MBARI Sensor Controller (MSC) Interface Specification
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/* Power Control */
The MBARI Sensor Controller (MSC) will be powered via latching relays (K1 and K3) on the MBARI APF Muxer board. Once powered, the MSC will need approximately 5 -10 seconds to initialize.

Once initialization is complete the MSC will immediately enter into ultra-low power **Suspend Mode**, where it draws approx. 50 – 150 uA. The outputs (TxD and RTS) of the RS232 transceivers are disabled during **Suspend Mode**.

By staying in ultra-low power **Suspend Mode** the MSC can stay powered for the entire duration of the profile (typically 2.77 hours for a 1000m profile – accent rate is typically 10 cm/sec) thus avoiding a lengthy initialization period if it were power cycled for each sample (typically 75 samples per profile).

The MSC will measure input voltage and current as well as housing temperature and humidity and will include them as part of each sensor's data record. While sampling, the ISUS sensor components consume approx. 6.5W and the DuraFET sensor components consume approx. 700mW.

The MSC will automatically enter into **Shutdown Mode** should its input voltage fall below 7.5 VDC while it is sampling (see TS command). The MSC will automatically power shed all of its loads (spectrometer and lamp) and log the error condition before entering **Shutdown Mode**.

No external bulkhead connector shall be used to connect the MSC to the "outside world".

/* Command Mode */
The MSC is managed via a master/slave arrangement; the APF controller acts as the "master" and the MSC as the "slave". The MSC will receive and respond to commands sent to it from the APF controller. When powered, the MSC initializes and then immediately enters **Suspend Mode.** Any serial "traffic" on its input (RxD, J1-4) will wake the MSC within 1 second. When the MSC is taken out of **Suspend Mode** it will immediately enter **Command Mode** where it will receive and respond to commands sent to it. The MSC asserts its RTS output (CTS input on APF) while in **Command Mode,** this includes **Menu Mode**. If it doesn't receive any input (commands) within 15 seconds it clears its RTS output and enters back into **Suspend Mode**. To prevent a permanent power on condition the MSC will automatically enter **Shutdown Mode** after 10 hours of continuous operation since the last power up.

<u>The MSC command set is as follows:</u>

(**W**)

Acknowledge the MBARI Sensor Controller is "awake" and ready to respond to commands.

Example: APF sends a W and MSC sends an "ACK" string.

(**C**)

Get ISUS|DURA configuration information. This command would typically be sent only once, upon initial power up (start of profile) and the values would be included as part of the sensor's data for each profile. Which configuration info is sent (ISUS or DURA) depends on the state of the MODE command.

Example: APF sends a C and MSC sends a formatted set of strings that lists the selected sensor's configuration info.

(**E**)

Get MSC_error counter value and event time (non-volatile). This command would typically be sent only twice, first at power up (start of profile) and then again at the end of the profile. If the two values don't agree then ISUS or DURA has experienced at least one error condition during the profile (see SE command for error message retrieval). Which error info is sent (ISUS or DURA) depends on the state of the MODE command.

Example: APF sends an E and MSC sends back as an acknowledgement "ACK,E,ULONG_ERROR_COUNTER_VALUE, ULONG_ESECS_LAST_ERROR_TIME".

(P)

Get MSC power on and system reset counter values and event time (non-volatile). This command would typically be sent before each sample during the profile. If there is a mismatch then the MSC has experienced a RESET/REBOOT. Possible sources could include a run-time error followed by a RESET from the hardware watchdog timer, or, a power fail condition during **Suspend Mode**.

Example: APF sends a P and MSC sends back as an acknowledgement "ACK,P, ULONG_POWER_CYCLE_COUNTER_VALUE,ULONG_SYS_RESET_COUNTER_VALUE, ULONG_ESECS_LAST_RESET_TIME".

(**S**)

Get MSC sample counter value (non-volatile). This command can be used at any time to obtain the total number of samples collected by either ISUS or DURA and the time of the last sample collection. Which counter values are sent (ISUS or DURA) depends on the state of the MODE command.

Example: APF sends an S and MSC sends back as an acknowledgement ACK,S, ULONG_SAMPLE_COUNTER_VALUE, ULONG_ESECS_LASTSAMPLE_TIME.

(**T**)

Get the time (in seconds) it took MSC to collect the last sample (see TS command). This command is meant for interface development purposes but can be useful in verifying the presence of a valid sample too. Should the APF issue the T command prior to having issued the TS command, that successfully completed, the MSC will respond with a "NAK,T,-1.0"

Example: APF sends a T and MSC sends back as an acknowledgement "ACK,T, FLOAT_LAST_DATA_AQUISITION_TIME. Which time values are sent (ISUS or DURA) depends on the state of the MODE command.

