GD SDR Automatic Gain Control Characterization Testing

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SCaN Testbed Flight System Overview

- 2 S-band SDRs
- 1 Ka-band SDR
- Ka-band TWTA
- S-band switch network
- Antennas
  - 2 - low gain S-band antennas
  - 1 - L-band GPS antenna
  - Medium gain S-band and Ka-band antenna on antenna pointing subsystem.
- Antenna pointing system
- Flight Computer/Avionics

- Launched on Japanese HTV-3 on July 20, 2012
- Installed on ISS August 7, 2012
- Checkout and Commissioning is in progress
SCaN Testbed GD SDR Description

- TDRSS S-band Transponder
  - 8 Forward link receive waveform configurations
  - 30 Return link transmit waveform configurations
- 1 Xilinx Virtex II QPro FPGA, 3 M gate
- ColdFire microprocessor with VxWorks RTOS running the Space Telecommunications Radio System (STRS) Architecture
- CRAM (Chalcogenide RAM) Memory (4 Mb)
- Analog (10 MHz filter bandwidth) and Digital (6 MHz filter bandwidth) automatic gain controls (AGCs)

<table>
<thead>
<tr>
<th>Waveform Number</th>
<th>Center Frequency</th>
<th>Data Rate (kbps)</th>
<th>Forward Error Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SA</td>
<td>18</td>
<td>Coded</td>
</tr>
<tr>
<td>2</td>
<td>SA</td>
<td>18</td>
<td>Uncoded</td>
</tr>
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<td>72</td>
<td>Uncoded</td>
</tr>
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<td>5</td>
<td>MA</td>
<td>18</td>
<td>Coded</td>
</tr>
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<td>MA</td>
<td>18</td>
<td>Uncoded</td>
</tr>
<tr>
<td>7</td>
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<tr>
<td>8</td>
<td>MA</td>
<td>72</td>
<td>Uncoded</td>
</tr>
</tbody>
</table>
Test Objective and Plan

• Characterize the relationship between:
  – SDR input power
  – SDR baseplate temperature
  – Waveform configuration
  – The digital and analog AGC values

• Temperature range:
  – -15 to +45 °C

• SDR input power range:
  – -90 to -130 dBm

• Results will be used to estimate SDR input power in future testing

• Testing phases included:
  – GD verification testing
  – GRC thermal vacuum (TVAC) testing
  – GRC verification testing

SCaN Testbed during TVAC testing, March 2011
S-Band TDRSS Simulator (TSIM) was used to emulate the forward link waveform. TSIM was connected to the SCaN Testbed using a test equipment interface circuit and RF cable. SDR input power was measured from a coupled port in the interface circuit using a power meter. The RF subsystem inside the SCaN Testbed was used to connect an antenna port to the GD SDR. During TVAC, the RF cable and SCaN Testbed were located in the vacuum chamber.
AGC Characterization Results at Ambient Temperature

**Analog AGC at 26 °C**

- Analog AGC varies with center frequency (MA/SA)

**Digital AGC at 26 °C**

- Digital AGC varies with symbol rate (coding + data rate)
AGC Characterization Results over Temperature

- Both analog and digital AGCs vary over temperature. The analog AGC variation is more significant.
Sources of Error in Data Collection

• Differences in the GD and GRC test setup (+/- .5 dB)

• Compensation method for the cable loss over temperature during thermal vacuum testing (+/- .5 dB)

• Data interpolated for waveforms with incomplete data sets (+/- 1 dB)

• System loss measurement error (+/- .3 dB)
SDR Input Power Estimation using Digital AGC

- The Digital AGC characterization data was used to estimate the SDR input power during operations on ISS (note: predicted power is TBD).

- The Eb/No was calculated from the SDR input power and used to create a BER curve.
Estimation of Interferer Signal Strength using Digital AGC

Digital AGC with and without Interferer

- Digital AGC shows received power is higher than expected due to an interferer.

- The purple curve was plotted with the Eb/No calculated from a measured power.
- The green curve was plotted with the Eb/No calculated from the digital AGC.
Recommendations and Forward Work

Recommendations
• Plan test phases and design a test setup that can be kept constant throughout each phase
• Balance SDR reconfigurable parameters with project test time

Forward Work
• 3 SDR input power estimation algorithms have been developed
• Characterize the SDR input power algorithms during on-orbit operations on ISS
• Utilize the engineering model (EM) characterization data to create SDR input power estimators for the EM
Questions?

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