DSS-13:
Configuration and Performance

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Contents

Chapter 1

Introduction

This document details the configuration and performance of the RF systems at DSS-13; the DSS-13 antenna is shown in Figure 1.1. During Late 2013 and early 2014 the Top and Tamw performance of most of the receiver systems was measured; the results of these measurements comprise the bulk of this report. The general configuration, layout and capabilities of the various positions as well as the control room were also documented. A list of the acronyms used in this document is included in the appendix.

Figure 1.1: DSS-13 Antenna

1.1 Measurement Methodology

The measurements detailed in this report were taken using an Agilent E4448A spectrum analyzer to perform Y-factor measurements utilizing methods and equations described in [1, 2] to calculate Top and Tamw. The spectrum analyzer has a built in preamplifier which negated the need for external preamplification to achieve an adequate power level. The instrument was set to 3.0 MHz resolution bandwidth and 51 Hz video bandwidth for all measurements. To calculate Top it is necessary to know Te of the LNA system; ramp test data was utilized for most of the measurements while a few systems required liquid nitrogen cold load measurements to calculate Te.

Atmospheric contributions were calculated using the model developed by Slobin [3]; this model requires accurate knowledge of altitude, barometric pressure, surface temperature and humidity. Errors using this method may arise with certain weather conditions including high humidity or overcast conditions.

Chapter 2

Pedestal Room

The pedestal room of DSS-13 contains six mirror positions for the main M5 switching mirror. Only one position can be in operation at any given time. Each position is capable of having multiple receiver systems or transmitters by using a system of planar mirrors and dichroics. The capabilities of each of these six positions are presented in this chapter. Figure 2.1 shows a general block diagram of the relative location of the various positions and a brief description of their capabilities.

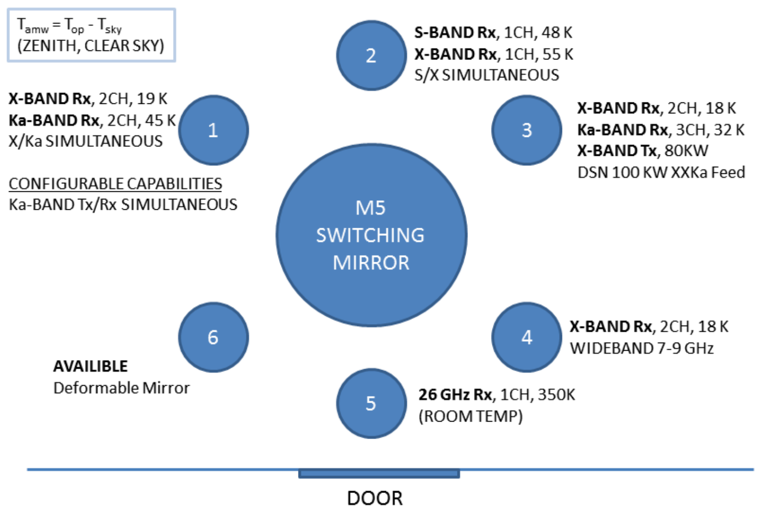

Figure 2.1: DSS-13 Pedestal Room General Block Diagram

2.1 Position 1

Position 1 consists of a cryogenic dual channel X-band receiver and a cryogenic dual channel Ka-band receiver. Both X and Ka can be utilized simultaneously with the use of the dichroic plate installed in that position. The use of the dichroic limits the useable bandwidth of the Ka-band system and slightly degrades the performance. The Ka-band receiver has two downconverters; one for narrow-band operation and one for wide-band operation. The optical configuration at Position 1 allows for a Ka-band transmitter to be installed and operated simultaneously with the currently installed Ka-band receiver. A picture of Position 1 is shown in Figure 2.2. A block diagram of the Position 1 RF systems can be seen in Figure 2.3. The performance of the X-band LNA receiver system at Position 1 is shown in Figure 2.6. The performance of the Ka-band LNA receiver using the wide-band downconverter and without the dichroic is shown in Figure 2.4. The performance of the Ka-band LNA receiver measured through the monopoulse downconverter and fiber-optic link at the control room is shown in Figure 2.5.

The Ka-band receiver was upgraded and installed in 2013; this work is documented in [4]. Shortly after installation the system developed a vacuum leak which was corrected in early 2014. The data in Figure 2.4 was taken after the system was repaired; no significant change was observed from the data taken in

2014 and the data documented in [4].