(**OFF**)

Put MSC into **Shutdown Mode**, This command would typically be sent at the end of a profile.

Example: APF sends "OFF" and MSC sends back as an acknowledgement, "ACK,OFF".

(**TS**)

Collect an ISUS or DURA data record
When the APF sends "TS" (take sample), the MSC will collect a single data record, which will not normally be greater in size than 333 Bytes and will be formatted as a CSV null terminated ASCII string. It will typically take 5-10 seconds from the time the MSC has received the command to the time data acquisition is complete. Since there is a delay, the MSC will first acknowledge receipt of the command then acknowledge the state of the actual data acquisition. To acknowledge the command the MSC will immediately return "ACK,TS,CMD". To acknowledge the state of the data acquisition, the MSC will return "ACK,TS,DAT" if successful or "NAK,TS,DAT" if unsuccessful. If data acquisition was unsuccessful no data will be available for retrieval (see SL command). Note, the "CTD" command (see below) is typically sent prior to issuing the "TS" command as the CTD values (temperature and salinity) are used by ISUS to make "on-the-fly" temperature corrections to the Bromide calibration spectra as well as for fixing the Bromide (salinity) concentration within the fitting algorithm. The CTD values have no current meaning as it relates to the DuraFET. The passed CTD values are included within the ISUS and DURA data record. Which instrument gets sampled (ISUS or DURA) depends on the state of the MODE command.

(**SL**)

Send the last ISUS or DURA data record
When the APF sends "SL" (send last) the MSC will transmit its data record, if present. If there is no data record available the MSC will return "NAK,SL". Data records are only maintained while the MSC is in the current instance of **Command Mode**. Should the APF issue the SL command prior to having issued the TS command, that successfully completed, the MSC will respond with a "NAK,SL". The first field of the data record will contain the record's 16 bit CRC which can be verified by the APF controller. If there is a mismatch between them, the APF can request the data record be sent again by issuing another SL command. Which instrument data gets sent (ISUS or DURA) depends on the state of the MODE command.

(**SLP**)

Put MSC in **Suspend Mode**, This command would typically be sent right after MSC has sent its data records via the SL command and the APF has successfully verified the record's CRC.

Example: APF sends "SLP" and MSC sends back as an acknowledgement, "ACK,SLP".

(**INIT**)

Initialize MSC for deployment. This command would typically be sent only once, upon initial deployment or at anytime it would be necessary to set the MSC values to their preset values.

Example: APF sends "INIT" and MSC sends back as an acknowledgement, "ACK,INIT". The following values are currently being initialized: reset error counter to zero, reset power cycle counter to zero, reset deployment counter (# of samples taken) to zero, set the error file size limit to the default value, set the ISUS fit window to its default values.

(**RTC**)

Set the MSC Realtime Clock, using the GPS corrected APF controller time. Time value is epoch 1970. This command would typically be sent only once, upon initial MSC power up (start of profile).

Example: APF sends "RTC, ULONG_ESECS_SENT" and MSC sends back as an acknowledgement, "ACK,RTC,ULONG_ESECS_READ, ULONG_ESECS_RTCVAL". If both ESECS_SENT and ESECS_READ agree, APF sends an "ACK". If ISUS doesn't receive an ACK, within 3 seconds, the value sent is discarded. If the value sent doesn't pass range checking MSC will reply with a "NAK,RTC,STR_ERR_MSG".

Get MSC Realtime Clock value.

Example: APF sends "RTC, ?" and ISUS sends back the current value in the following format. "ACK,RTC?,ULONG_ESECS_RTCVAL".

(**CTD**)

Send the most recent CTD values to the MSC.

Example: APF sends "CTD, ULONG_CTD_TIME_SENT, FLOAT_CTD_TEMP_SENT, FLOAT_CTD_SAL_SENT, FLOAT_CTD_DEPTH_SENT" and MSC sends back as an acknowledgment, "ACK,CTD, ULONG_CTD_TIME_READ, FLOAT_CTD_TEMP_READ, FLOAT_CTD_SAL_READ, FLOAT_CTD_DEPTH_READ". If both agree, APF sends an "ACK". If the MSC doesn't receive an ACK, within 3 seconds, the values sent are discarded. If the values sent don't pass range checking the MSC will reply with a "NAK,CTD,STR_ERR_MSG".

Read the current CTD values being used by the MSC.

