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To: Broadband Development Group

From: C. J. Beaudoin

Subject: GPIB over Ethernet capability, system temperature, and LNA status at MV3

Introduction

On 2 July 2008, a National Instruments GPIB-ENET/100 Ethernet-to-GPIB controller was successfully installed at the MV3 antenna facility using the existing MARK V network infrastructure. The installation of the device provides the capability to control any device at MV3 fitted with a GPIB interface via an ethernet connection behind the Haystack firewall. A basic diagram of the network setup is shown in figure 1. In order to successfully communicate with the device, any firewalls or switches in the network path must have all ports 5000 and up enabled.

After completing the installation, system temperature estimates of the MV3 receive chain were obtained using the Y-Factor method in order to assess the state of the LNAs installed in the Dewar. The experimental setup used for the data collection is shown in figure 2 and the spectrum analyzer parameters are shown in Table 1. The weather at MV3 was described as "mostly sunny some clouds temp was around 86F low humidity" and was deemed adequate for use of the sky the Y-Factor cold load measurement. During the cold (sky) and hot (290 K absorber in the aperture of the Dewar) load measurements the antenna was pointed at zenith. Figures 3a[1] and b display spectra collected during the absorber and sky measurements, respectively, while Figure 3c displays the estimate of the system temperature obtained using the Y-Factor method. Table 2 displays the Caltech-specified and recent bias settings of the LNAs installed in the MV3 Dewar.

From conversations I have had with others in the BBD group, Y-Factor measurements obtained using the MV3 front-end just after the Dewar was installed indicated a system temperature of ~50 K. The results in Figure 3c then indicate that the overall temperature has increased by roughly 25K. Considering the damage that we have experienced with the LNAs installed in the Westford Dewar, the immediate response to the increase in system temperature at MV3 is damaged LNAs. As described in memo [1], damage in an LNA was marked by an increase in the drain current by 30% or more. In turn, this increase in drain current lead to an increase in the system temperature of the

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[1] In the sky power spectrum in Figure 3b, there appears to be a significant amount of V-pol RFI in the 3-7 GHz band

receive chain. As shown in Table 2, the LNA in the H-pol channel has experienced a significant increase in drain current (~300%) while the V-pol LNA has only experienced a 10% increase. It is curious that despite the drastic difference in the drain currents, the system temperature estimates of each channel are remarkably similar. Again referencing memo [1], a damaged stage in the LNA resulted in periodic structure in the system temperature estimates (see [1], figure 7 H-pol T_{sys}). This type of behavior is not exhibited in Figure 3c which instills some doubt as to whether or not the system temperature increase is due to a bad LNA(s).

To add another wrinkle, the drain current in the H-pol LNA is invariant (relatively fixed at 73 mA) to it's respective drain voltage setting. In practice, the drain current should be strongly dependent on the drain voltage; the V-pol LNA does exhibit this dependence.

Bias Box Investigation

Firstly, and because this was a relatively simple experiment, the dependence of each LNA's drain current on the respective unit's drain voltage was observed. In order to do so, the drain voltage was set to 3 different voltages (0.7, 1.2, and 1.7) and the resultant currents as indicated on the bias box were measured[2]. The recorded currents are shown in Table 3. Clearly, there is a very small dependence of the H-pol LNA's drain current on drain voltage while the V-pol LNA is exhibiting the expected behavior. In order to determine whether the problem resided in the bias box or the LNA itself, the bias boxes for each LNA were swapped and the experiment was repeated. In doing so it was observed that the drain current statistics in Table 1 swapped polarizations, thereby leading to the conclusion that the bias box is faulty. Furthermore, it is believed that only the current monitoring section of the bias box is at fault because the H and V-pol system temperature estimates in Figure 3c are nearly identical. If there was an issue with an excess amount of current supplied to the LNA, the system temperature estimates for each polarization are expected to be drastically different.