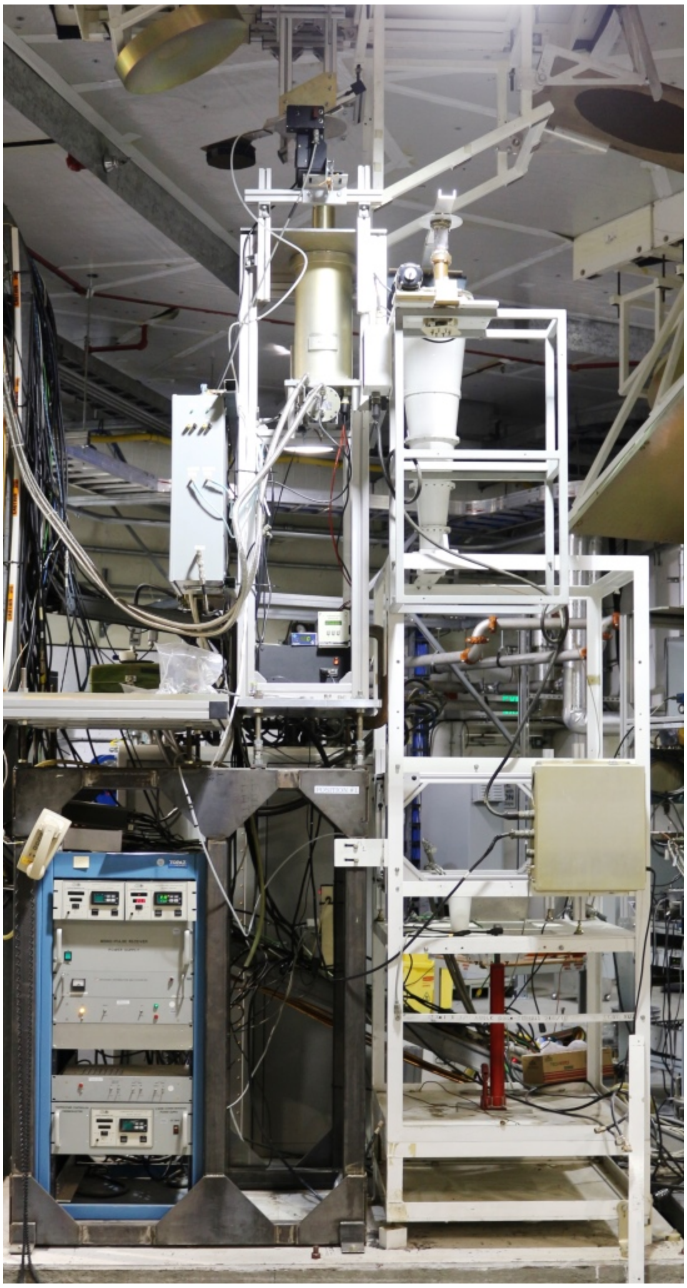

Figure 2.2: Position 1 Photo

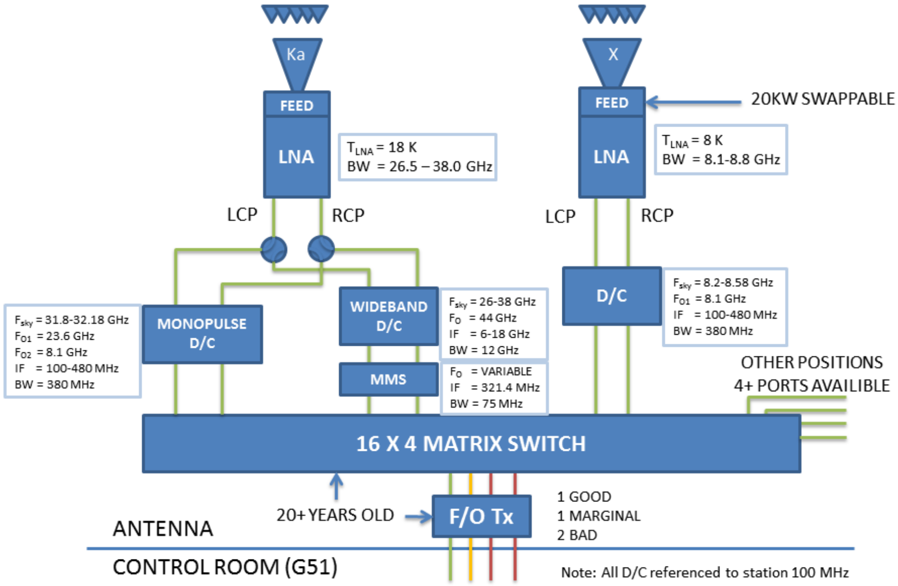

Figure 2.3: Position 1 Block Diagram

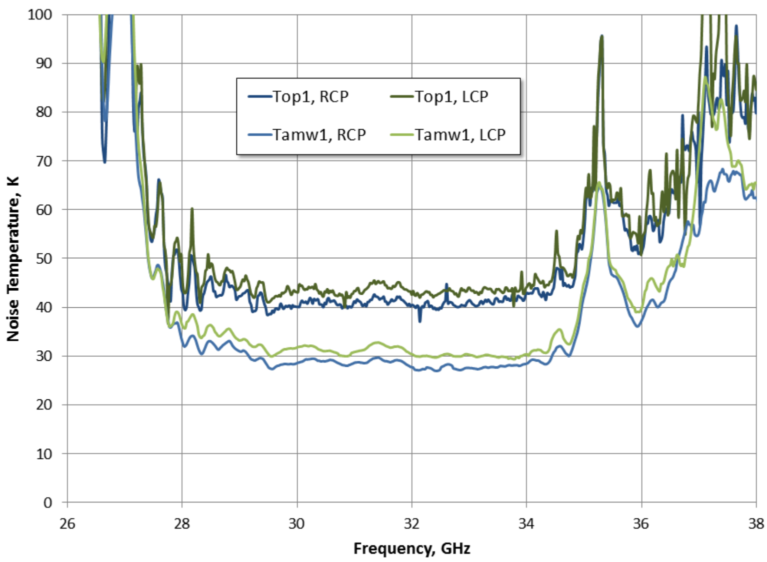

Figure 2.4: Position 1 Ka-band LNA Receiver Performance

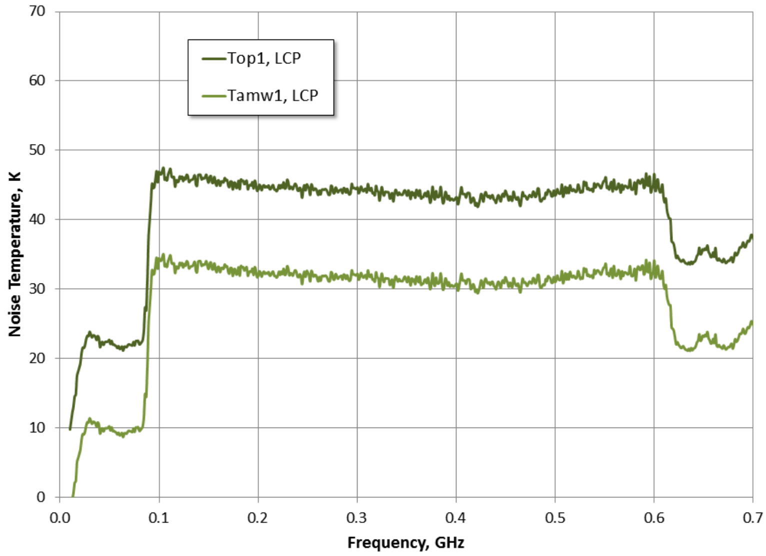

Figure 2.5: Position 1 Ka-band Measured Through Monopulse DC and FO Link

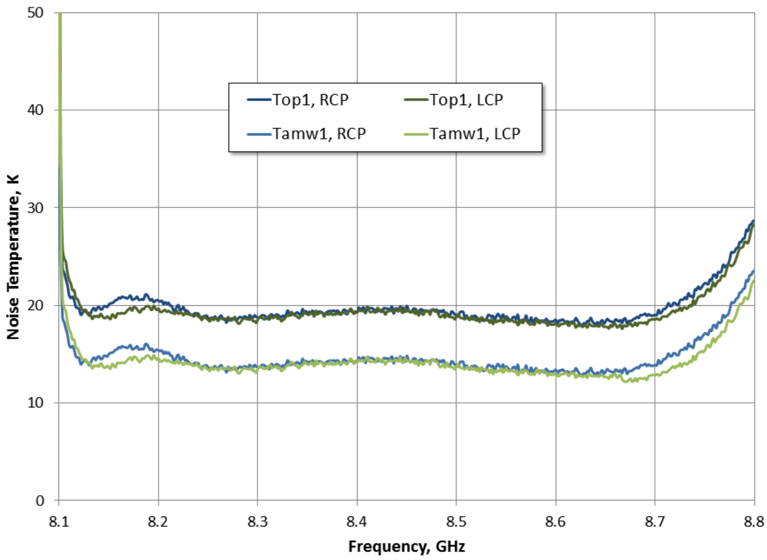

Figure 2.6: Position 1 X-band LNA Receiver Performance

2.2 Position 2

Position 2 contains a single channel S-band LNA receiver and a single channel X-band LNA receiver both housed in the same cryogenic unit. A picture of Position 2 is shown in Figure 2.7. A block diagram of the Position 2 RF systems can be seen in Figure 2.8. The performance of the LNA receiver systems at Position 2 are shown in Figures 2.9 and 2.11. Measurements of the LNA systems taken through the downconverter and fiber-optic link at the control room are shown in Figures 2.10 and 2.12. This receivers in Position 2 are used in continuing support of GAVRT.
Much of the input components for the two LNA systems are room temperature thus increasing their noise temperature significantly. This position would see a dramatic improvement to the noise performance if the two LNA system were housed in separate cryogenic systems thus reducing the amount of ambient transmission line. Also replacing the waveguide loads and switches with swing arm loads would help with reducing noise temperature for the same reason.

