



GD SDR Automatic Gain Control Characterization Testing

Jennifer Nappier

NASA Glenn Research Center, Cleveland, Ohio

Co-Author: Janette Briones

NASA Glenn Research Center, Cleveland, Ohio

SDR-WInnComm

January 2013



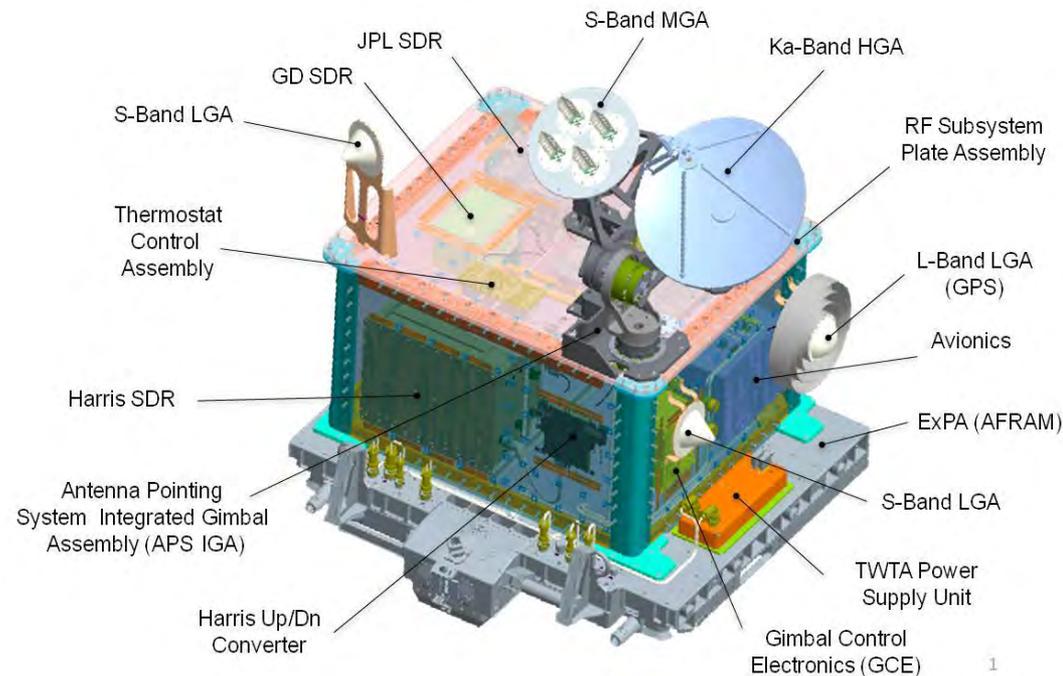
Presentation Contents

- SCaN Testbed Overview
- GD SDR Description
- AGC Characterization Test Objectives
- Test Setup
- Test Results
- Useful Applications of the AGC Characterization Testing Data
- Recommendations



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

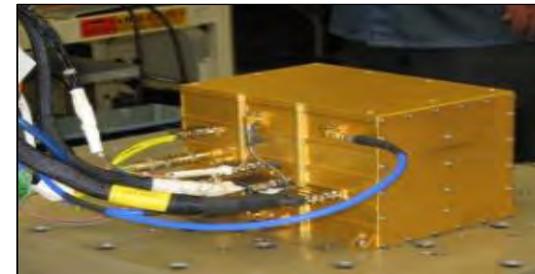


- Launched on Japanese HTV-3 on July 20, 2012
- Installed on ISS August 7, 2012
- Checkout and Commissioning is in progress



SCaN Testbed General Dynamics 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)



Waveform Number	Center Frequency	Data Rate (kbps)	Forward Error Correction
1	SA	18	Coded
2	SA	18	Uncoded
3	SA	72	Coded
4	SA	72	Uncoded
5	MA	18	Coded
6	MA	18	Uncoded
7	MA	72	Coded
8	MA	72	Uncoded