Further evidence supporting this is in the fact that the current test point was initially thought to be a current probe-in-series measurement as opposed to the voltage-type probes-parallel measurement it is in actuality(an easy mistake to make since there are no markings to the contrary). In current measurement mode, the path through the meter is very low impedance. This low impedance connected between the current test point on the bias box and ground may have damaged the current sensing circuit in the bias box without impacting the actual power delivery circuitry. In any event, the bias box should be repaired or replaced.

System Temperature and LNA Investigation

On 8 July 2008, I spoke with Sandy Weinreb about the increase in system temperature at MV3, our concern about potential damage to the LNAs at MV3, and described the 2 July results to him. Based on the fact that both channels experienced approximately the same increase in system temperature, he was more concerned that

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[2] The drain current test point on the bias box is actually monitored as a voltage measurement. The voltage to current conversion is simply 1 mA for every 1 mV measured at the drain current test point.

condensation may be building up on the Dewar window than damaged LNAs and he described a humidity extraction scheme that is being employed on the GAVRT system[3]. As a surprise to myself, I learned from Jay Redmond that MV3 has already employed such a dehumidifying measure but mentioned that the condenser needed servicing as the stones had turned pink indicating that they are in need of replacement. In response to Sandy's concern, Jay removed the de-humidifier from the Dewar to inspect the window; there were no signs of condensation.

Having not observed any condensation in the window, absorber and sky load spectra were once again collected in the interest of gaining more information into the unexpectedly high system temperature estimates obtained on 2 July. The experimental setup was identical to that shown in Figure 2 and parameters in Table 1. The climate conditions at MV3 were described as hot and humid, mostly sunny, and 92.5°F. The absorber and sky spectra are shown in Figures 4a and 4b[4], respectively, and the system temperature estimate is shown in Figure 4c. In analyzing Figure 4c, one will note a significant and equal increase in the H and V-pol system temperatures compared to those observed on 2 July. The crucial piece of information here is the fact that the H and V-pol system temperature estimates increased in unison. The reason for this increase is believed to be two-fold.

The first factor believed to be contributing to the increased system temperature observed on 8 July is due to the fact that the ambient temperature at MV3 increased from 86°F on 2 July to 92.5°F on 8 July. Jay Redmond noted the readings displayed on the Dewar temperature monitor (50 and 30K)[5] and mentioned that he had never observed the Dewar temperature ever reaching these levels[6]. Unfortunately, the Dewar temperature readings on 2 July are not available.

The second factor believed to have caused the drastic increase in system temperature was the removal of the dehumidifier from the Dewar. The dehumidifier is basically a balloon bounding the volume of the climate-controlled air in front of the Dewar window. This balloon also offers protection from sunlight directly incident upon the Dewar window. In the absence of the dehumidifier, sunlight is allowed to directly warm the Dewar through the window. All in all, these results indicate a strong dependence of the overall system temperature on the ambient temperature during the collection. Perhaps the Dewar temperature should be monitored/collected as part of the collection sequence? Is the refrigeration system not able to keep up on hot days?

In conclusion, the fact that the system temperature estimates in both H and V-pol channels track one another very closely lends credence to the supposition that the LNAs are not damaged. If they were in fact damaged, both LNAs would have had to have experienced identical failures in order to have observed the similarity in the H and V-pol system temperature estimates as the Dewar temperature increased between the 2 July and 8 July collections. Unfortunately, with the information gathered for this memo we can

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[3] Sandy also mentioned the Dewar design for the GAVRT system is now employing 20 layers of 1 mil Teflon in order to combat condensation.

[4] V-pol RFI is also observed in the sky power spectrum collected on 8 July

[5] As of the date of this memo, the sensor inputs on the temperature meter at MV3 have not been labeled so it is not clear what sensor corresponds to the LNA, the station, or the fin. According to Jay Redmond, the third sensor has always yielded erratic readings and was not documented in the text above. Typically, the coolest temperature reading is that of the refrigeration station as it is a temperature sink.