Figure 2.7: Position 2 Photo

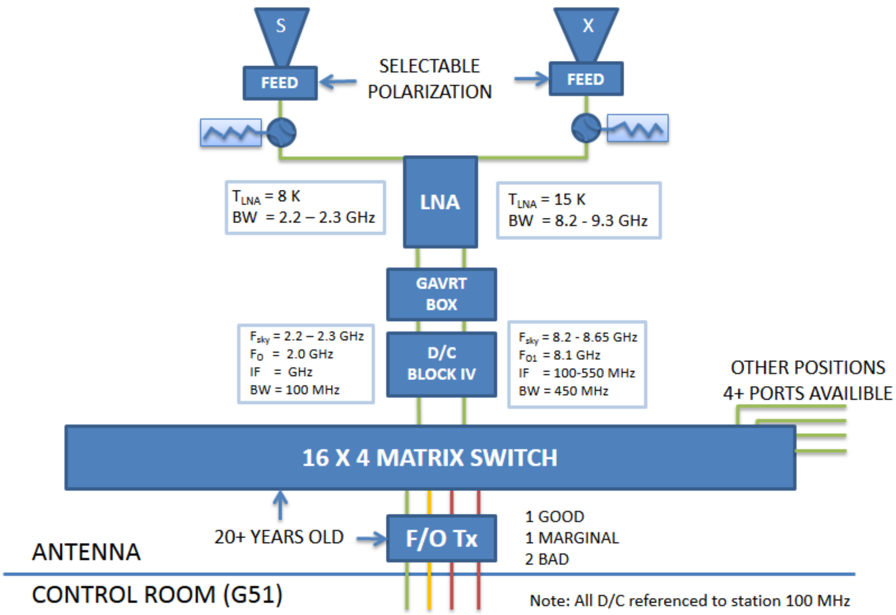

Figure 2.8: Position 2 Block Diagram

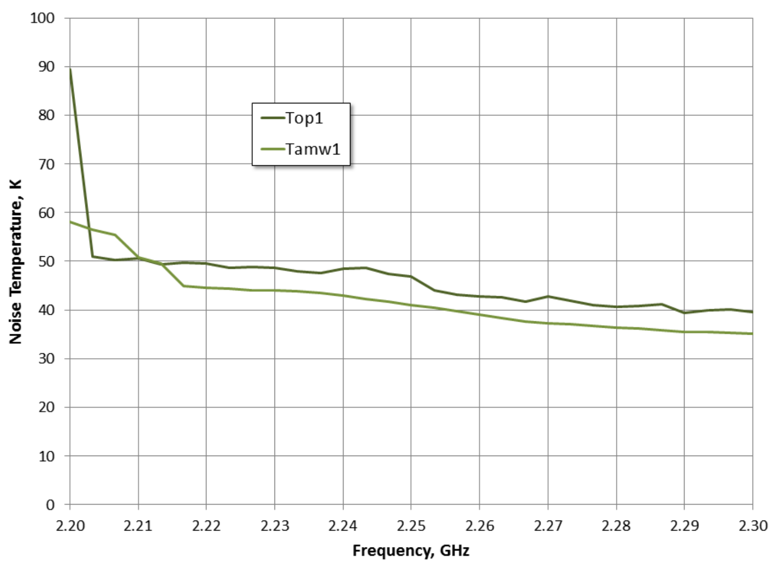

Figure 2.9: Position 2 S-band LNA Receiver Performance

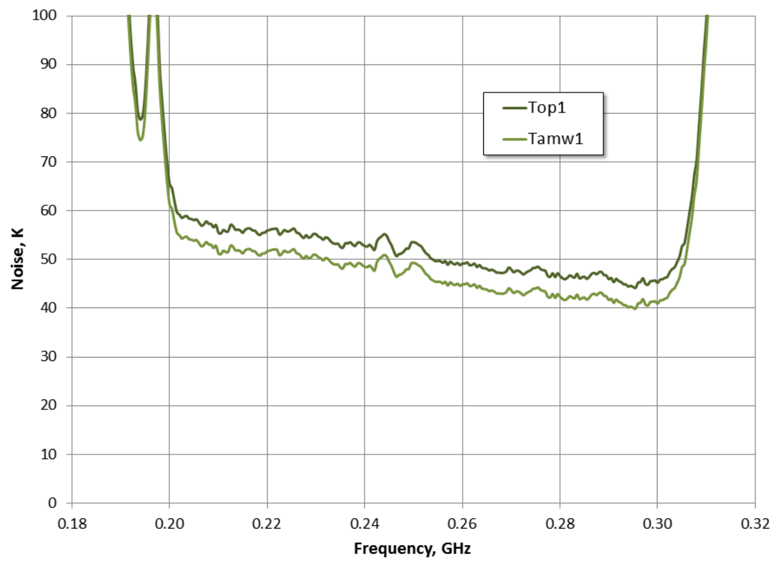

Figure 2.10: Position 2 S-band LNA Measured Through DC and FO Link

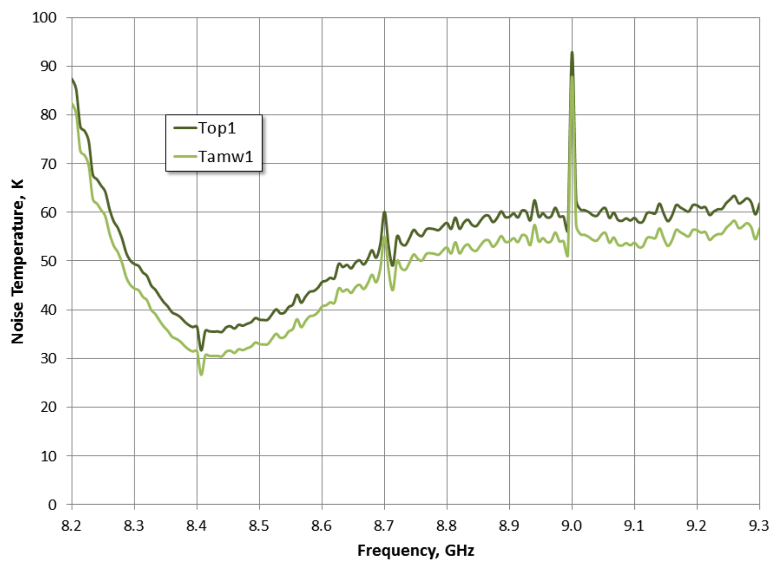

Figure 2.11: Position 2 X-band LNA Receiver Performance

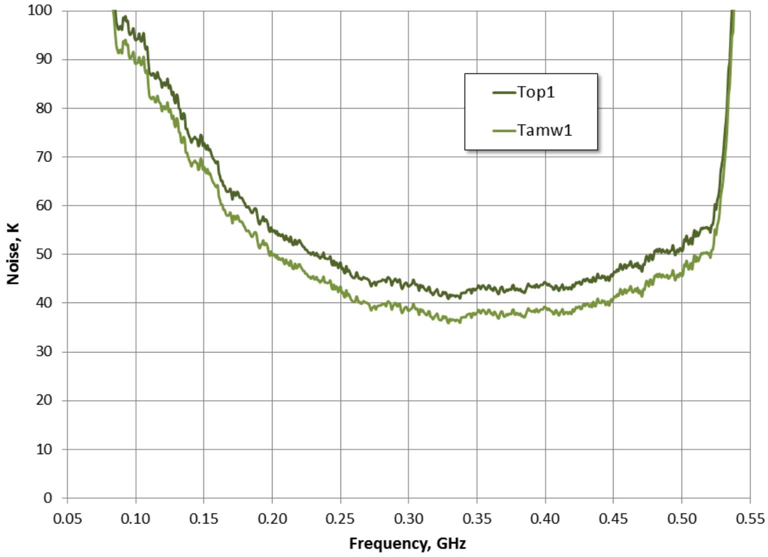

Figure 2.12: Position 2 X-band LNA Measured Through DC and FO Link

2.3 Position 3

Position 3 currently houses an XXKa receiver and an 80kW transmitter. The XXKa system has dual channel X-band and dual channel Ka-band LNA receivers along with a Ka-band monopulse coupler error channel. A picture of Position 3 is shown in Figure 2.13. A block diagram of the Position 3 RF systems can be seen in Figure 2.14. The performance of the LNA receiver systems at Position 3 are shown in Figures 2.15 and 2.16. A downconverter is for the XXKa system is currently being worked on.