Test Objective and Plan

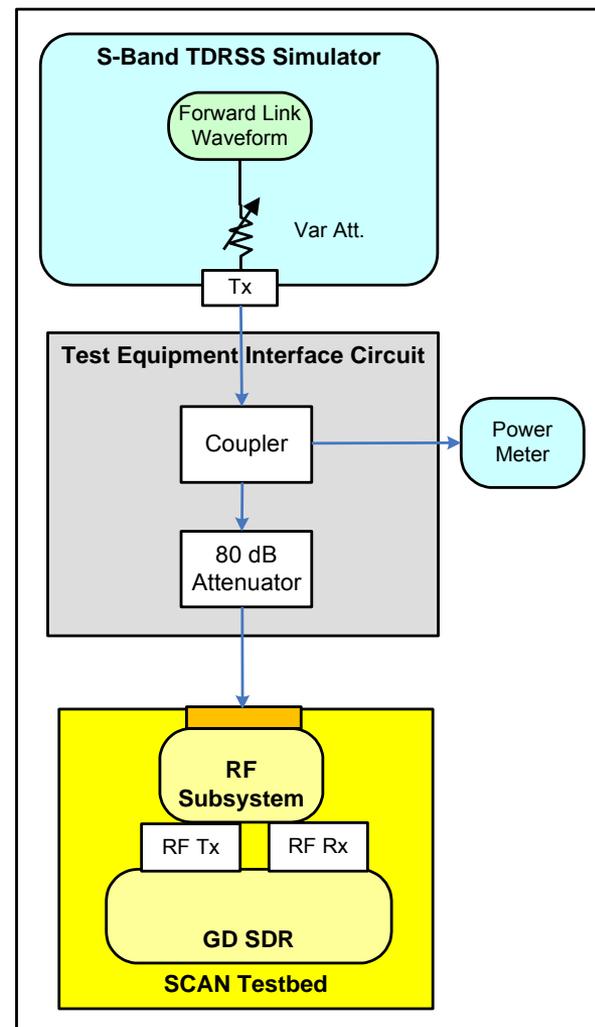
- Characterize the relationship between:
 - SDR input power
 - SDR baseplate temperature
 - Waveform configuration
 - The digital and analog AGC values
- Temperature range:
 - -15 to +45 °C
- SDR input power range:
 - -90 to -130 dBm
- Results will be used to estimate SDR input power in future testing
- Testing phases included:
 - GD verification testing
 - GRC thermal vacuum (TVAC) testing
 - GRC verification testing