[6] The Dewar maintained vacuum during the experiment.

only make inferences about the state of the LNAs. In order to truly assess the state of the LNAs requires that both S-parameter and noise temperature of the LNAs be characterized externally to the Dewar. If it is determined that we require more definitive answers as to the state of the LNAs, an alternative experimental setup will have to be investigated.
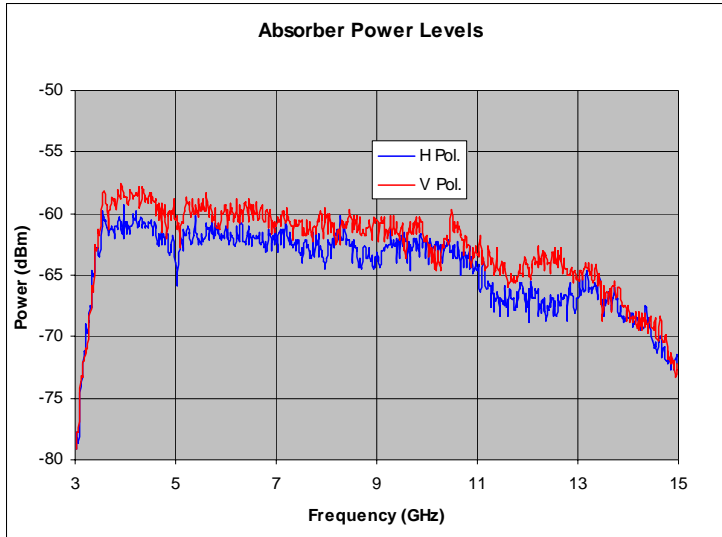
References