Figure 2.13: Position 3 Photo

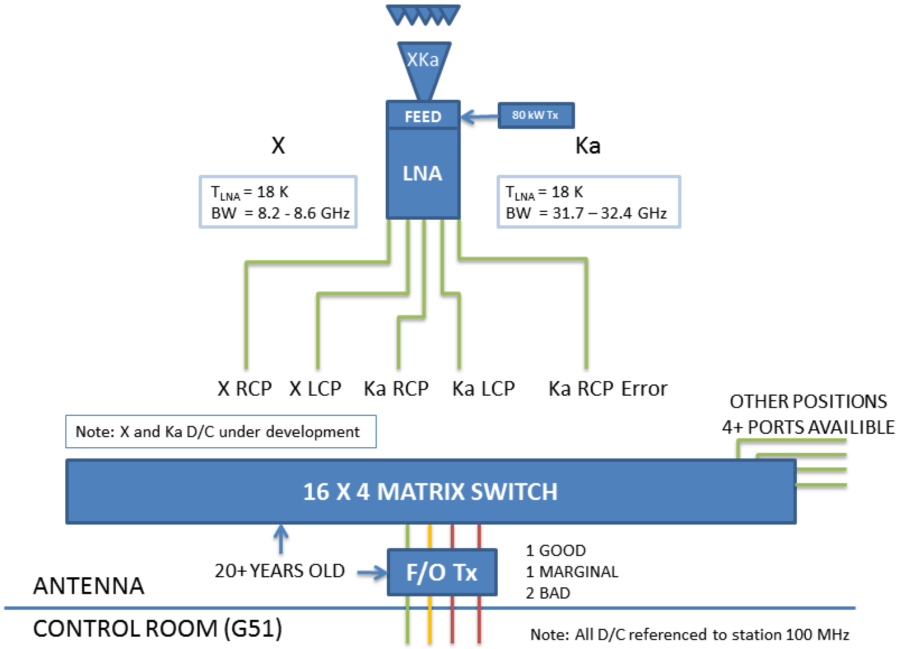

Figure 2.14: Position 3 Block Diagram

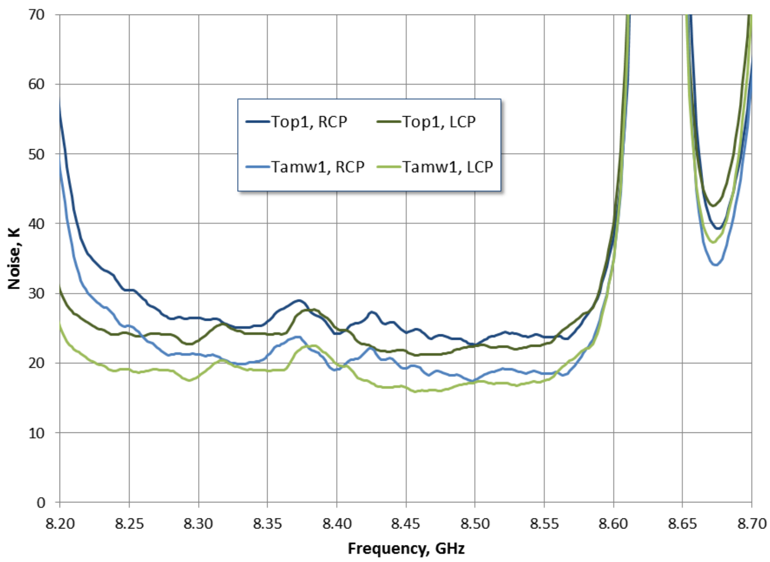

Figure 2.15: Position 3 X-band LNA Receiver Performance

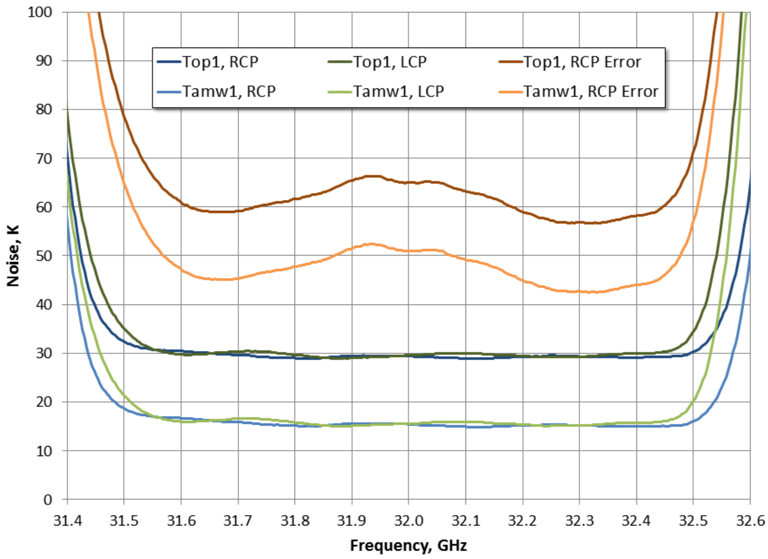

Figure 2.16: Position 3 Ka-band LNA Receiver Performance

2.4 Position 4

Position 4 houses a wide-band X-band LNA receiver. A picture of Position 4 is shown in Figure 2.17. A block diagram of the Position 4 RF systems can be seen in Figure 2.18. The performance of the LNA receiver system at Position 4 is shown in Figure 2.19. A measurement of the LNA system through the GSSR downconverter and fiber-optic link in the control room is shown in Figure 2.20.

