XRT Mode

This page outlines issues reported by customers, associated solutions, and recommendations for troubleshooting.

XRT Expert Commands

There are a number of expert-level XRT configuration commands the majority of which were useful mainly for troubleshooting XRT during development. Two of the commands may be useful for enhancing the performance of XRT for particularly challenging environmental conditions. It's important to understand the root cause of unreliable bottom track detection before using these commands as in certain situations using a non-standard/default XRT configuration will have adverse affects.

- &B1H <min> <max>
    - sets the minimum and maximum altitude for XRT detection and velocity processing
    - Useful if the either the acoustic absorption or bottom scattering coefficients are more or less than the assumed value. For example:
        - Using van Moll absorption formula at 614.4KHz, 5 deg C, 35 ppt, 0m depth: 0.0717 dB/m
        - Per TRDI performance model at 614KHz: -29.7 dB
    - If the expected bottom scattering coefficient is greater or water absorption is less, increase &B1H max.
    - If the expected bottom scattering coefficient is less or water absorption is more, decrease &B1H min.
    - In typical conditions reducing &B1H min will increase the probability of false bottom-detection
- &B1C <correlation threshold 1> <correlation threshold 2> <correlation switching altitude>
    - A XRT correlation result above correlation threshold 1 between "&B1H min" and "&B1C correlation switching altitude" results in a bottom detection
    - A XRT correlation result above correlation threshold 2 between "&B1C correlation switching altitude" and "&B1H max" results in a bottom detection
    - Useful if a boundary layer with a high volume scattering coefficient (life layer for example) exists in the area of operation
        - Set &B1C correlation switching altitude to be deeper than the life layer
        - Set &B1C correlation threshold 1 below the expected correlation result from the life layer
        - For a submersible these configuration parameters would need to updated dynamically based on altitude (and expected range to life layer)

EMI

XRT mode provides a significantly increased bottom-track range by detecting very weak signals that would look like noise to our traditional bottom mode 9. Therefore, it is also very sensitive to electromagnetic interference (EMI). External EMI that is within the bandwidth $6364fc \leq f \leq 6564fc$ bandwidth should in particular be avoided. Additionally, very strong

EMI outside of that range may also adversely affect the performance of the XRT mode, as the XRT-mode filters do provide finite attenuation.

The most common adverse EMI effect when operating in XRT mode is false detects at altitudes that are within the range $hmin \le h \le hmax$, where *h* is altitude, hmin is the minimum XRT altitude and hmax is the maximum XRT altitude.

A clean EMI environment is the responsibility of the customer.

Measuring EMI

Performing discrete Fourier analysis of the DVL I and Q data is useful for determining the frequency of interference terms within the receive spectrum. The DVL firmware provides multiple ways to output DVL I and Q data:

- PT99x command (used by NGSPFFT)
  - x = 6,7,89 = 512, 1024, 2048, 4096 I and Q points
  - Hard limited receive path only
  - Selectable high/low gain, wide or narrow-bandwidth filtering
  - Binary output format
- &m49
  - 8-9999 I and Q points
  - Selectable high/low gain, wide or narrow-bandwidth filtering, linear or hard limited data
  - Ascii binary, hex, or decimal output
  - The following matlab script will perform an FFT of logged &m49 data:

FFT_m49.m

Note:

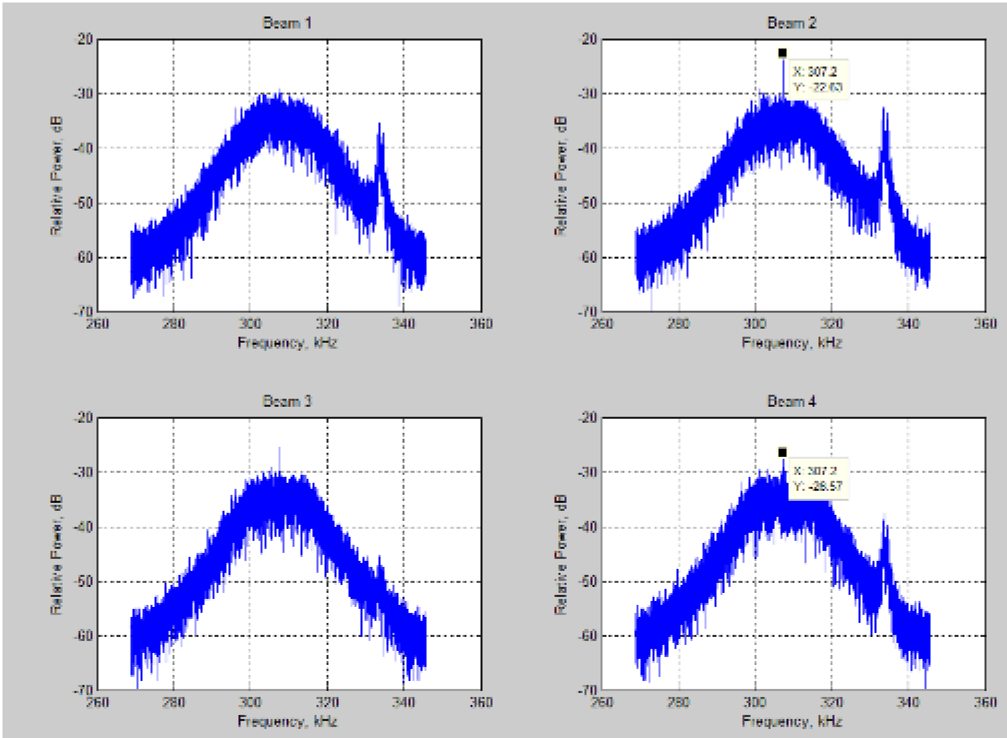
Additional digital filtering is performed on the data received in XRT mode versus conventional narrow-bandwidth bottom track which reduces the bandwidth by approximately 1/5 (7dB). Therefore the interference level should be adjusted by this amount to determine whether it is capable of causing false detects.

Recommendations:

1. Average at least 5 datasets in the frequency domain
2. Capture a minimum of 4096 samples per DFT

Example:

The following plots were generated from 5 sets of 4096 I and Q points output from a Tasman 300 using the &m49 command:



The peak level measured on beam 2 is at the system frequency (307.2KHz) and is -22.6dB above the noise floor in narrow bandwidth mode. This would be equivalent to -15.6dB above the XRT noise floor.   A correlation threshold of 0.15 is equivalent to -7dB SNR so this interference would not cause false detects.

Correlation Approach

The correlation output in the bottom-track data type, defined in the diagram below, can be used to assess the EMI level. The correlation coefficient $0 \leq \rho \leq 1$ is computed by dividing the 8-bit correlation estimate in the bottom-track data type by 255.

Two correlation coefficient thresholds are used within the XRT operating range. The correlation switch depth (h_{th}) is used to determine which threshold is used. Correlation threshold 1 is used $h_{min} <= h_{th}$ and correlation threshold 2 is used for $h_{th} < h_{max}$. The expert command for setting the correlation thresholds is as follows:

&B1C [correlation threshold1] [correlation threshold2] [correlation switch altitude (cm)]

XRT bottom detection is determined on whether correlation exceeds the threshold pertaining to the detected depth. When there is no EMI present, the measured correlation will be below the correlation-detection threshold the majority of the time.