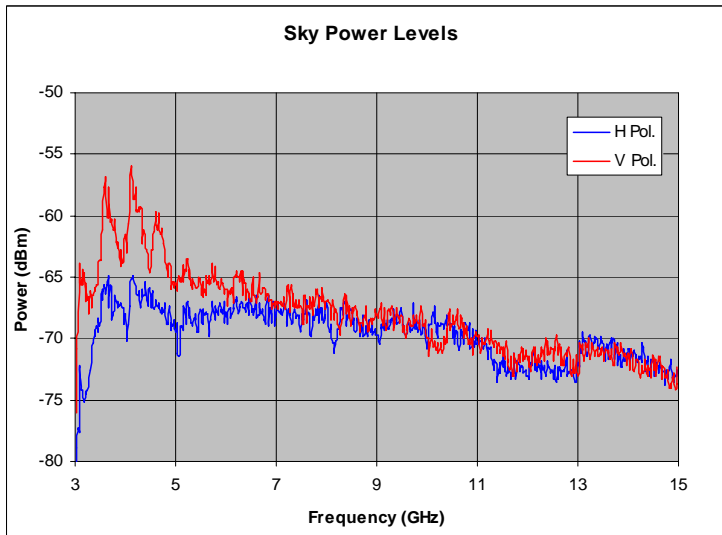[1]   C.J. Beaudoin et al. "*Results of Westford Dewar Y Factor Measurements*", VLBI Broadband Development Memo Series, No. 15
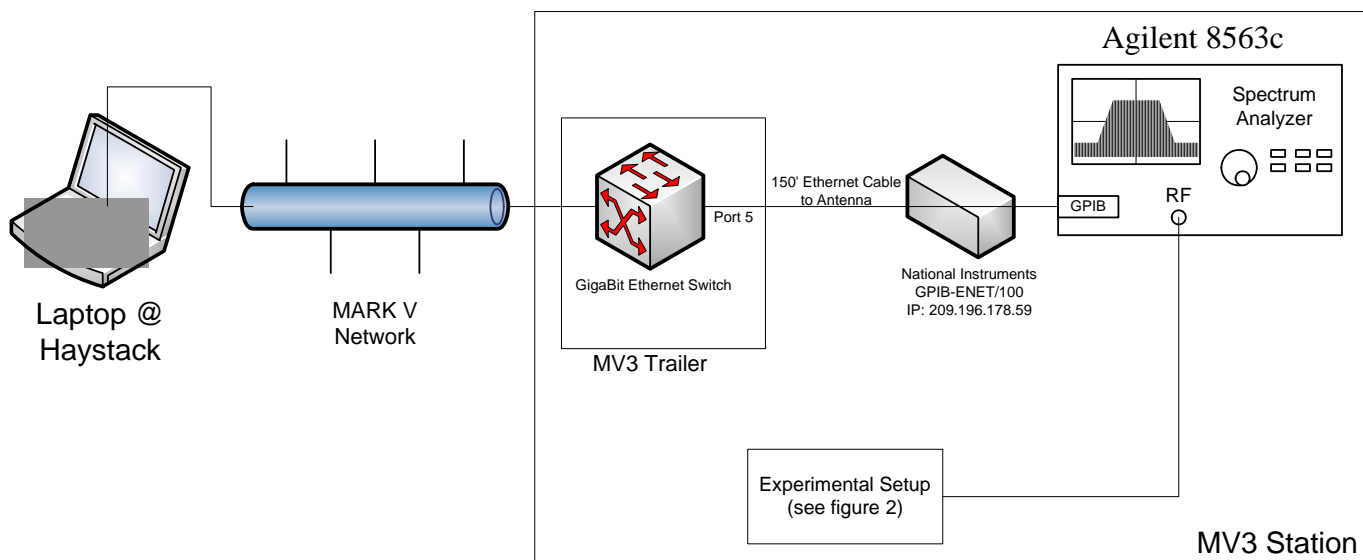
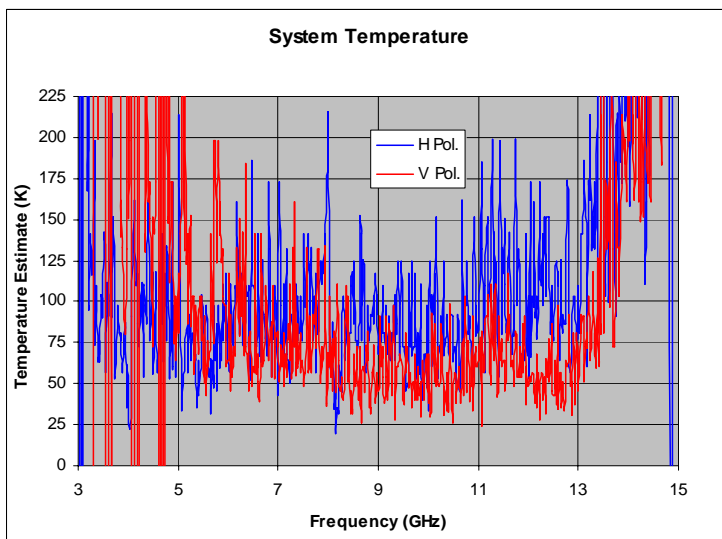Figures 1: Basic network setup used for the GPIB-to-Ethernet Controller
