Raw Output Data Format

Data output from the SBE 11 Interface (RS-232 or IEEE-488) is raw data - frequencies and A/D voltages. This raw data can be saved in a .hex file.

Note:
MSB = most significant bit
LSB = least significant bit

IEEE-488 Output

Data is output in the following order:

Word	Byte	Description	Discussion
0	0-2	Primary temperature	Frequency f = (Byte 0 * 256) + Byte 1 + (Byte 2 / 256)
1	3-5	Primary conductivity	Frequency f = (Byte 3 * 256) + Byte 4 + (Byte 5 / 256)
2	6-8	Pressure	Frequency f = (Byte 6 * 256) + Byte 7 + (Byte 8 / 256)
3	9-11	Secondary temperature	Frequency f = (Byte 9 * 256) + Byte 10 + (Byte 11 / 256)
4	12-14	Secondary conductivity	Frequency f = (Byte 12 * 256) + Byte 13 + (Byte 14 / 256)
5	15	A/D channel **0** (8 MSBs)	Each 12-bit number (N) is a binary representation of analog voltage. N's value is 4095 for 0 volts, 0 for 5 volts: V = 5 (1 - [N / 4095]) *Example:* Byte 15 = **00110111** Byte 16 = **0100**1111 For A/D channel 0, N = **001101110100** = 884 decimal V = 5 (1 - [884 / 4095]) = 3.921 volts
	16	A/D channel **0** (4 LSBs 4-7) & **1** (4 MSBs 0-3)	
	17	A/D channel **1** (8 LSBs)	
6	18	A/D channel **2** (8 MSBs)	
	19	A/D channel **2** (4 LSBs 4-7) & **3** (4 MSBs 0-3)	
	20	A/D channel **3** (8 LSBs)	
7	21	A/D channel **4** (8 MSBs)	
	22	A/D channel **4** (4 LSBs 4-7) & **5** (4 MSBs 0-3)	
	23	A/D channel **5** (8 LSBs)	
8	24	A/D channel **6** (8 MSBs)	
	25	A/D channel **6** (4 LSBs 4-7) & **7** (4 MSBs 0-3)	
	26	A/D channel **7** (8 LSBs)	
9	27	Unused	Surface PAR: 12-bit number (N) is binary representation of analog voltage. N's value is 0 for 0 volts, 4095 for 5 volts: V = N / 819 *Example:* Byte 34 = 1111**0011** Byte 35 = **01110100** N = **001101110100** = 884 decimal V = 884 / 819 = 1.079 volts
	28	First 4 bits unused Surface PAR channel (4 MSBs 0-3)	
	29	Surface PAR channel (8 LSBs)	
10	30	Pressure sensor temperature (8 MSBs)	**Pressure sensor temperature**: 12-bit number is binary representation of temperature, ranging from 0 to 4095 (2500 corresponds to approximately 22 ºC, typical room temperature). **CTD status**: • Bit 0 Pump status - 1 = pump on, 0 = pump off. • Bit 1 Bottom contact switch status - 1 = switch open (no contact), 0 = switch closed. • Bit 2 G.O. 1015 water sampler interface confirm signal or manual pump control signal - 1 = Deck Unit detects confirm signal from G.O. 1015 or detects manual pump control installed in 9*plus*, 0 = not detected. • Bit 3 CTD modem carrier detect - 0 = CTD modem detects Deck Unit modem carrier signal, 1 = not detected.
	31	Pressure sensor temperature (4 LSBs 4-7) CTD status (0-3)	
	32	Modulo count (EOI line asserted).	8-bit number from CTD increments 1 count for each scan (cycles from 0 to 255, then restarts at 0). If Deck Unit averages data, modulo increments by number of scans averaged. Modulo provides a check on data integrity. Missed scans caused by sea cable errors cause *jumps* in the count.
End of scan	-	NMEA data	See *Section 6: Setting Up NMEA Interface*.

