DATA PRODUCT SPECIFICATION
FOR TEMPERATURE ARRAY IN
SPATIAL GRID

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Consortium for Ocean Leadership
1201 New York Ave NW, 4th Floor, Washington DC 20005
www.OceanLeadership.org

in Cooperation with

University of California, San Diego
University of Washington
Woods Hole Oceanographic Institution
Oregon State University
Scripps Institution of Oceanography
Rutgers University
## Document Control Sheet

<table>
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<th>Version</th>
<th>Date</th>
<th>Description</th>
<th>Author</th>
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<td>2012-11-06</td>
<td>Initial Draft</td>
<td>G. Proskurowski</td>
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<tr>
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Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer: ____________________________

Date: ____________________________ 2013-05-10

This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

OOI CI Signing Authority: ____________________________

Date: ____________________________
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1 Abstract
This document describes the computation used to calculate the OOI Level 1 Temperature Array in Spatial Grid data product from the TMPSF instrument, custom built thermistor array with a RBR XR-420 data logger. This data product is a simple parsing of calibrated temperature values measured by 24 thermistors positioned on the instrument. The instrument temperature output is a “real-time” streaming value that has internally been converted from raw voltage to scientific units using the onboard calibration coefficients of the instrument.

2 Introduction

2.1 Author Contact Information
Please contact Giora Proskurowski (giora@uw.edu) or the Data Product Specification lead (DPS@lists.oceanobservatories.org) for more information concerning the computation and other items in this document.

2.2 Metadata Information

2.2.1 Data Product Name
The OOI Core Data Product Name for this product is
- TEMPSFL

The OOI Core Data Product Descriptive Name for this product is
- Temperature Array in Spatial Grid

2.2.2 Data Product Abstract (for Metadata)
The OOI Level 1 Temperature Array in Spatial Grid core data product is the measured temperature at each of 24 thermistors arranged in a spatial array.

2.2.3 Computation Name
Not required for data products.

2.2.4 Computation Abstract (for Metadata)
This algorithm parses the OOI Level 1 Temperature Array in Spatial Grid core data product, from the instrument data string.

2.2.5 Instrument-Specific Metadata
See Section 4.4 for instrument-specific metadata fields that must be part of the output data.

2.2.6 Data Product Synonyms
Synonyms for this data product are
- Vent temperature

2.2.7 Similar Data Products
Similar products that this data product may be confused with are “Vent Temperature-RASFL” or “TRHPH-Temperature” which is measured on different instrument class and calculated using different methodology.

2.3 Instruments
For information on the instruments from which the L1 Temperature Array in Spatial Grid core data product inputs are obtained, see the TMPSF Data Processing Flow document (DCN 1342-
This document contains information on instrument classes and make/models; it also describes the flow of data from the instrument through all of the relevant QC, calibration, and data product computations and procedures.

Please see the Instrument Application in the SAF for specifics of instrument locations and platforms.

2.4 Literature and Reference Documents
RBR: OEM Command Reference for RBR Submersible Data Loggers
Stored on Alfresco:
OOI > REFERENCE > Data Product Specification Artifacts > 1341-00130_TEMPSFL
As RBR_logger_OEM-ref.pdf.

2.5 Terminology
2.5.1 Definitions
Not Applicable.

2.5.2 Acronyms, Abbreviations and Notations
General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database (DOORS). The following acronyms and abbreviations are defined here for use throughout this document.

2.5.3 Variables and Symbols
The following variables and symbols are defined here for use throughout this document.

$t_1$ Temperature, °C, at thermistor #1 (furthest from logger)
...
$t_{24}$ Temperature, °C, at thermistor #24 (closest to logger)

3 Theory
3.1 Description
Temperature is measured at 24 locations along the thermistor string. Onboard the data logger the raw measurements are converted to °C using the calibration coefficients associated with each individual thermistor. The position of each thermistor is given in the metadata, using <x y z> coordinates in centimeters with an origin at the seafloor beneath thermistor #2.

3.2 Mathematical Theory
Not Applicable.

3.3 Known Theoretical Limitations
Not Applicable.

3.4 Revision History
Revisions to test data set based on ION-beta interactions.
4 Implementation

4.1 Overview
Instrument output in °C is parsed into 24 individual thermistor temperature measurements. The instrument agent driver for TMPSF converts the raw battery voltage into volts.