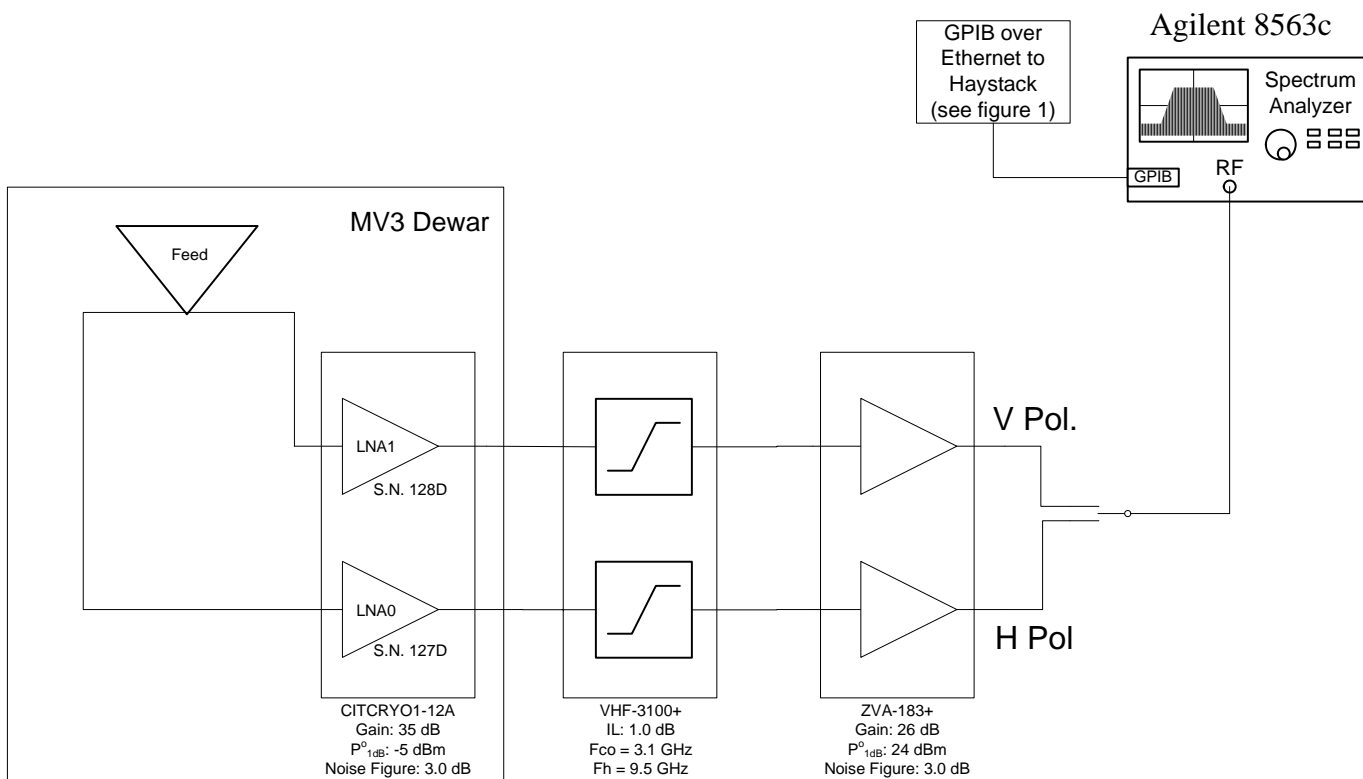
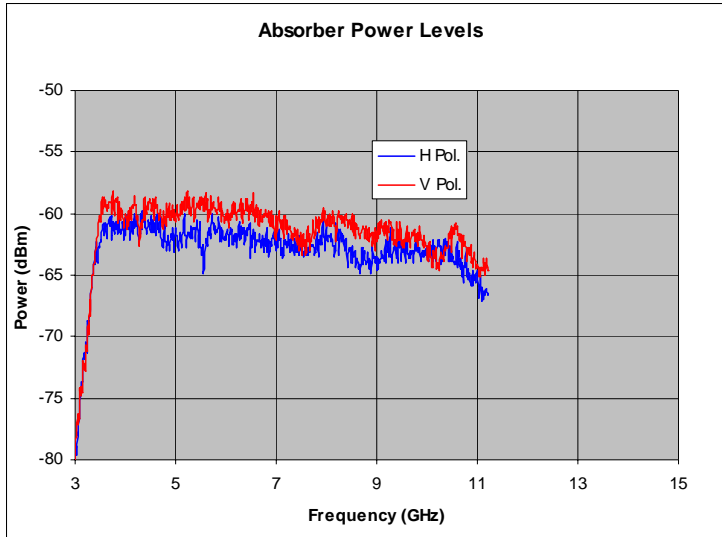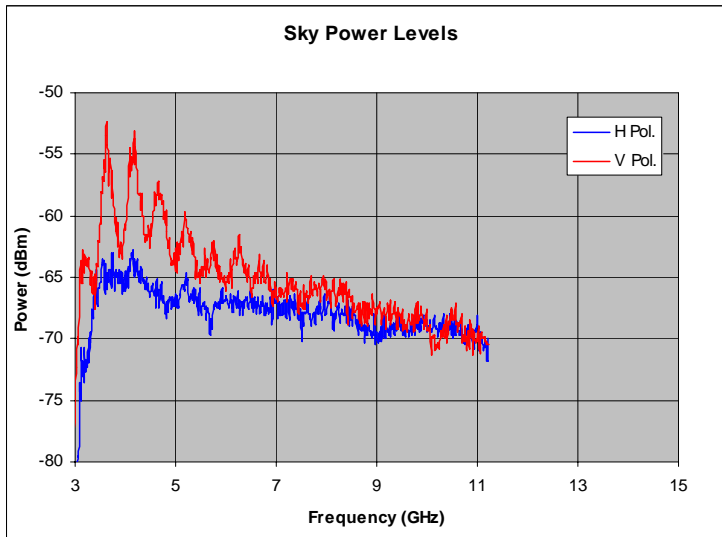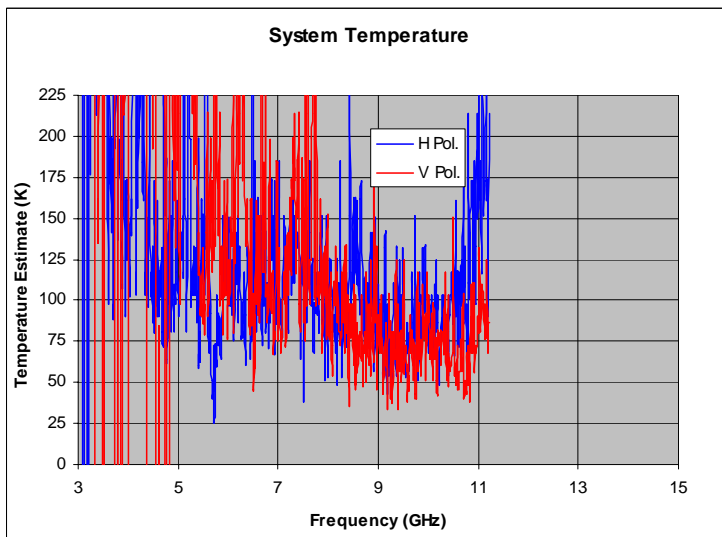Figures 2: Experimental setup used to collect spectra for Y-Factor system temperature estimates

