

# EDGES Lowband-2 2016 Calibration

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## Summary of Measurements

The second EDGES lowband receiver, lowband-2, was characterized in the lab between Sept 25, 2016 and March 1, 2017. Three sets of calibration data were taken at different temperatures: 25 C, 35 C, and 15 C. When taking spectra, the resistance of the load's thermistor was recorded using a Fluke logging multimeter and stored on a netbook computer.

The Receiver's S11 values were remeasured in 2017 in February, again at three temperatures, for an hour immediately following the cessation of switching. Spectra were recorded for one special measurement at 25 C with the 4 position switch set to the open position and Sim Ant 2 attached to the receiver.

Noise source measurements were made at 15 C and 25 C. A VNA power level sensitivity study was performed as well as a study of the noise source itself using 3 different built in attenuation values (0, 3 dB, and 6 dB). The noise source was used in the intrinsic 3 dB configuration. Extra attenuation was added to this baseline for some of the studies. We eventually decided that 6 dB attenuation was the optimum amount, but no spectra was recorded for the lowband in this configuration.

## Measurement Details:

Measurement	25 C Duration (days)	35 C Duration (days)	15 C Duration (days)
Ambient Load	3	3	3
Hot Load (+12 V applied)	3	3	3
Open Cable	2	1	1
Shorted Cable	2	1	1
Ant Sim1	4	4	4
Ant Sim2	4	4	4
4 Pos Switch → Open (28 V) with Sim Ant2 attached	1	1	1
Powered (12V) Noise Source (3dB version). Extra 0 dB, 3dB, & 6 dB	3 each	NA	1 each
Noise Source + 3dB + Cable Box	4	NA	NA
Dates of Calibration	Sept 25 – Nov 2	Nov 3 – Nov 21	Nov 26 – Dec 12
Receiver S11 Measurement(s)	Sept 25 Nov 21 Dec 22	Nov 19	Nov 22

## VNA settings:

Settings	Loads	Receiver	Noise Source
Frequency Range (MHz)	50 – 100	50 - 100	50 - 100
Frequency Interval (kHz)	250	250	250
Frequency Steps	201 (4 x 50 + 1)	201	201
IF (Hz)	100	100	100
Average	10	100	varied
Power level	0 dBm	-35 dBm	varied

## Directories of the calibration files:

/data5/edges/data/calibration\_files\_25C\_sept\_2016/

/data5/edges/data/calibration\_files\_15C\_nov\_2016/

/data5/edges/data/calibration\_files\_35C\_nov\_2016/

## Receiver S11 temperature sensitivity due to switching: 2017 1 hour Measurements

Because the S11 of the receiver was not measured quickly after switching had stopped, a study was conducted to observe the S11 of the receiver for one hour after switching had stopped. These 1 hour measurements were done at the three temperatures of 15 C, 25 C, and 35 C, and the VNA settings were:

Power level = -30 dBm, 30 trace averaging, IF 100 Hz, 50 to 100 MHz, 201 frequency steps.

S11 measurements were taken immediately after switching had ceased (<1 min) and then every 5 minutes for the first 30 mins and then every 10 mins for the next 30 mins. These results are stored in:

/data5/edges/data/LowBand\_1hr\_measurements/

## Sensitivity of the Noise Source to VNA power levels: February 21 to March 1, 2017

The S11 of the Noise Source (intrinsic 3 dB attenuator) was measured at three different power levels:

-20 dBm 50 trace averaging

-10 dBm 30 trace averaging

0 dBm 10 trace averaging

It was found that the -10 dBm and -20 dBm settings produced similar results and that the -20 dBm setting is recommended when using a 3 dB intrinsic attenuator on the Noise Source. These files are kept at

/data5/edges/data/calibration\_files\_sept\_2016/S11/AlansLoad/

In addition, the spectra was recorded with the 4 positions switch set to open (+28 V applied) with the receiver maintained at 25 C. Sim Ant 2 was attached to the receiver and the resistance of its thermistor was recorded.

There are no S11 files associated with this measurement, only the temperature and spectra files.

/data5/edges/data/LowBand\_1hr\_measurements/resistance/OpenSimAnt2.csv

/data5/edges/data/LowBand\_1hr\_measurements/spectra/4PosSwitchOpen\_with\_SimAnt2\_25C\_2017\_060\_00.acq

## **Corrected Files – 8 total files**

There are three S11 corrected files from the 2016 calibration, three from the 2017 calibration, and two from the Noise Source measurements. The file names and locations are given here:

enterprise:/data5/edges/data\$ ll calibration\_files\_??C\*\_2016/S11/corrected  
calibration\_files 15C nov 2016/S11/corrected:

noise\_source\_s-parameters.txt\*  
s11\_calibration\_low\_band\_LNA15degC\_2016-12-14-23-01-53.txt  
s11\_calibration\_low\_band\_LNA15degC\_2017-03-02-05-48-33.txt

calibration\_files 25C sept 2016/S11/corrected:

noise\_source\_s-parameters.txt\*  
s11\_calibration\_low\_band\_LNA25degC\_2016-10-31-13-02-58.txt  
s11\_calibration\_low\_band\_LNA25degC\_2017-03-02-02-53-40.txt

calibration\_files 35C nov 2016/S11/corrected:

s11\_calibration\_low\_band\_LNA35degC\_2016-12-14-23-35-37.txt  
s11\_calibration\_low\_band\_LNA35degC\_2017-03-03-20-52-01.txt

The format of the files is given below.

