

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
**HAYSTACK OBSERVATORY**  
 WESTFORD, MASSACHUSETTS 01886  
 November 21, 2006

*Telephone: 781-981-5407*  
*Fax: 781-981-0590*

To: EDGES Group  
 From: Alan E.E. Rogers  
 Subject: Using EDGES spectrometer to measure the antenna reflection coefficient.

If a noise source is coupled into a long coax cable to the antenna the spectral ripple amplitude produced by this noise is

$$\Gamma_a \alpha b/2$$

where the factor of 2 is the voltage loss in a 16.67 resistive tee.

The calibrated difference spectrum taken between the noise on and noise off

$$P_{on} - P_{off} = T_{noise} \left( 1 + |\Gamma| \alpha \cos(2\pi\tau + \phi) + |\Gamma|^2 \alpha^2/4 \right)$$

where  $\Gamma_a$  is the antenna reflection coefficient

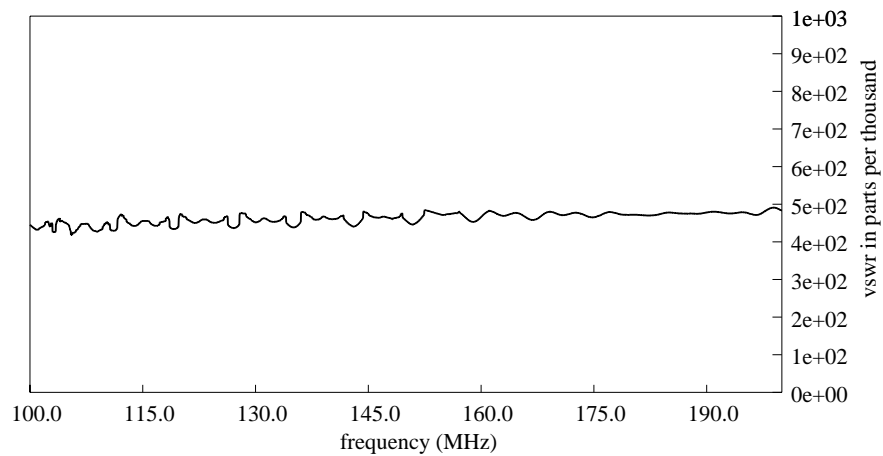
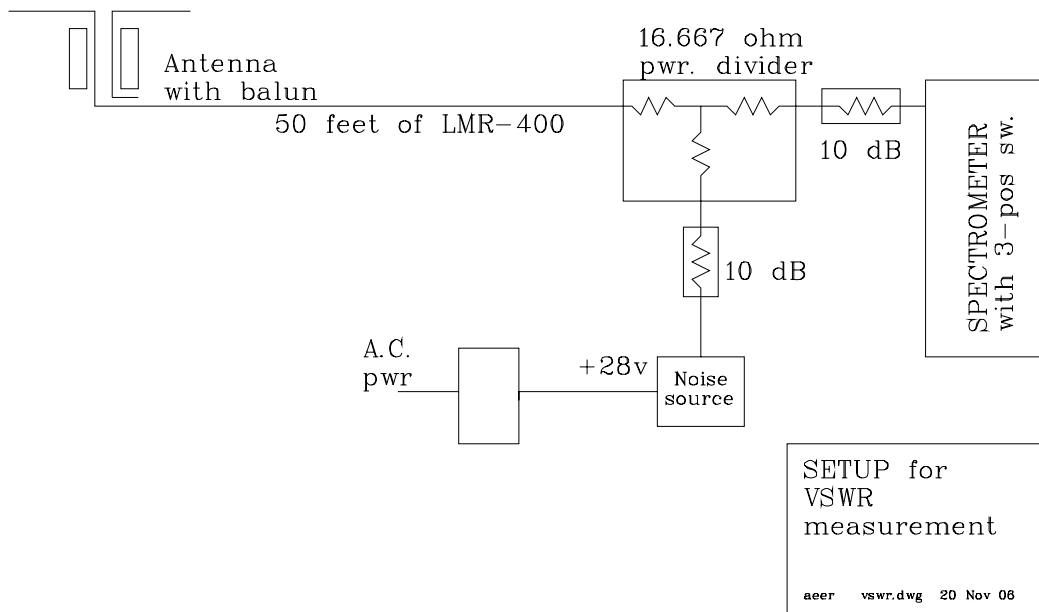
$\alpha$  is the 2-way voltage loss in the cable

$\phi$  is the reflection phase

$\tau$  is the 2-way cable delay

$T_{noise}$  is the noise source temperature

To make the reflected noise from the antenna dominant over the sky noise a  $10^6$  K noise source is first attenuated by 10 dB to improve its match and then the entire signal is attenuated by 10 dB before the 3-position switching LNA input. Figure 1 shows a block diagram of the set-up and figure 2 shows a plot of the VSWR measurement of a 3 dB attenuator open at one end.



cor 5 npoly 0 dtyp 99 smooth 0 mdl 0.00 t150MHz 1531 tr 57 tc 443 file: 2006\_324\_16.acq  
 Acqiris atn 0 fpgatm 42.8 degC adc 4 accum 0 fsv 0.50 pwr 2.2e+11 5.3e+11 8.4e+11  
 start 2006:324:16:57:13 stop 2006:324:16:57:13 resolution 122.0 kHz

Mon Nov 20 12:57:25 2006