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

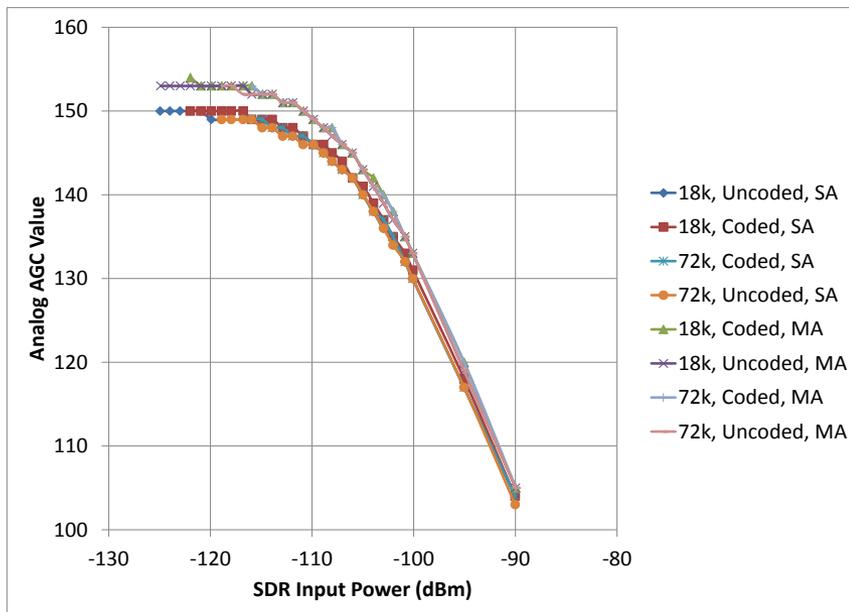


GRC Test Setup

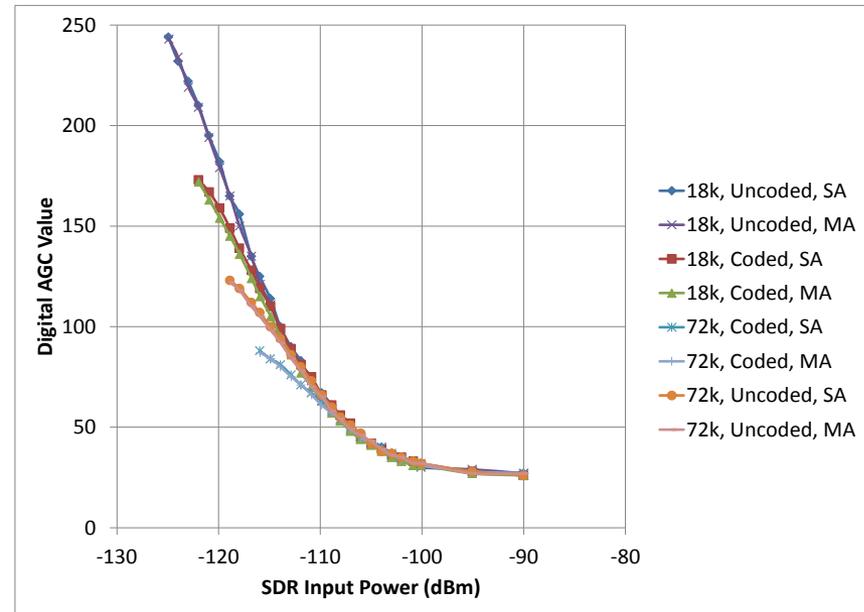


AGC Characterization Results at Ambient Temperature

Analog AGC at 26 °C



Digital AGC at 26 °C

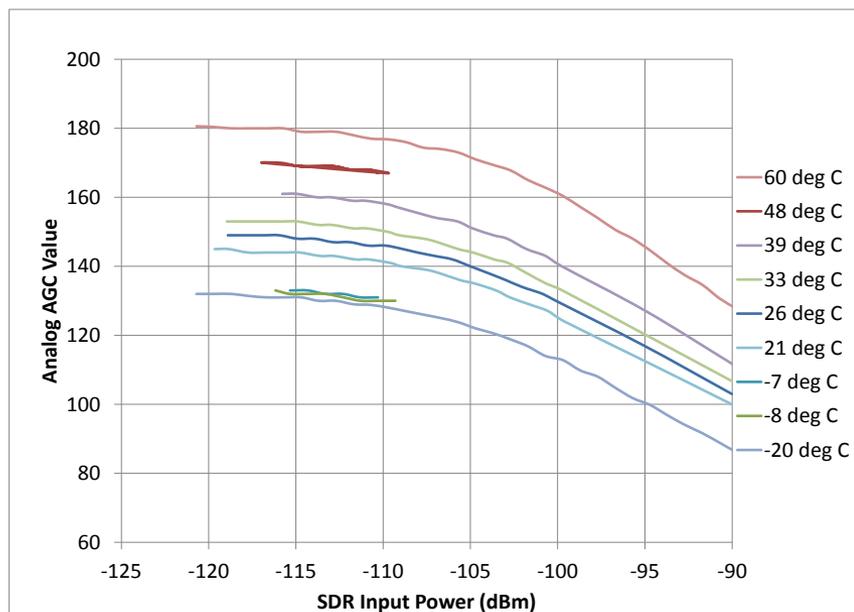


- Analog AGC varies with center frequency (MA/SA)
- Digital AGC varies with symbol rate (coding + data rate)