Example: APF sends "CTD,?" and MSC sends back the current values in the following format: "ACK,CTD?,ULONG_CTD_TIME, FLOAT_CTD_TEMP,FLOAT_CTD_SAL, FLOAT_CTD_DEPTH".

(**FIT**)

Set ISUS fit window values. This command will be a "remote" command that is initially set on the shore side and which propagates to the float via the telemetry system and is finally set on the MSC. This typically needs to occur only once, upon initial MSC power up (start of profile). The default (see INIT command) fit window range is [217, 240] nm.

Example: APF sends "FIT, INT_WL_BEG_SENT, INT_WL_END_SENT" and MSC sends back as an acknowledgement, "ACK,FIT, INT_WL_BEG_READ, INT_WL_END_READ". If both agree, APF sends an "ACK". If the MSC doesn't receive an ACK, within 3 seconds, the values sent are discarded. If the values sent don't pass range checking ISUS will reply with a "NAK,FIT,STR_ERR_MSG".

Get MSC fit window values.

Example: APF sends "FIT,?". The MSC sends back the current values in the following format. "ACK,FIT?,INT_WL_BEG,INT_WL_END".

(**SPECTRA**)

Set reported (see SL command) ISUS spectra data range. This command will be a "remote" command that is initially set on the shore side and which propagates to the float via the telemetry system and is finally set on the MSC. This typically needs to occur only once, upon initial MSC power up (start of profile). The default (see INIT command) reported spectra data range is [217, 250] nm.

Example: APF sends "SPECTRA, INT_WL_BEG_SENT, INT_WL_END_SENT" and MSC sends back as an acknowledgement, "ACK,SPECTRA, INT_WL_BEG_READ, INT_WL_END_READ". If both agree, APF sends an "ACK". If MSC doesn't receive an ACK, within 3 seconds, the values sent are discarded. If the values sent don't pass range checking the MSC will reply with a "NAK,SPECTRA,STR_ERR_MSG".

Get MSC data window values.

Example: APF sends "SPECTRA,?". The MSC sends back the current values in the following format. "ACK,SPECTRA?,INT_WL_BEG,INT_WL_END".

(**BAKE**)

Activates the ISUS UV lamp for a defined period of time, the UV exposure can, in some cases, act as a biocide. This command will be a "remote" command that is initially set on the shore side and which propagates to the float via the telemetry system and is finally sent to the MSC. This command will typically be used when the ISUS optics appear to be fouling. Since there is a delay, as defined by the lamp on time, ISUS will first acknowledge receipt of the command then acknowledge the state of the actual lamp cycling.

Example: APF sends 'BAKE, INT_DURATION" and MSC immediately sends back "ACK,BAKE,CMD,INT_DURATION" to acknowledge the command. If both passed values agree, APF sends an "ACK". If the MSC doesn't receive an ACK, within 3 seconds the command is rejected. If the value sent doesn't pass range checking the MSC will reply with a "NAK,BAKE,STR_ERR_MSG". After accepting the command the MSC will acknowledge the state of the lamp cycling by returning "ACK,BAKE,STAT" if successful or "NAK,BAKE,STAT" if unsuccessful.

(**SE**)

Retrieve MSC error messages. The error log is typically retrieved at the end of a profile (see E command). Since it can take a few seconds for the MSC to respond with the number of pending records, a timeout of 5-7 seconds is suggested. During operation if the error log grows beyond a user defined limit (128kB typ.), the MSC removes the file and logs a file removal message into a newly created error log. The MSC will reply with a NAK,SE,INT_ERR_CODE should there be a file access error. All error records are stored by the MSC in a common file (C:\ERROR.LOG).

Example: APF sends "SE,?" and MSC sends back as an acknowledgement, "ACK,SE?,n" where n is the number of data records pending. To avoid a serial overflow condition on the APF controller ISUS will only send one record at a time. The APF controller will request each record, one at a time, by sending an SE string. After all of the records have been successfully sent the MSC will remove the file and send as an acknowledgement "EOF". The "EOF" string should not be interpreted as data.

(MODE)

Determines which sensor “mode” the MSC will use when sampling (see TS command). The selection range is [0,2], with 0 = No Sensor, 1 = ISUS and 2 = DuraFET .The Mode value is always set to 0 (no sensor selected) every time the controller enters **Command Mode**. All previous data (see T and SL commands) are cleared whenever the mode value is changed. The following commands are affected by the state, or change of state, of the MODE command: [C,E,S,T,TS and SL].