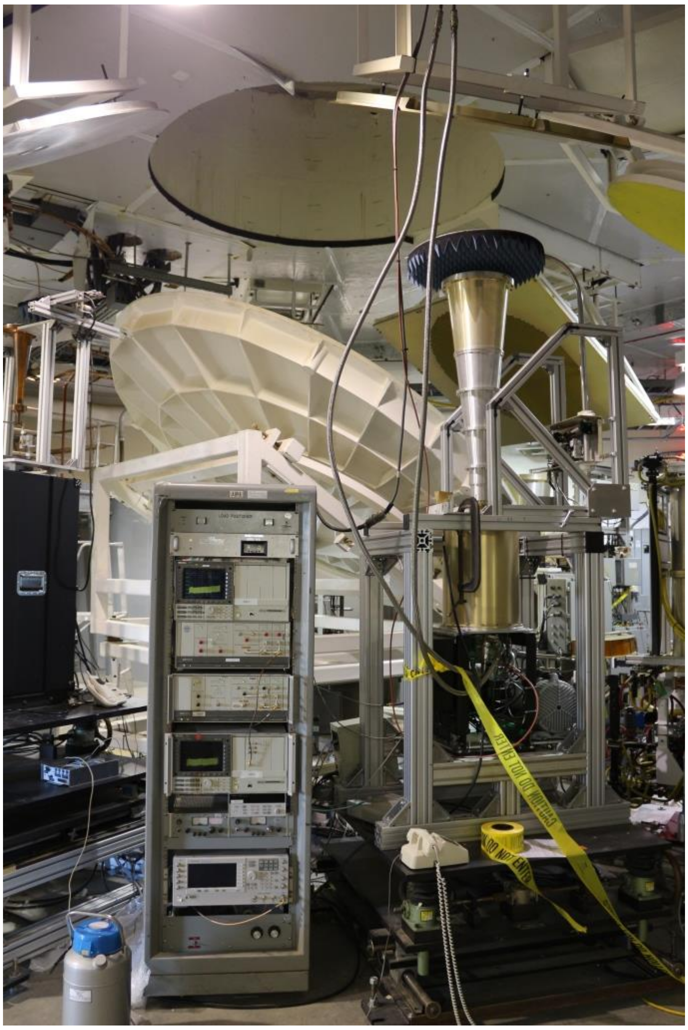

Figure 2.17: Position 4 Photo

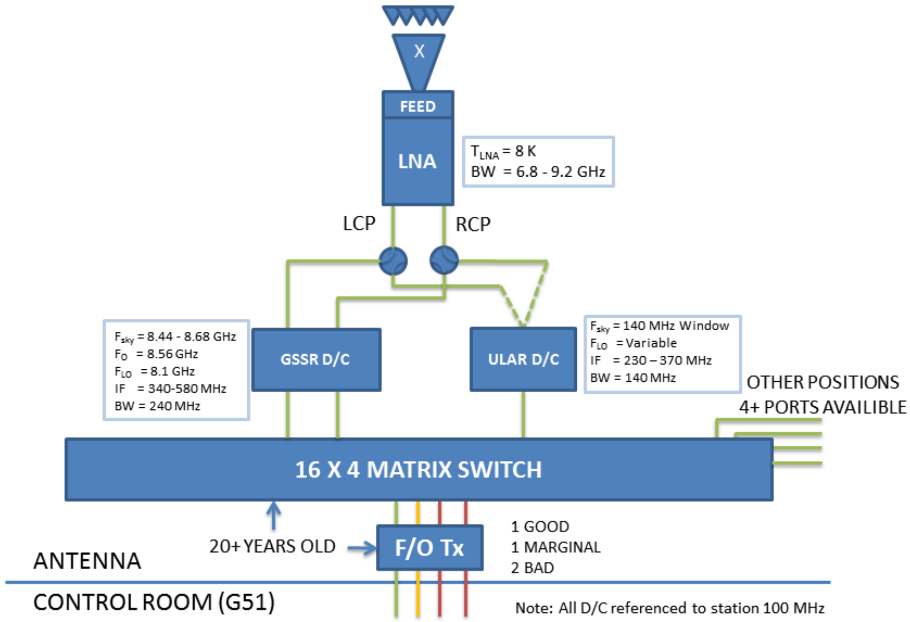

Figure 2.18: Position 4 Block Diagram

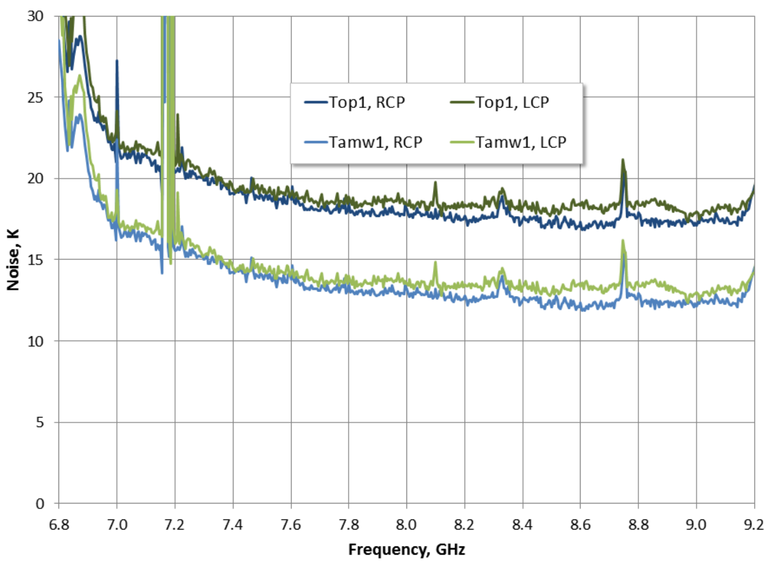

Figure 2.19: Position 4 X-band LNA Receiver Performance

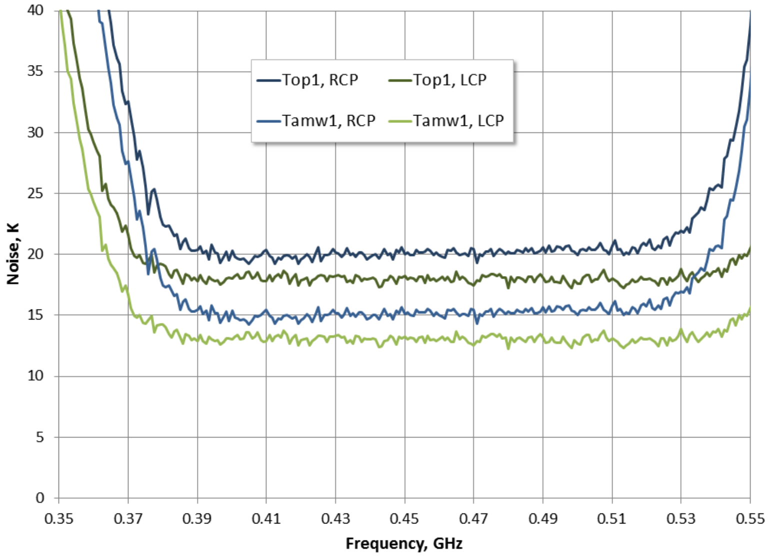

Figure 2.20: Position 4 X-band Measured Through GSSR DC and FO Link

2.5 Position 5

Position 5 houses a 26 GHz ambient receiver. A picture of Position 5 is shown in Figure 2.21. A block diagram of the Position 5 RF systems can be seen in Figure 2.22. The performance of the LNA receiver system at Position 5 is shown in Figure 2.23. A measurement of the LNA system through the downconverter and fiber-optic link at the control room is shown in Figure 2.24 The LNA was replaced with one from JPL resulting in a 150 K improvement in the noise temperature. A better LNA is on order and will be installed later in 2014 to provide another 150 K improvement in the noise temperature.