To reduce data storage space requirements, the Deck Unit can suppress unused words, based on the system configuration, from the data stream. For example:
- If secondary temperature and conductivity sensors are not used, words 3 and 4 can be stripped from the data stream.
- If not all A/D channels are used, the unused words can be stripped from the data stream (words 5 through 8 as applicable). Words are suppressed from last to first. For example, for a system with only two A/D voltage words, the channels are V0, V1, V2, and V3.
- If Surface PAR is not used, word 9 can be stripped from the data stream.

This suppression is done automatically if using Seasave. The information in the instrument configuration (.xmlcon or .con) file is used by Seasave to automatically program the Deck Unit to delete unused words.

If words are suppressed, the listing above is shortened. For example, for a system with CTD only (secondary temperature and conductivity, all A/D channels, and Surface PAR all suppressed; and no NMEA data), the IEE-488 output is:

Word	Byte	Description
0	0-2	Primary temperature
1	3-5	Primary conductivity
2	6-8	Pressure
3	9	Pressure sensor temperature (8 MSBs)
	10	CTD status (4 LSBs) Pressure sensor temperature (4 MSBs)
	11	Modulo count (EOI line asserted)

RS-232 Output

Data output format is the same as described above for IEE-488 output, **except**:

- Each byte is sent as two ASCII-encoded characters. The first character is the hexadecimal representation of the most significant 4 bits; the second character is the hexadecimal representation of the least significant 4 bits.

  For example, a byte with a value of 42 (base 10) or 2A (hexadecimal) is sent as:
  First character 32 (ASCII for 2)
  Second character 41 (ASCII for A)

- The two characters representing the modulo count is preceded by two pressure sensor temperature characters and two *zero* characters. The modulo characters are followed by a carriage return character (0D, base 16) and then a line feed character (0A, base 16). Thus, the number of **characters per scan** is:

  (words/scan * 3 bytes/word * 2 characters/byte) + 2 (carriage return & line feed)

  For example, for a 4-word data stream:
  (4 words/scan * 3 bytes/word * 2 characters/byte) + 2 = 26 characters

- NMEA data is output on a line by itself, once per second, instead of being appended to the end of each scan.

Calculation of Engineering Units in Seasave

Seasave allows you to select raw (frequencies and voltages) and/or converted data (decibars, ºC, etc.) for display during data acquisition. Seasave calculates converted data in engineering units by applying the calibration coefficients in the configuration (.xmlcon or .con) file to the raw data from each sensor.

Each sensor's Calibration Sheet lists its calibration coefficients as well as the equation used by Seasave to derive engineering units from the raw data. An exception is the calculation of pressure temperature compensation for the Paroscientific Digiquartz pressure sensor, which is described below:

Pressure Temperature Compensation

$T_D = M * (12\text{-bit pressure temperature compensation word}) + B$ (°C)
Where M = AD590M and B = AD590B from the calibration sheet

Raw pressure temperature compensation has a decimal value between 0 and 4095.

Example:
Byte 30 = **10101000** Byte 31 = **0001**0101
M = 0.01258 and B = -9.844 (from calibration sheet)

N = **101010000001** binary = 2689 decimal
$T_D = (0.01258 * 2689) – 9.844 = 23.98$ °C

Pressure temperature is computed using a backward-looking 30-second running average to prevent bit transitions in pressure temperature from causing small jumps in computed pressure. Because the heavily insulated pressure sensor has a thermal time constant on the order of one hour, the 30-second average does not significantly alter the computed pressure temperature.

Calculation of Engineering Units in SBE Data Processing

Our data processing program, SBE Data Processing, starts with the raw (.hex) data, converts it to engineering units using the information in the configuration (.xmlcon or .con) file, and then processes it. Thus, even if calibration coefficients in your .xmlcon or .con file were incorrect during data acquisition (Seasave), the saved raw data is correct, and can be processed with the corrected calibration coefficients.