## File Formats

Noise source S11 parameters for the 15 C calibration file:

/data1/edges/data/calibration\_files\_15C\_nov\_2016/S11/corrected/noise\_source\_s-parameters.txt

Col.	Description	Notes
1	Frequency	50 to 100 MHz (0.25 MHz steps)
2	real(rc_noise_source)	the base noise source has an intrinsic 3-dB attenuator in front
3	imag(rc_noise_source)	
4	real(rc_noise_source + 3 dB)	the 3-dB attenuator is an EXTRA attenuator, in front of the base
5	imag(rc_noise_source + 3 dB)	
6	real(rc_noise_source + 6 dB)	the 6-dB attenuator is an EXTRA attenuator, in front of the base
7	imag(rc_noise_source + 6 dB)	
8	real(s11_3dB atten),	Extra 3 dB attenuator measurements
9	imag(s11_3dB atten)	
10	real(s12s21_3dB atten)	
11	imag(s12s21_3dB atten)	
12	real(s22_3dB atten),	
13	imag(s22_3dB atten)	
14	real(s11_6dB atten),	Extra 6 dB attenuator measurements
15	imag(s11_6dB atten)	
16	real(s12s21_6dB atten)	
17	imag(s12s21_6dB atten)	
18	real(s22_6dB atten),	
19	imag(s22_6dB atten)	

'rc' stands for reflection coefficient

The ports of the EXTRA attenuators are:

Port 1 (male) facing the receiver input.

Port 2 (female) facing the noise source (+ base 3dB-attn).

Noise source S11 parameters for the 25 C calibration file:

/data1/edges/data/calibration\_files\_25C\_sept\_2016/S11/corrected/noise\_source\_s-parameters.txt

Col.	Description	Notes
1	Frequency	50 to 100 MHz (0.25 MHz steps)
2	real(rc_noise_source)	the base noise source has an intrinsic 3-dB attenuator in front 'rc' stands for reflection coefficient
3	imag(rc_noise_source)	
4	real(rc_noise_source + 3 dB)	the 3-dB attenuator is an EXTRA attenuator, in front of the base
5	imag(rc_noise_source + 3 dB)	
6	real(rc_noise_source + 6 dB)	the 6-dB attenuator is an EXTRA attenuator, in front of the base
7	imag(rc_noise_source + 6 dB)	
8	real(rc_noise_source with cable box)	The noise source has an intrinsic 3-dB attenuator in front as before
9	imag(rc_noise_source with cable box)	
10	real(s11_3dB atten),	Extra 3 dB attenuator measurements
11	imag(s11_3dB atten)	
12	real(s12s21_3dB atten)	
13	imag(s12s21_3dB atten)	
14	real(s22_3dB atten),	
15	imag(s22_3dB atten)	
16	real(s11_6dB atten),	Extra 6 dB attenuator measurements
17	imag(s11_6dB atten)	
18	real(s12s21_6dB atten)	
19	imag(s12s21_6dB atten)	
20	real(s22_6dB atten),	
21	imag(s22_6dB atten)	
22	real(s11_6dB atten),	Cable Box Measurements
23	imag(s11_6dB atten)	
24	real(s12s21_6dB atten)	
25	imag(s12s21_6dB atten)	
26	real(s22_6dB atten),	
27	imag(s22_6dB atten)	

'rc' stands for reflection coefficient

The reflection coefficients were measured at -20 dBm.

The S-parameters of the attenuators were measured at 0 dBm.

The port of the attenuators and cable box are:

Port 1 (male) facing the receiver input.

Port 2 (female) facing the noise source.

The ports of the EXTRA attenuators are:

Port 1 (male) facing the receiver input.

Port 2 (female) facing the noise source (+ base 3dB-attn).

S11 parameters for the 15, 25, and 35 C calibration files (2016 and 2017 results):

/data1/edges/data/calibration\_files\_15C\_nov\_2016/S11/corrected/

s11\_calibration\_low\_band\_LNA15degC\_2016-12-14-23-01-53.txt

s11\_calibration\_low\_band\_LNA15degC\_2017-03-02-05-48-33.txt

/data1/edges/data/calibration\_files\_25C\_sept\_2016/S11/corrected/

s11\_calibration\_low\_band\_LNA25degC\_2016-10-31-13-02-58.txt

s11\_calibration\_low\_band\_LNA25degC\_2017-03-02-02-53-40.txt

/data1/edges/data/calibration\_files\_35C\_nov\_2016/S11/corrected/

s11\_calibration\_low\_band\_LNA35degC\_2016-12-14-23-35-37.txt

s11\_calibration\_low\_band\_LNA35degC\_2017-03-03-20-52-01.txt

Col.	Description	Notes
1	Frequency	50 to 100 MHz (0.25 MHz steps)
2	real(LNA)	LNA
3	imag(LNA)	
4	real(amb)	Ambient Load
5	imag(amb)	
6	real(hot)	Hot Load (12 V applied)
7	imag(hot)	
8	real(open)	Open Cable. Placed inside the Faraday cage.
9	imag(open)	
10	real(short)	Shorted Cable. Placed inside the Faraday cage.
11	imag(short)	
12	real(semi_rigid_s11)	Semi Rigid Cable
13	imag(semi_rigid_s11)	
14	real(semi_rigid_s12s21)	
15	imag(semi_rigid_s12s21)	
16	real(semi_rigid_s22)	
17	imag(semi_rigid_s22)	
18	real(antsim1)	Antenna Simulator #1
19	imag(antsim1)	
20	real(antsim2)	Antenna Simulator #2
21	imag(antsim2)	
22	real(antsim2_REP2)	Only for the 15 C calibration: Repeat of the Ant Sim 2 measurements
23	imag(antsim2_REP2)	