Character/EC	5	UChar	!	Indicates the end of a message.

Remarks:

2. None.

Message Name: Thruster Motor Controller Reset Command

Destination: Thruster Motor Controller

Message Purpose: This message is used to reset the Thruster Motor Controller.

Timing Constraints:

This message shall be sent to the Thruster Motor Controller whenever the user wants to change the address back to factory default (0x55.) This does not require knowledge of the current address

Message Format

ASCII String

Note that values in Range of Values are ASCII characters.
0 – F = 0x30 – 0x39, 0x41-0x46 $ = 0x24, ! = 0x21

Example:

$0000!

Message Format Chart

Char	0 7
0	SC
1	C1
2	C2
3	CSUM1
4	CSUM2
5	EC

Message Description Table

Field Name/Symbol	Char	Data Type	Range of Values	Remarks
Start Character/SC	0	UChar	$	Indicates the beginning of a message
Command 1/C1	1	UChar	0	This is the first character of the address in hex.
Command 2/C2	2	UChar	0	This is the second character of the address in hex.
Checksum1 /CSUM1	3	UChar	0	This is the first character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. For this message, this equals the first character of the command.
Checksum2 /CSUM2	4	UChar	0	This is the second character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. For this message, this equals the second character of the command.
End Character/EC	5	UChar	!	Indicates the end of a message.

Remarks:

3. None.

Message Name: Thruster Motor Controller Change Address

Destination: Thruster Motor Controller

Message Purpose: This message is used to order the Thruster Motor Controller to the change addresses.

Timing Constraints:

This message shall be sent to the Thruster Motor Controller whenever the user requires an update to the previously ordered thruster address.

Message Format

ASCII String

Note that values in Range of Values are ASCII characters.
0 – F = 0x30 – 0x39, 0x41-0x46 $ = 0x24, ! = 0x21

Example:

$550B1070!

Message Format Chart

Char	0 7
0	SC
1	A1
2	A2
3	C1
4	C2
5	NA1
6	NA2
7	CSUM1
8	CSUM2
9	EC

Message Description Table

Field Name/Symbol	Char	Data Type	Range of Values	Remarks
Start Character/SC	0	UChar	$	Indicates the beginning of a message
Address1/A1	1	UChar	0 - F	This is the first character of the address in hex.
Address/A2	2	UChar	0 - F	This is the second character of the address in hex.
Command1/C1	3	UChar	0	This is the first character of the command. Command 0B changes the thruster address.
Command2/C2	4	UChar	B	This is the second character of the command. Command 0B changes the thruster address.
New Address1/NA1	5	UChar	0 - F	This is the first character of the new thruster address in hex. Address 0x00 is invalid.
New Address2/NA2	6	UChar	0 - F	This is the second character of the new thruster address in hex. Address 0x00 is invalid.
Checksum1 /CSUM1	7	UChar	0 – F	This is the first character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. This does not include the start character. Ex. – 0x55+0x0B+0x10 = 0x70. First character is "7" or 0x37.
Checksum2 /CSUM2	8	UChar	0 - F	This is the second character of the checksum byte in hex. Indicates the calculated eight bit unsigned addition without carry of the above fields. This does not include the start character. Ex. – 0x55+0x0B+0x10 = 0x70. Second character is "0" or 0x30.
End Character/EC	9	UChar	!	Indicates the end of a message.

Remarks:

4. None.

8.4 Messages from Thruster Motor Controller

Message Name: Thruster Motor Controller Read Response

Origin: Thruster Motor Controller

Message Purpose: This message is sent to identify the status of the Thruster Motor Controller.

Timing Constraints:
1. This message shall be sent upon receipt of the Thruster Motor Controller read command.

Message Format

ASCII String

Note that values in Range of Values are ASCII characters.
0 – F = 0x30 – 0x39, 0x41-0x46 $ = 0x24, ! = 0x21, etc

Example:

$550B1070!