4.2 Inputs
- Raw Seafloor Temperature ASCII string
- Raw battery voltage engineering data

Input Data Formats:
The instrument provides a “real-time” output formatted as an ASCII text string:

TIM YYMMDDhhmmss xx.xxxx xx.xxxx xx.xxxx … xx.xxxx BV: xx.xxxx SN: xxxxxx
FET<CR><LF>

The inputs to be parsed, the series of 24 xx.xxxx temperature values, are formatted as space delimited 4 decimal place floating point value (%.4f), followed by battery voltage “BV:” (%.4f) and Serial Number “SN:” (%.0f).

Example TMPSF “real-time” data output:


4.3 Processing Flow

The specific steps necessary to create all calibrated and quality controlled data products for each OOI core instrument are described in the instrument-specific Processing Flow documents (DCN 1342-00130). These processing flow documents contain flow diagrams detailing all of the specific procedures (data product and QC) necessary to compute all levels of data products from the instrument and the order in which these procedures.

The processing flow for the pressure computation is as follows:

Step 1:
Receive measurement data

Step 2:
Parse t1 through t24 from instrument ASCII string to create L0 data product of 24 parameters, each parameter representing a temperature value with identical formats, but unique spatial position (see Appendix C).

Step 3:
The instrument agent driver for TMPSF converts the raw battery voltage into volts using the following:

\[ \text{Voltage} = 0.254170 + (0.0816485 \times 84) = 7.112644 \text{V} \]

Step 4:
Create L1 data product from L0 data product and include position matrix in metadata
4.4 Outputs

The outputs of the parsing are
- Time, YYMMDhhmms (not used, use DigiPort timestamp for time)
- Temperature, °C, %.4f. (goes to L0)
- Greater of Input voltage and Battery voltage, V, %.4f. (goes to metadata)
- Serial Number, SN, %.0f. (goes to metadata)

L1 product includes the 24 L0 Temperature Array in Spatial Grid product merged with the time stamp information. There are 24 temperature outputs, t1:t24, corresponding to the 24 thermistor pods on the instrument. The 24 temperature values can be stored in an array, but should have the full functionality during plotting and downloads of 24 parameters. The spatial arrangement of these 24 thermistors is defined in a matrix.

- L1 metadata includes Spatial position of each thermistor, as a matrix of <thermistor# x y z> where x,y,z are coordinate position in cm from an origin at the seafloor beneath thermistor #2. See Appendix C for an updated matrix, following build and first deployments.

See Appendix B for a discussion of the accuracy of the output.

4.5 Computational and Numerical Considerations

4.5.1 Numerical Programming Considerations
There are no numerical programming considerations for this computation. No special numerical methods are used.

4.5.2 Computational Requirements
Not Applicable.

4.6 Code Verification and Test Data Set
The code will be verified using the test data set provided, which contains inputs and their associated correct outputs. CI will verify that the code is correct by checking that the output, generated using the test data inputs, is identical to the test data output.

The test data set below provides a few data points over the extent of the water column.

Input:


L0 Temperature Array in Spatial Grid Output:

Instrument Timestamp (don’t use—use DigiPort timestamp)

24 Temperature values (stored as an array, but with the functionality during plotting or download as 24 parameters):
t1 25.3884
Data Product Specification for Temperature Array in Spatial Grid

Metadata:
Battery Voltage 11.5916
Serial Number 021968

L1 Temperature Array in Spatial Grid Output:

Metadata fields from L0 (Battery Voltage and Serial Number) and Position Metadata from Position Matrix (See Appendix C)

1 x 25 array (the printed version below is wrapped to fit on the page), this array should have the full plotting and download functionality of a timestamp and 24 parameters (e.g. plotting of any or all of the 24 temperatures vs time, downloaded files that consist of a single row per timestamp):

<table>
<thead>
<tr>
<th>timestamp</th>
<th>t1</th>
<th>t2</th>
<th>t3</th>
<th>t4</th>
<th>t5</th>
<th>t6</th>
<th>t7</th>
<th>cont</th>
</tr>
</thead>
<tbody>
<tr>
<td>t8</td>
<td>t9</td>
<td>t10</td>
<td>t11</td>
<td>t12</td>
<td>t13</td>
<td>t14</td>
<td>t15</td>
<td>cont</td>
</tr>
<tr>
<td>15.2883</td>
<td>16.3374</td>
<td>14.5883</td>
<td>15.7253</td>
<td>18.4383</td>
<td>15.3488</td>
<td>17.2993</td>
<td>10.2111</td>
<td></td>
</tr>
<tr>
<td>t16</td>
<td>t17</td>
<td>t18</td>
<td>t19</td>
<td>t20</td>
<td>t21</td>
<td>t22</td>
<td>t23</td>
<td>t24</td>
</tr>
</tbody>
</table>

Quality control flags will operate on the whole array (e.g. if one array member is flagged, the whole array gets the flag).
Appendix A      Example Code

Example matlab code:

Assume for each measurement parsed temperature data is in a 1x24 matrix “t”

%NaN is a common notation for “not a number”

L0T = NaN(24,1); %NaN(a,b) is a function that creates an aXb matrix filled initially with NaNs

L0T = t(1:24) %Temperature results from parsed raw data stream

L1T = NaN(1:25);

L1T(1) = timestamp;
L1T(2:25) = L0T
Appendix B  Output Accuracy

The accuracy of the L1 product is identical to the instrument accuracy.