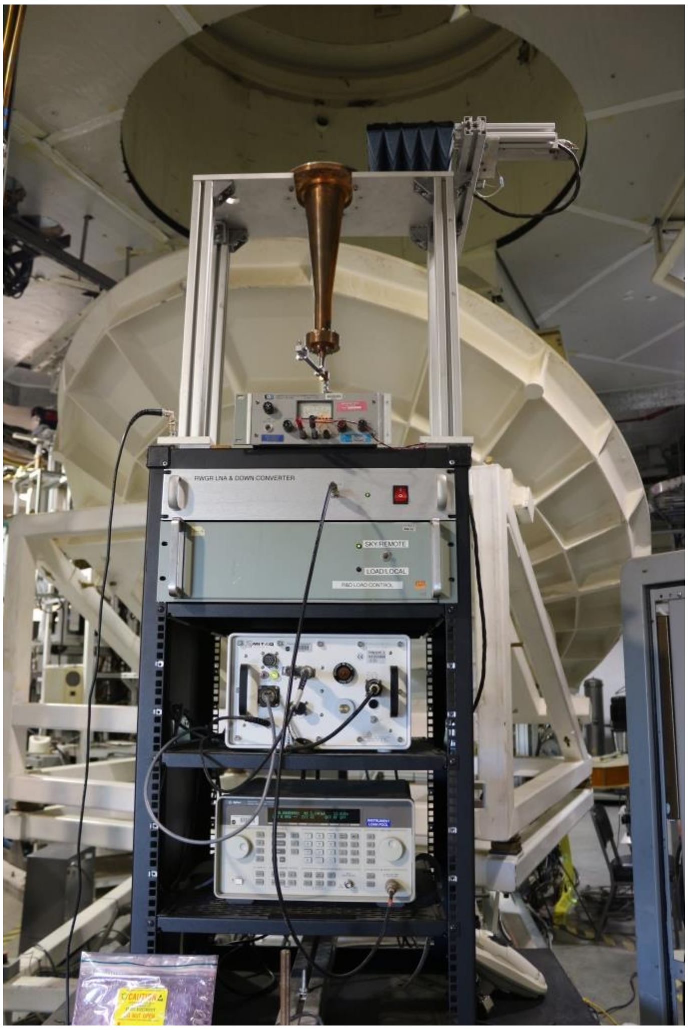

Figure 2.21: Position 5 Photo

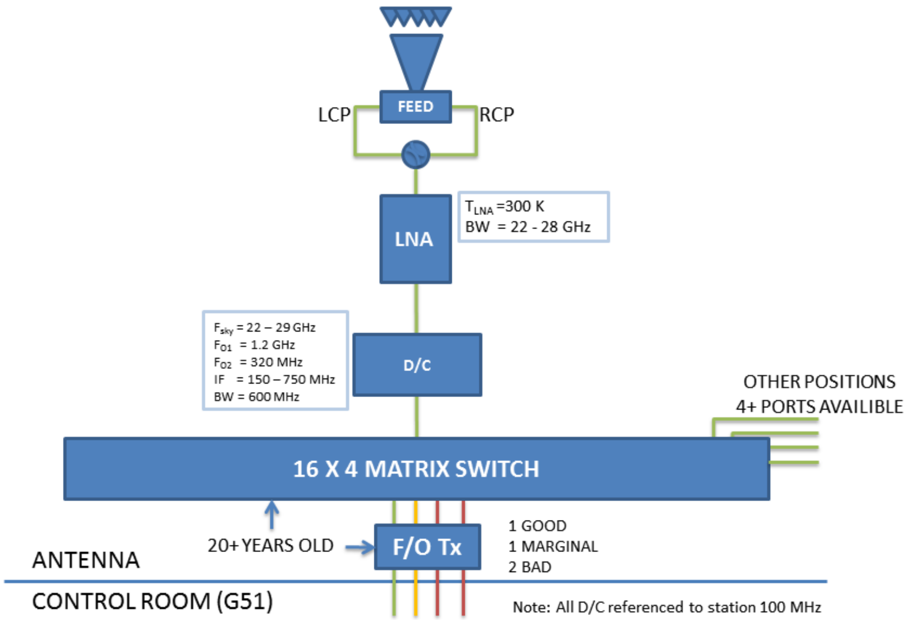

Figure 2.22: Position 5 Block Diagram

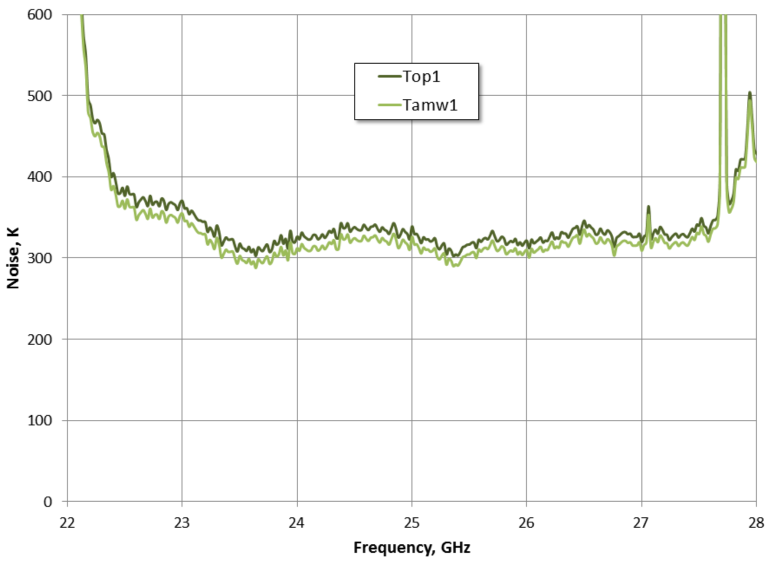

Figure 2.23: Position 5 26 GHz LNA Receiver Performance

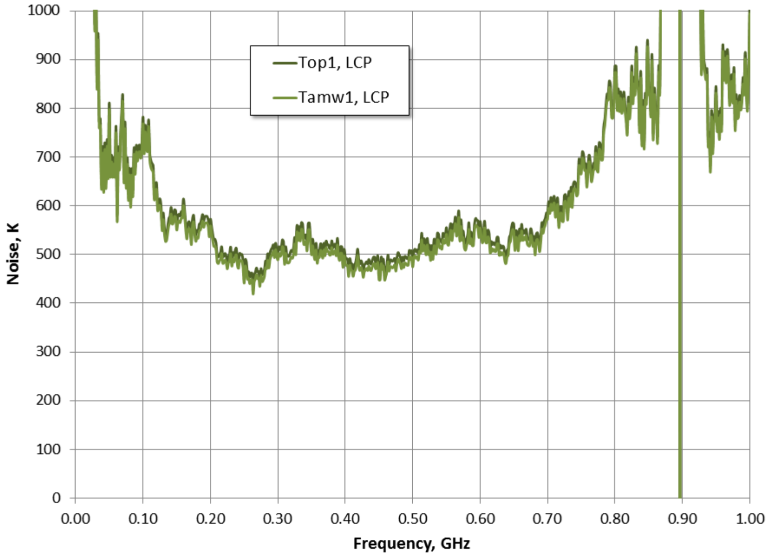

Figure 2.24: Position 5 26 GHz LNA Measured Through DC and FO Link

2.6 Position 6

Position 6 does not currently house any receivers or transmitters. A picture of Position 6 is shown in Figure 