Figures 3: Y Factor Measurements (a), (b) and T_{sys} Estimate (c) on 07/02/2008

Figures 4: Y Factor Measurements (a), (b) and T_{sys} Estimate (c) on 07/08/2008

Center Frequency (GHz)	*9 (2 July), 7 (8 July)*[7]
Span (GHz)	*12 (2 July), 8.5 (8 July)*[7]
Resolution BW (MHz)	*1*
Video BW (MHz)	*1*
Video Averaging Factor	*30*
Input Attenuation (dB)	*0*

Table 1: Spectrum analyzer settings used during the experiment.

	V-pol		H-pol.	
	Recent	Specified	Recent	Specified
Vd	1.2V	1.2 V	1.2 V	1.2 V
Vg1	1.0 V	1.0 V	2.0 V	2.0 V
Vg2	1.0 V	1.0 V	2.0 V	2.0 V
Id	22 mA	20.0 mA	73 mA	20.2 mA

Table 2: Specified and recent bias settings on the LNAs

Vd (V)	V-pol Id (mA)	H-pol Id (mA)
0.7	14	72
1.2	24	73
1.7	34	74

Table 3: LNA drain current dependence on drain voltage

[7] The reason for the different spans settings on 2 and 8 July is due to the quirky nature of the spectrum analyzer at MV3. The analyzer cannot span more than 8.5 GHz if the start frequency is less than 3 GHz. The collection on 8 July was originally set to 12 GHz span but it wasn't until the following day that it was realized the span was automatically reset by the spectrum analyzer.