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>3</td>
<td>SA</td>
<td>72</td>
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<td>4</td>
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<tr>
<td>7</td>
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<td>72</td>
<td>Coded</td>
</tr>
<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
GRC Test Setup

- 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

Digital AGC at 26 °C

- Analog AGC varies with center frequency (MA/SA)
- Digital AGC varies with symbol rate (coding + data rate)
AGC Characterization Results over Temperature

Analog AGC

Digital AGC

- 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.

![Graph showing calculated vs predicted power and BER curve on ISS 11-14-12](image)
Estimation of Interferer Signal Strength using Digital AGC

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

- The purple curve was plotted with the $\text{Eb}/\text{No}$ calculated from a measured power.

- The green curve was plotted with the $\text{Eb}/\text{No}$ calculated from the digital AGC.

![Graph showing Digital AGC with and without Interferer](image1)

![Graph showing BER Curve for MA, Uncoded, 18kbps](image2)
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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