2.25. This position does have an availible deformable mirror that is shown in Figure 2.26.

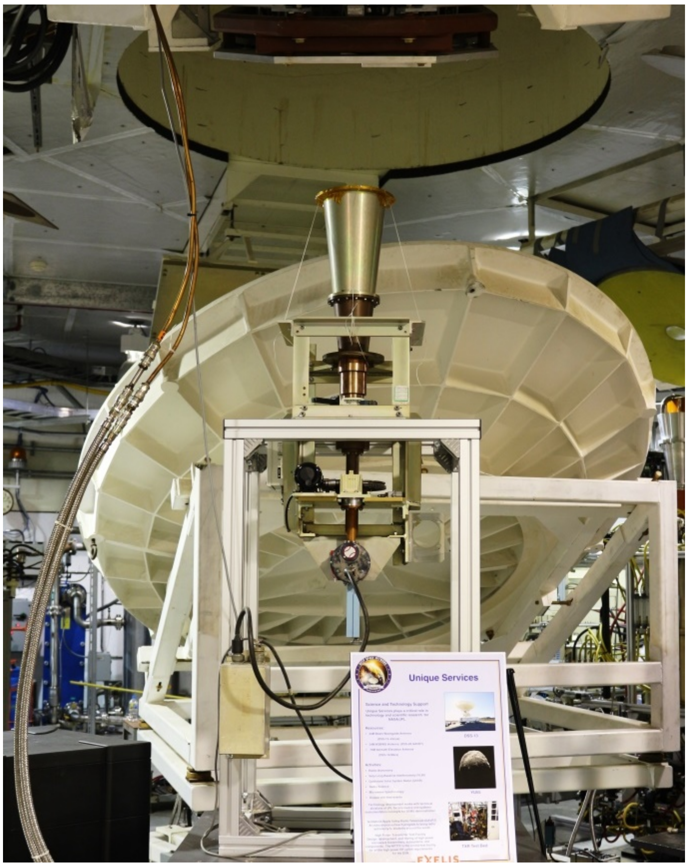

Figure 2.25: Position 6 Photo

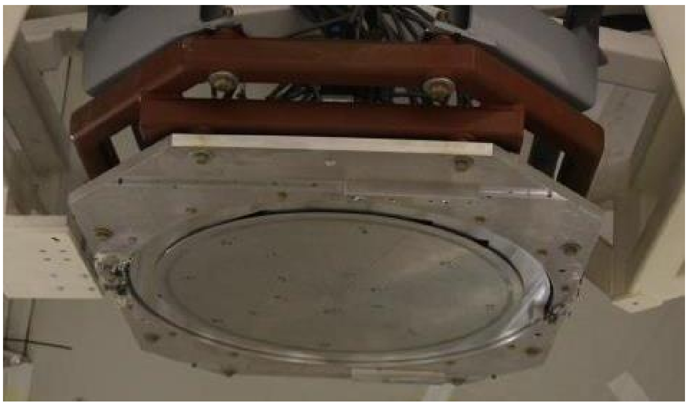

Figure 2.26: Position 6 Deformable Mirror

Chapter 3

Control Room

The control room, building G51, houses equipment to control the antenna and its various systems, it also contains equipment to receive and process data. A general block diagram of the control room is shown in Figure 3.1.

