RFI MEMO #011

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To: RFI Group

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Subject: Revised RFI monitor block diagram

Figure 1 shows the revised block diagram of the RFI monitor.

A] Spectrum analyzer

The Tektronix RSA3303A has the best dynamic range of the analyzers we tested (see memo #007).

B] Connection to the internet

The Linux PC provides a convenient and relatively secure way of acquiring the data, controlling the monitor and connecting to the outside world. Linux provides ssh and sftp connections. The spectrum analyzer is controlled via GPIB which avoids any interactions with the windows operating system. RS232 is used to control the input switch noise source and optional antenna rotator.

C] LNA

The spectrum analyzer has a relatively high noise figure (~20dB) so that it is derivable to amplify the antenna output with a LNA. The WJ AH1 provides about 13 dB of gain with a 2.7 dB noise figure and a high dynamic range (IIP3 ~ 27 dBm). A feedback network (design from Chalmers Institute of Technology) is needed to maintain stability at the low frequency end of the band. The level of noise that is emitted from the preamp and how the level at which this noise correlates with the output noise of the preamp is important.

D] Input switch

The mechanical switch provides a good match and has less than 0.15 dB from 30 to 500 MHz.

E] Solid state switch for control

A Weeder WTSSR-M RS232 module is used to control the power to the input switch and noise diode. The Weeder allows another RS232 device to be "stacked" on the same port so that if an antenna rotator is used it also can be controlled without requiring a separate serial port.

F] Antenna

Finding a broadband antenna with low VSWR and reasonable response patterns is difficult. The omnidirectional R&S HK033 has VSWR less than 2 and a horizon gain of about 2 dBi. Alternately a broadband log periodic (Tennadyne T-28) can be used with a rotator. This antenna has a gain of about 8 dBi and VSWR less than 1.7. The azimuth beamwidth, when mounted for vertical polarization, is about 60 degrees so that 6 positions are needed to cover the horizon. An added advantage to the directional antenna is that it gives information on the angle of arrival (AoA) of the RFI.

G] Theoretical performance

The 1 sigma noise in the measurement of the isotropic interference temperature is given by

$$\Delta T = 2\left(10^{G_a/10}\right)(290)\left[10^{-G_p/10}\left(10^{N_s/10}-1\right)+\left(10^{N_p/10}-1\right)\right]\left(BTf_s f_a\right)^{-1/2}$$

where G_a = antenna gain (dBi)

G_p = preamp gain – analyzer input attenuation (dB)

N_s = spectrum analyzer noise figure (dB)

N_p = preamp noise figure (dB)

B = resolution (Hz)

f_s = spectral analyzer spectral efficiency

f_a = fraction of antenna time in each direction

T = integration time (sec)

For $G_a = 8$, $G_p = 13$, $N_s = 20$, $N_p = 3$, $B = 10^6$ and $T = 3600$, $f_s = 0.001\times10^{-2}$, $f_a = 1/6$, $\Delta T = 7$K

The "isotropic interference temperature" is the antenna temperature of an isotropic antenna which has 0 dBi gain.

If we define a dynamic range as the ratio between the maximum signal for which the intermod product would equal the calculated ΔT above and $K\Delta TB$,

$$DR2 = \left(IIP2 - G_p - 10\log_{10}\left(K\Delta TB\right)+30\right)/2$$

$$DR3 = 2\left(IIP3 - G_p - 10\log_{10}\left(K\Delta TB\right)+30\right)/3$$

and the maximum input at this dynamic range are

$$m2 = IIP2 - G_p - DR2$$

and $$m3 = IIP3 - G_p - DR3/2.0$$

For $IIP2 = 14dBm$ and IIP3= -3 dBm

the achievable dynamic range is about 65 and 76 dB for IP2 and IP3 respectively and is largely independent of G_p. However the maximum signal levels to reach this dynamic range depend on G_p and are -60 and -50 dBm for IP2 and IP3 respectively for G_p = 8 dB. If the intermod performance of the preamp is much better than the analyzer the input attenuator of the analyzer can be used to set G_p. In practice a value of G_p = 8 dB which corresponds to an analyzer input attenuation of 5 dB for a 13 dB preamp is sufficient for the Haystack location. At quieter locations G_p can be increased to improve sensitivity.