Example: APF sends "MODE,ULONG_MODE" and MSC sends back as an acknowledgement, "ACK,MODE,ULONG_MODE”. If both agree, APF sends an "ACK". If MSC doesn’t receive an ACK, within 3 seconds, the values sent are discarded. If the values sent don’t pass range checking the MSC will reply with a “NAK,MODE,STR_ERR_MSG”.

Get MSC MODE value.

Example: APF sends "MODE,?”. MSC sends back the current state in the following format. “ACK,MODE?,ULONG_MODE”.

/* MSC Errors */
Should the MSC encounter an internal error, for whatever reason, it will increment an error record counter (see E command) and will store the associated error message within a log. The error counter value is also included within the MSC data record (see SL command). The error log contents should be retrieved (see SE command) prior to placing the MSC into **Shutdown Mode**.

/* MSC Recovery Mode */
Listed below are the steps to be taken to put the CF2 into a known state as part of a **Recovery Mode** for the MSC. Note, the APF9 will always attempt to use /WAKE first as this will normally force the CF2 out of any pending **Suspend Mode**. Interrupting a CF2 suspend cycle with a power cycle can lead to serious problems but the application checks for this internally and an external remedy (Final Attempt) is provided as well.

FIRST ATTEMPT: Send characters to assert /WAKE low via a NPN circuit driven by RxD (J1-3). Note, the application is normally in **Suspend Mode** and this is the default way of "waking" the controller and getting access to the command interpreter. See W command above.

SECOND ATTEMPT: Send an extended BREAK to assert /WAKE low via a NPN circuit driven by RxD (J1-3).

FINAL ATTEMPT: Force the CF2 into its Permanent Boot Monitor (PBM) and reboot the application:

1. Power the MSC OFF for approx. 5-10 seconds.
2. Assert /IRQ5 low via a NPN circuit driven by CTS (J1-6).
3. Power the MSC back ON.
4. This should vector the CF2 into running the Permanent Boot Monitor (PBM).
5. Release /IRQ5 via a NPN circuit driven by CTS (J1-6).
6. From the PBM prompt issue the following command: "pico". This will vector the CF2 into running PicoDOS.
7. From the PicoDOS prompt issue the following command: "ccc 1" (this will clear the SRAM keys still present from any broken suspend mode).
8. From the PicoDOS prompt issue the following command: "app" (this will launch the application).

/* MSC Gateway Mode */

The APF controller can be commanded to enter into **Gateway Mode** whereby all serial I/O to the APF controller, via the SAIL loop, will be redirected to the MSC communications port. This will allow for direct communications to the MSC from the "outside world" which is necessary for configuration, testing and troubleshooting. Should the APF controller not receive any input within a predefined timeout period (say, 3 mins) the APF controller will automatically exit from **Gateway Mode**.

/* MSC Power and Communications Connections to the MBARI APF Muxer */

The MSC will be powered by four ElectroChem CSC93 30Ah cells wired in series (15.6 VDC nom.). The input voltage range for the MSC power supply is [7-22 VDC]. If the voltage level drops below 7.5 VDC when the ISUS sensor is sampling, the MSC will enter into **Shutdown Mode.** Power connection is made at J8-1 (+) and J8-2 (-) on the MSC PCB.

The backup power supply for the DuraFET ph data acquisition daughter board shall be powered by three Tadiran TL-5937C 40Ah cells diode ORed in parallel via an **electrically isolated** array of Schottky diodes. The diode ORed output voltage of the three cells is connected to J8-3 (+) and J8-4 (-) on the MSC PCB.

/* MSC Wiring/Connections with MBARI MUXER */

WIRE	FUNCTION	MSC CONNECTION	MUXER CONNECTION
20AWG	APF_PWR	MSC J8-1	MUXER PER POWER J5.5 (K1)
20AWG	APF_GND	MSC J8-2	MUXER PER POWER J5.6 (K1)
22AWG	DURA BACKUP PWR	MSC J8-3	MUXER PER POWER J5.9 (K3)
22AWG	DURA BACKUP GND	MSC J8-4	MUXER PER POWER J5.10 (K3)
24AWG	APF_RS232_RXD	MSC J1-3	MUXER SERIAL J1.3
24AWG	APF_RS232_CTS	MSC J1-5	MUXER SERIAL J1.4
24AWG	APF_RS232_TXD	MSC J1-4	MUXER SERIAL J1.5
24AWG	APF_RS232_RTS	MSC J1-6	MUXER SERIAL J1.6

DO NOT MAKE ANY GROUND CONNECTION TO THE MSC OTHER THAN THOSE SHOWN ABOVE.