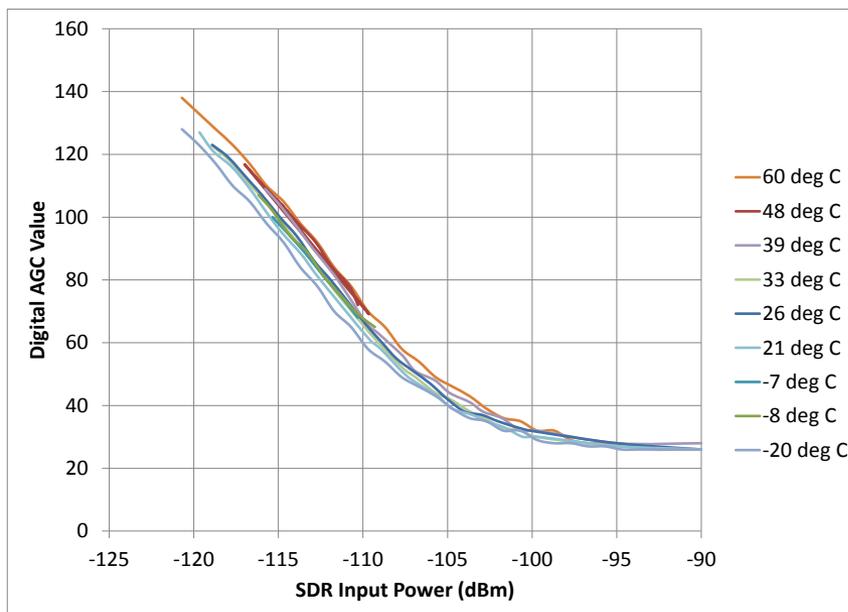


AGC Characterization Results over Temperature

Analog AGC



Digital AGC

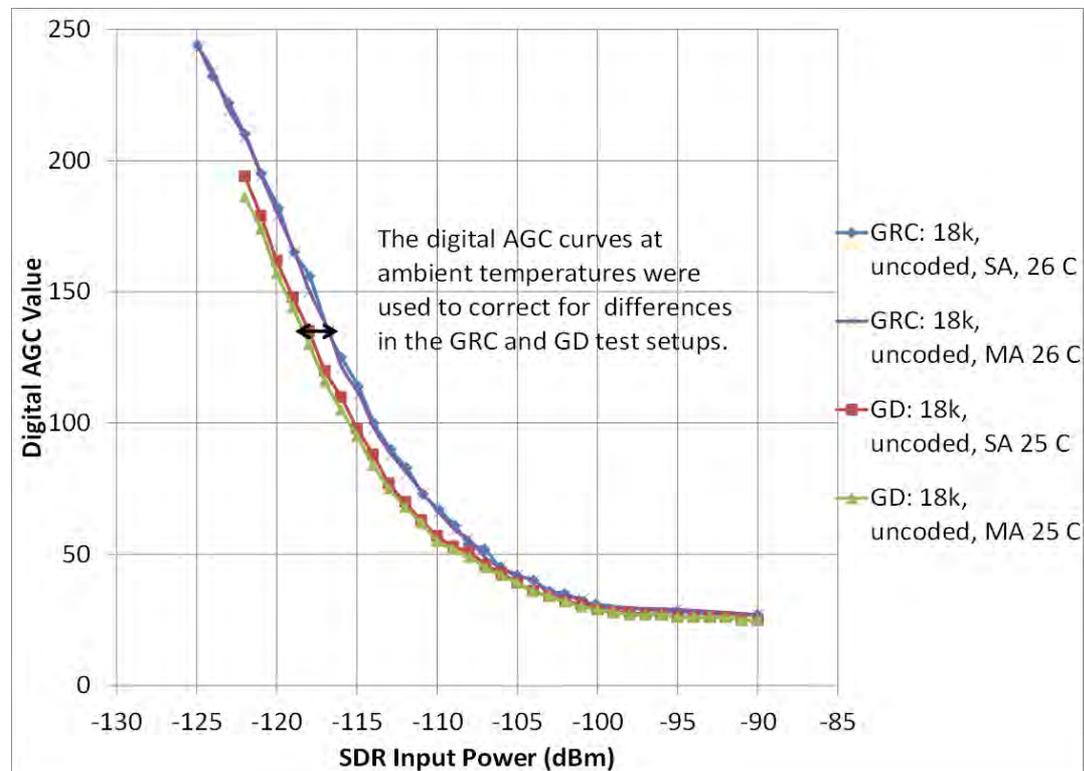


- Both analog and digital AGCs vary over temperature. The analog AGC variation is more significant.