Binary Bottom-Track Data Format

<table>
<tr><th rowspan="2">BYTE</th><th colspan="8">BIT POSITIONS</th><th rowspan="2"></th></tr>
<tr><th>7/S</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td colspan="8" rowspan="2">BOTTOM-TRACK ID</td><td>LSB 00h</td></tr>
<tr><td>2</td><td>MSB 06h</td></tr>
<tr><td>3</td><td colspan="8" rowspan="2">BT PINGS PER ENSEMBLE</td><td>LSB</td></tr>
<tr><td>4</td><td>MSB</td></tr>
<tr><td>5</td><td colspan="8" rowspan="2">RESERVED</td><td>LSB</td></tr>
<tr><td>6</td><td>MSB</td></tr>
<tr><td>7</td><td colspan="8">BT CORR MAG MIN</td><td></td></tr>
<tr><td>8</td><td colspan="8">BT EVAL AMP MIN</td><td></td></tr>
<tr><td>9</td><td colspan="8">RESERVED</td><td></td></tr>
<tr><td>10</td><td colspan="8">BT MODE</td><td></td></tr>
<tr><td>11</td><td colspan="8" rowspan="2">BT ERR VEL MAX</td><td>LSB</td></tr>
<tr><td>12</td><td>MSB</td></tr>
<tr><td>13</td><td colspan="8" rowspan="4">RESERVED</td><td></td></tr>
<tr><td>14</td><td></td></tr>
<tr><td>15</td><td></td></tr>
<tr><td>16</td><td></td></tr>
<tr><td>17</td><td colspan="8" rowspan="2">BEAM#1 BT RANGE</td><td>LSB</td></tr>
<tr><td>18</td><td>MSB</td></tr>
<tr><td>19</td><td colspan="8" rowspan="2">BEAM#2 BT RANGE</td><td>LSB</td></tr>
<tr><td>20</td><td>MSB</td></tr>
<tr><td>21</td><td colspan="8" rowspan="2">BEAM#3 BT RANGE</td><td>LSB</td></tr>
<tr><td>22</td><td>MSB</td></tr>
<tr><td>23</td><td colspan="8" rowspan="2">BEAM#4 BT RANGE</td><td>LSB</td></tr>
<tr><td>24</td><td>MSB</td></tr>
<tr><td>25</td><td colspan="8" rowspan="2">BEAM#1 BT VEL</td><td>LSB</td></tr>
<tr><td>26</td><td>MSB</td></tr>
<tr><td>27</td><td colspan="8" rowspan="2">BEAM#2 BT VEL</td><td>LSB</td></tr>
<tr><td>28</td><td>MSB</td></tr>
<tr><td>29</td><td colspan="8" rowspan="2">BEAM#3 BT VEL</td><td>LSB</td></tr>
<tr><td>30</td><td>MSB</td></tr>
<tr><td>31</td><td colspan="8" rowspan="2">BEAM#4 BT VEL</td><td>LSB</td></tr>
<tr><td>32</td><td>MSB</td></tr>
<tr><td>33</td><td colspan="8">BEAM#1 BT CORR.</td><td></td></tr>
<tr><td>34</td><td colspan="8">BEAM#2 BT CORR.</td><td></td></tr>
<tr><td>35</td><td colspan="8">BEAM#3 BT CORR.</td><td></td></tr>
<tr><td>36</td><td colspan="8">BEAM#4 BT CORR.</td><td></td></tr>
</table>

To assess EMI using correlation:

- Install the instrument in the environment in which EMI should be assessed
- Disable transmit by setting &T0
- Set a fixed bottom altitude, using the BF command, to a value within the XRT range: hmin≤BF≤hmax

- Start pinging
- Evaluate the correlation output in the bottom-track data type

If the measured correlation, normalized by 255, frequently exceeds the 0.15, then there is excessive EMI present. The preferred solution is to eliminate the source of the external EMI. Alternatively, the correlation threshold can be increased such that the measured correlation rarely exceeds it. The tradeoff is of course decreased maximum XRT range.

Changeover from BM9 to XRT

The bottom-detection performance depends on environmental parameters such as absorption and bottom-scattering strength. In challenging conditions, there may be a range of altitudes around the switch-over point between BM9 and XRT that the system fails to detect the bottom in BM9. This issue can be remedied by reducing the minimum XRT bottom-detection altitude using the &B1H command.

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