The OOI-RSN requirements for the accuracy, precision, resolution and drift of the Temperature Array in Spatial Grid measurement, as represented in DOORS are:

The diffuse fluid 3-D temperature array shall make fluid temperature measurements with an accuracy of 0.1°C. <L4-RSN-IP-RQ-202>

The diffuse fluid 3-D temperature array shall make fluid temperature measurements with resolution of 0.1°C. <L4-RSN-IP-RQ-203>

From RBR XR-420 Logger and Thermistor Chain manual:

Range: +5°C to 50°C
Accuracy: ±0.005 °C
Resolution: <0.00005 °C
Appendix C  Sensor Calibration Effects and Position Metadata

This instrument is calibrated at the factory, resulting in a series of coefficients that allow for raw counts to be transformed into a viable temperature values. The instrument data output in “real-time” mode is a temperature value that has been internally computed using the onboard calibration coefficients. These coefficients will be associated with each instrument instance deployment, and periodically checked to insure that they remain constant over the deployment.

The position of each thermistor sensor will be updated with the physical construction of each individual instrument. An example of the position matrix (with header row and columns), taken from the first build of the instrument is below, units in cm, origin is the seafloor beneath thermistor #2. The provided matrix will be a <24x3> matrix, with the row number corresponding to the thermistor number, and the columns representing x, y, z coordinates.

**ISOMETRIC VIEW**

![Isometric View of Thermistor Positions](image_url)
## Thermistor COORDINATES (updated 2016-12-22)

<table>
<thead>
<tr>
<th>Thermistor</th>
<th>X (cm)</th>
<th>Y (cm)</th>
<th>Z (cm)</th>
<th>X (in)</th>
<th>Y (in)</th>
<th>Z (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.7</td>
<td>25.4</td>
<td>5.1</td>
<td>5.77</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>5.1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>22.0</td>
<td>12.7</td>
<td>5.1</td>
<td>8.66</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>44.0</td>
<td>25.4</td>
<td>5.1</td>
<td>17.32</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>22.0</td>
<td>38.1</td>
<td>5.1</td>
<td>8.66</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>0.0</td>
<td>50.8</td>
<td>5.1</td>
<td>0</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>0.0</td>
<td>25.4</td>
<td>5.1</td>
<td>0</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>0.0</td>
<td>25.4</td>
<td>17.8</td>
<td>0</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>0.0</td>
<td>25.4</td>
<td>17.8</td>
<td>0</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>0.0</td>
<td>50.8</td>
<td>17.8</td>
<td>8.66</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>22.0</td>
<td>38.1</td>
<td>17.8</td>
<td>17.32</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>44.0</td>
<td>25.4</td>
<td>17.8</td>
<td>8.66</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>22.0</td>
<td>12.7</td>
<td>17.8</td>
<td>0</td>
<td>0</td>
<td>7</td>
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<td>17.8</td>
<td>5.77</td>
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<td>7</td>
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<td>14.7</td>
<td>25.4</td>
<td>43.2</td>
<td>5.77</td>
<td>10</td>
<td>17</td>
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<tr>
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<td>0.0</td>
<td>43.2</td>
<td>0</td>
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<td>17</td>
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<td>12.7</td>
<td>43.2</td>
<td>8.66</td>
<td>5</td>
<td>17</td>
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<td>17.32</td>
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<td>8.66</td>
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<td>17</td>
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<td>50.8</td>
<td>43.2</td>
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<tr>
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<td>32</td>
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<td>17.32</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>24</td>
<td>0.0</td>
<td>0.0</td>
<td>81.3</td>
<td>0</td>
<td>0</td>
<td>32</td>
</tr>
</tbody>
</table>
5 TOP VIEW
6  Top View, Z=81.3 cm (32 in)
7 TOP VIEW, Z=43.2 cm (17 in)
8 TOP VIEW, Z=17.8 cm (7 in)
9   TOP VIEW, Z=5.1 cm (2 in)