Sources of Error in Data Collection

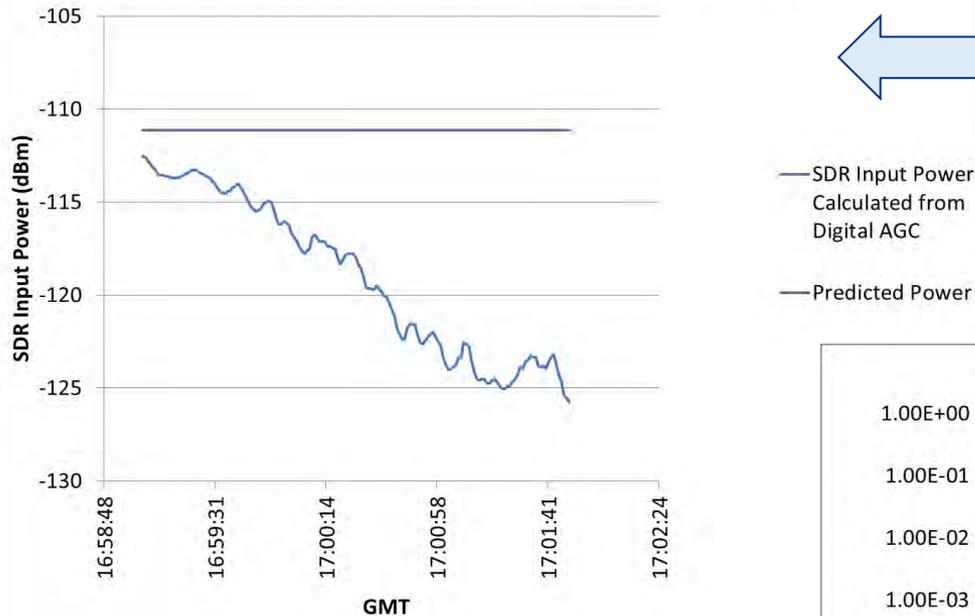
- Differences in the GD and GRC test setup (± 0.5 dB)
- Compensation method for the cable loss over temperature during thermal vacuum testing (± 0.5 dB)
- Data interpolated for waveforms with incomplete data sets (± 1 dB)
- System loss measurement error (± 0.3 dB)





SDR Input Power Estimation using Digital AGC

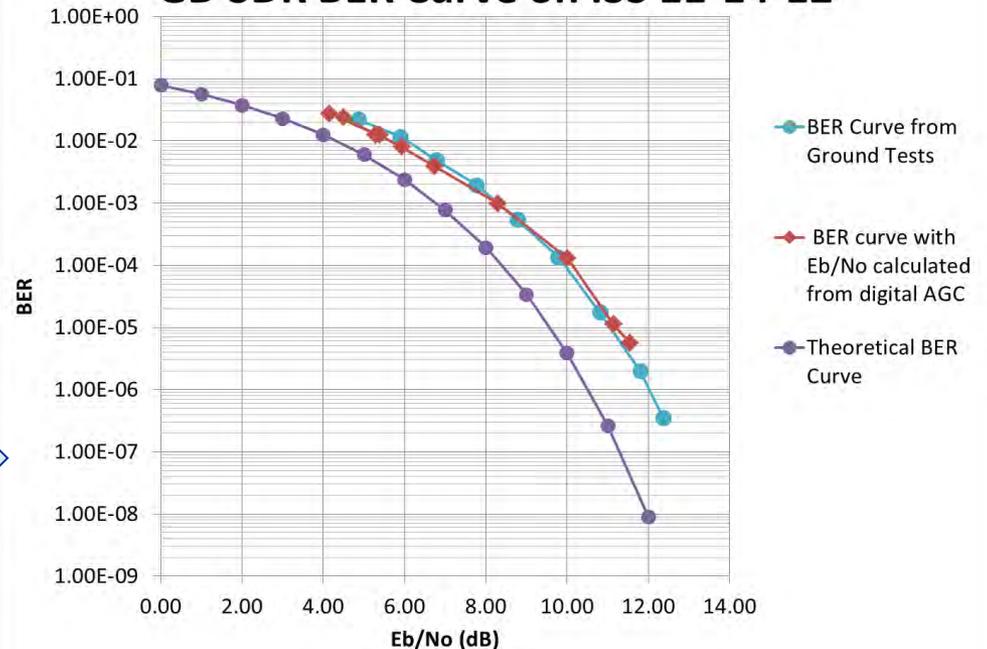
Calculated vs. Predicted Power



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

- The E_b/N_0 was calculated from the SDR input power and used to create a BER curve