Message Format Chart

Char	0 7
0	SC
1	A1
2	A2
3-8	S1 - S6
9	Space
10-12	C1-C3
13	Space
14-16	T1-T3
17	Space
18-20	TF1-TF3
21	Space
22-24	V1 – V3
25	Space
26-28	W1-W3
29	Space
30-32	ST1-ST3
33	Space
34-36	F1-F3
37	Space
38	CSUM1
39	CSUM2
40	EC

Message Description Table

Field Name/Symbol	Char	Data Type	Range of Values	Remarks
Start Character/SC	0	UChar	$	Indicates the beginning of a message
Address1/A1	1	UChar	0 - F	This is the first character of the address in hex.
Address/A2	2	UChar	0 - F	This is the second character of the address in hex.
Speed/S1-S6	3-8	UChar	0-9, -, or " "	The speed of the motor in RPM as a text string.
Space	9	UChar	" "	Space to separate values for readability.
Current/C1-C3	10-12	UChar	0-9 or " "	The current draw in Amps*10 as a text string.
Space	13	UChar	" "	Space to separate values for readability.
Temperature/T1 -T3	14-16	UChar	0-9 or " "	Motor winding temperature in Celsius as a text string.
Space	17	UChar	" "	Space to separate values for readability.
FET Temperature/ FT1- FT3	18-20	UChar	0-9 or " "	Controller FET temperature in Celsius as a text string.
Space	21	UChar	" "	Space to separate values for readability.
Voltage/V1-V3	22-24	UChar	0-9 or " "	Controller voltage as text string.
Space	25	UChar	" "	Space to separate values for readability.
Water Detect/W1-W3	26-28	UChar	0-9 or " "	Water detect ADC reading. Values range from 511 (5V) to 0. Water detect fails at 475, GFI fails at 340.
Space	29	UChar	" "	Space to separate values for readability.
Status/ST1 – ST3	30-32	UChar	0-9 or " "	Status byte. **Bits 4-7** Indicates the revision number of the Thruster Motor Controller software. 0 – Original thruster software for brushless motor with SeaBotix controller, all bits zero. **Bits 2-3** **Future growth** **Bit 1** 0 - Indicates brushed motor. 1 - Indicates brushless motor. **Bit 0** 0 - Indicates current limited version of the Thruster Motor Controller software. 1 - Indicates non current limiting version of the Thruster Motor Controller software.
Space	33	UChar	" "	Space to separate values for readability.
Faults/F1 – F3	34-36	UChar	0-9 or " "	Faults byte. Indicates the fault status of the thruster. Bit is set to indicate fault. Bit 0 – Overtemp Bit 1 – Stalled Motor Bit 2 – Hall Sensor Error Bit 3 – Ground Fault Bit 4 – Water Detect Bit 5 – (future growth) Bit 6 – (future growth) Bit 7 – (future growth)
Space	37	UChar	" "	Space to separate values for readability.
Checksum1	38	UChar	" " or 1-F	First character of checksum – see note
Checksum1	39	UChar	0-F	Second character of checksum – see note
End Character/EC	40	UChar	!	Indicates the end of a message.

Remarks:

1. In the event of an error being reported in the FAULT field, the thruster motor controller shall continue to communicate with the LBV motherboard.
2. In the event of a Water Detect error, the thruster motor controller shall continue driving the motor. This error occurs when the resistance between the water detect sensors is below one megohm and is an initial warning that there may be water in the thruster and the vehicle should be brought to the surface. If the resistance rises above one mega-ohm the fault flag clears.
3. In the event of a Ground Fault error, the thruster motor controller shall discontinue driving the motor. This error shall not be cleared until power is cycled on the thruster motor controller. This error occurs when the resistance between the water detect sensors drops below 100 kilo-ohms.
4. In the event of a Hall Sensor error, the thruster motor controller shall discontinue driving the motor. This error may be cleared when the thruster motor controller detects the hall sensors are in a normal state.
5. In the event of a Stalled Motor error, the thruster motor controller shall discontinue driving the motor. The brushless motor controller shall set the Stalled Motor fault when the duty cycle is above 8% and less than 3 hall sensor pulses are detected within 400ms.
6. In the event of an Overtemp error, the thruster motor controller shall discontinue driving the motor. The brushless motor controller shall set the Overtemp fault at 110C and clear the fault at 100C, at which time the thruster motor controller may continue driving the motor.
7. Checksum is calculated by adding the values in each of the fields and converting the last eight bits of the result to hex. Note that this does not include start character, stop character, or spaces. Also, the address field is in hex while the other fields are in decimal. Examples follow:

   $55 -3662 2 41 41 28 511 2 0 78!

   0x55 - 3662 + 2 + 41 + 41 + 28 + 511 + 2 + 0 = -2952 = 0xF478

   so last 8 bits are hex 78.

   $55 2019 1 37 37 28 511 2 0 A0!

   0x55 + 2019 + 1 + 37 + 37 + 28 + 511 + 2 + 0 = 2720 = 0x0AA0

   so last 8 bits are hex A0.