EDGES MEMO #067

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To: EDGES Group

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Subject: Additional systematics in EDGES electronics

Introduction

The major sources of systematics in the EDGES electronics were ADC non-linearity and level dependent spurious signals. The use of out of band noise conditioning and improved ADC have reduced the systematics so that other smaller effects are now evident.

1] Flatness of noise diode

EDGES uses a NC302L noise diode made by Noisecom for internal calibration. The flatness of this source is critical to the accuracy of the antenna temperature measurements. An examination of the noise diode shows that the output and its slope depends on the diode current. At the recommended current of 6 ma the output drops by about 10% from 40 to 200 MHz. This slope varies from one diode to the next, at least for diodes from different production batches. In addition there is a small level of cross-coupling on the PC board which effects the flatness. The cross-coupling is eliminated by mounting the noise diode and its associated DC filter on a SMA connector flange connected directly to the 30 dB attenuator. The noise diode slope can be corrected in software using parameters derived from measurements made with a standard calibrated noise diode connected to EDGES.

2] Change of bandpass with current in bias tees.

The current in the cable changes with the state of the coax input switch. In recent versions of EDGES there is circuitry which maintains a constant current by switching in a compensating resistor load to equalize the current.

An unbalance of 100 ma produces peak to peak ripple of about 200 mK out of 1000 K. These ripples are correlated with the ripple in the bandpass.

3] Drifts of gain with time and temperature

The 3-position switching takes out drifts on time scales longer than the switch rate. The switch rate is limited to the longevity of the coax switch. The current switch (Dow-key 401-2208) is limited to about 1 million cycles. A 5 million cycle version is available (4010-2208) and will be used in upgraded EDGES as 2 of the million cycle switches have already failed in the lifetime of EDGES. At 5 million cycles the switch rate could be increased to about 0.1 Hz and still maintain a 2 year lifetime.

4] Current level of performance

Frequency range	# poly terms	Signal level	rms	Resolution
80-190 MHz	3	300 K	45 mK	5 MHz
80-190 MHz	5	300 K	2 mK	5 MHz
40-80 MHz	3	300 K	30 mK	5 MHz
40-80 MHz	5	300 K	8 mK	5 MHz
80-190 MHz	3	1200 K	240 mK	5 MHz
80-190 MHz	5	1200 K	10 mK	5 MHz
40-80 MHz	3	1200 K	300 mK	5 MHz
40-80 MHz	5	1200 K	7 mK	5 MHz

5] Modification of bias tees

A close examination of the bias tees showed that they contained a ferrite rod inside the solenoid which forms the series inductance. 2 bias tees where modified by replacing the solenoid with one of a 0.26” diameter consisting of about 30 turns 30 a.w.g. kynar wire to provide about the same inductance without the need for the ferrite. The unmodified bias tees had a loss change of about 0.01 dB/100 ma in the 30 to 200 MHz range. After modification no sensitivity to current could be detected.