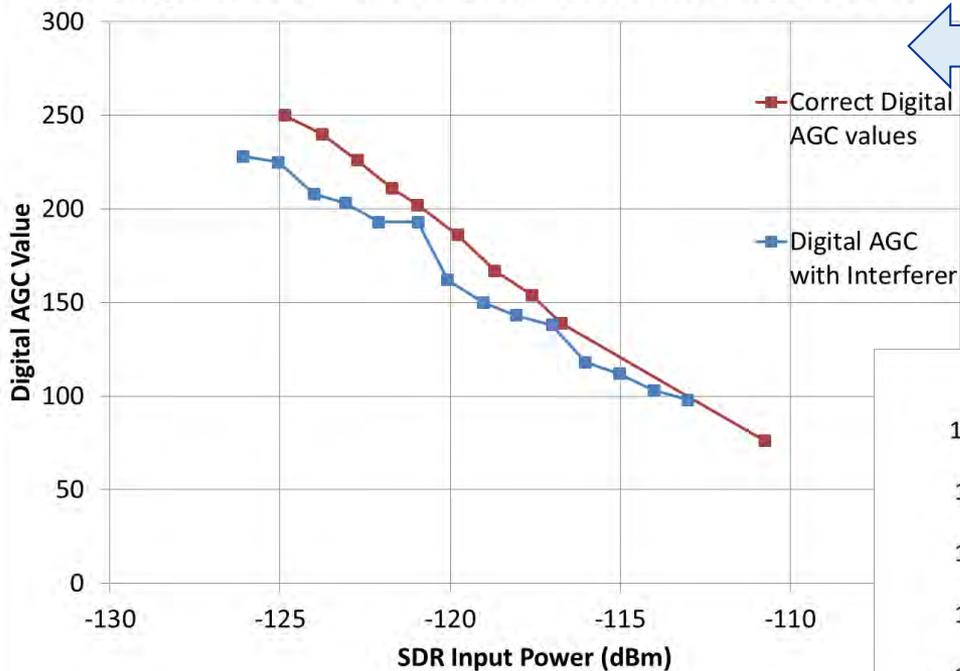
GD SDR BER Curve on ISS 11-14-12





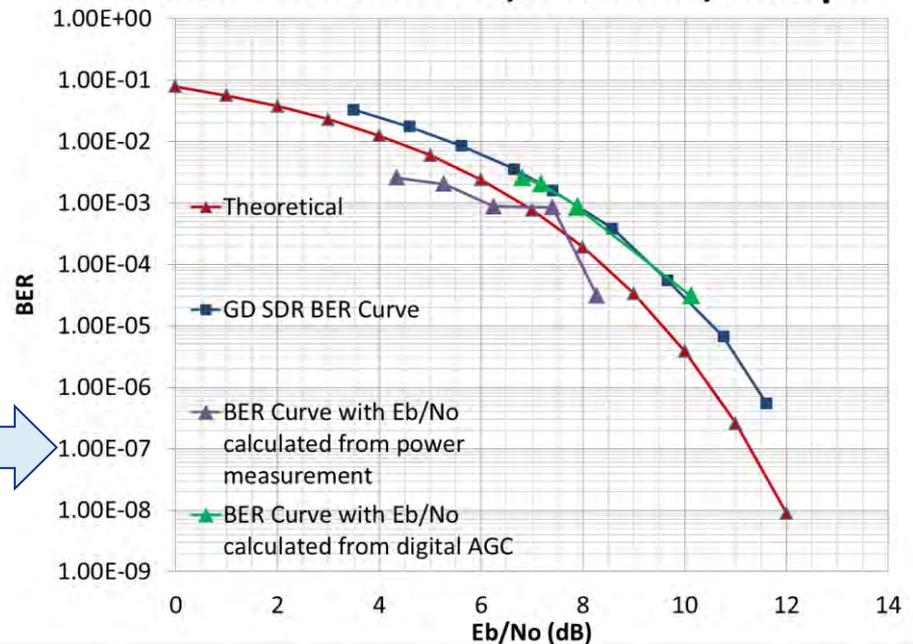
Estimation of Interferer Signal Strength using Digital AGC

Digital AGC with and without Interferer



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

BER Curve for MA, Uncoded, 18kbps



The purple curve was plotted with the E_b/N_0 calculated from a measured power.

The green curve was plotted with the E_b/N_0 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?

jennifer.m.nappier@nasa.gov

216-433-6521