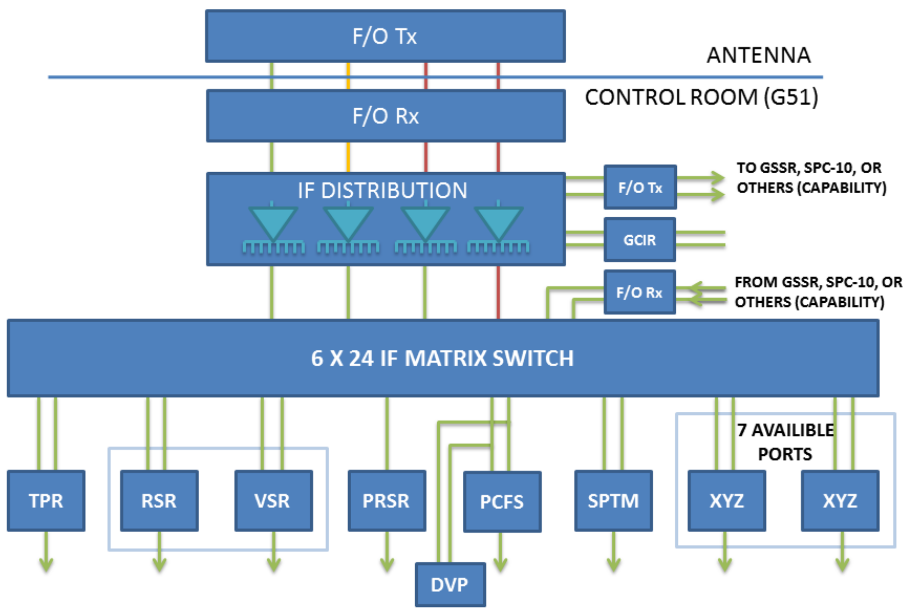

Figure 3.1: Control Room General Block Diagram

3.1 Control Console

The control console is the central control station for mechanical movement of the antenna. Figure 3.2 shows the control console. In addition the control console governs various microwave systems such as switches, loads, or signal paths. The console is equipped with total power radiometers (TPR) and contains power meters, switches and a spectrum analyzer. Video feeds of the antenna and pedestal room are also available from this console. The control console now also houses the Equipment Access Controller (EAC).

Figure 3.2: Control Room Control Console

3.2 Equipment Racks

Pictures of the various instrument racks in the control room are shown in Figures 3.3 to 3.6. From left to right, Figure 3.3 displays: a rack containing the fiber-optic interface to the pedestal, a rack containing the matrix switch and distribution amplifiers, a 20 kW remote control rack (obsolete), the guest customer interface rack (GCIR), and an experimental radio astronomy rack. From left to right, Figure 3.4 displays: a file server rack connected to JPL, an experimental radio astronomy rack, the old EAC rack (obsolete), and a rack containing GAVRT equipment and a weather station readout. Figure 3.5 displays three racks containing the DSCC VLBI Processor (DVP) and the PC Field System (PCFS). From left to right, Figure 3.6 displays: a rack housing the Radio Astronomy Receiver (RAR), a rack with GAVRT equipment, a rack containing frequency and timing equipment, and a rack with LAN and fiber-optic network distribution. A block diagram of the GCIR is shown in Figure 3.7.

Figure 3.3: Control Room Racks: Pedestal FO Link, Matrix Switch and Distribution Amplifiers, Obsolete 20 kW Control, GCIR, Experimental

Figure 3.4: Control Room Racks: File Server, Experimental, Obsolete EAC, GAVRT

Figure 3.5: Control Room Racks Housing the DVP and PCFS

Figure 3.6: Control Room Racks: RAR, GAVRT, Frequency and Timing, FO-LAN

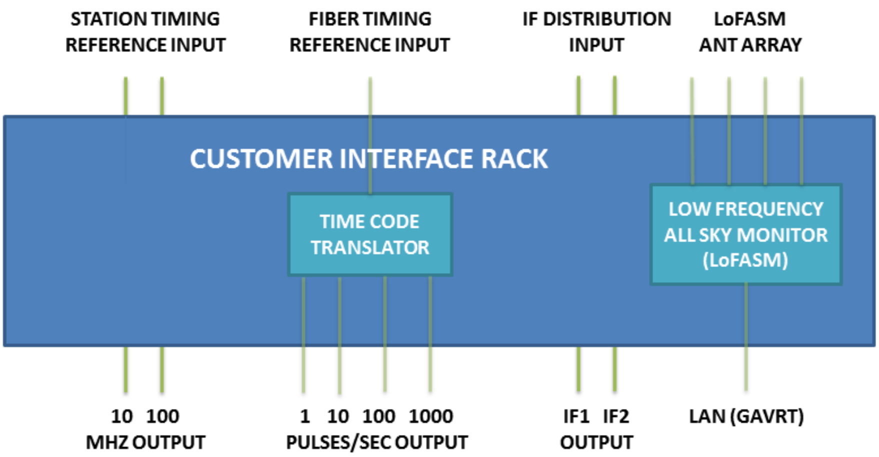

Figure 3.7: Guest Customer Interface Rack Block Diagram

Bibliography

[1] M. Reid, *Low-Noise Systems in the Deep Space Network.* Wiley, 2008, pp. 13–93.

[2] M. Britcliffe, "Standard Noise Temperature Measurement Procedure for DSN LNA Systems," Jet Propulsion Laboratory, DSN Specification Document 869-000192, June 2008.

[3] S. Slobin, "Atmospheric and Environmental Effects," Jet Propulsion Laboratory, DSN Telecommunications Link, Design Handbook 810-005-105, September 2009.

[4] D. Russel, E. Long, S. Montanez, and M. Young, "DSS-13 Ka Receiver Upgrades," Jet Propulsion Laboratory, IPN Progress Report 42-195, November 2013.

List of Figures

Appendix A

Acronyms

Table A.1 is a list of the acronyms used in this document.

Table A.1: List of Acronyms

Acronym	Definition
BW	Band Width
DSCC	Deep Space Communications Complex
DSS	Deep Space Station
DVP	DSCC VLBI Processor
EAC	Equipment Access Controller
FO	Fiber-Optic
GAVRT	Gold Stone Apple Valley Radio Telescope
GSSR	Gold Stone Solar System Radar
GCIR	Guest Customer Interface Rack
IF	Intermediate Frequency
LCP	Left Circular Polarization
LNA	Low Noise Amplifier
LoFASM	Low Frequency All Sky Monitor
MMS	Modular Measurement System
PCFS	PC Field System
PRSR	Portable Radio Science Receiver
RAR	Radio Astronomy and Radar
RARG	Radio Astronomy and Radar Group
RCP	Right Circular Polarization
RSR	Radio Science Receiver
Rx	Receive
SPTM	Spectrometer
TPR	Total Power Radiometer
Tx	Transmit
ULAR	Up Link Array Receiver
VLBI	Very Long Base Line Interferometer