PBAR NOTE NO. 601
S PARAMETER MEASUREMENTS OF THE HORIZONTAL BAND 1 PICKUP ARRAY

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INTRODUCTION

The pickup arrays for Horizontal Band 1 (HB1) of the 4-8 GHz Debuncher Upgrade are designed to operate between 3.8 and 4.9 GHz. The lower sub-band of HB1 is centered at 4.15 GHz with a 10dB bandwidth of 300 MHz. The upper sub-band is centered at 4.6 GHz with a 10dB bandwidth of 400 MHz. Each array contains 284 slots. Each slot has a width of 0.080" and the metal space between each slot is also 0.080" wide. The total length of the slot section for each array is 45.36". The length of the slots for the lower sub-band array is 0.910". ". The length of the slots for the upper sub-band array is 0.800". The horizontal beam pipe aperture is 2.36". The vertical beam pipe aperture is 1.985". The width of the output waveguide is 2.290" and the height is 0.660". The pickup sensitivity is for the sum and difference mode is shown in Figures 1 and 2, respectively. The difference mode impedance is defined as[1]:

$$P_{\Delta} = \frac{1}{2}\left(Zn_{\Delta pu}\right)i_b^{\,2}\,\frac{\varepsilon_b}{1\pi - mm - mrad} \qquad (1)$$

where P_{Δ} is the total power received from the pickup, i_b is the beam current, ε_b is the un-normalized beam emittance. The sum mode impedance is defined as:

$$P_{\Sigma} = \frac{1}{2} Z_{\Sigma pu}^{new} i_b^{\,2} \qquad (2)$$

S PARAMETER MEASUREMENTS

The port numbering for the S-parameter measurements is shown in Figure 3. A moment method program is used to calculate the S-parameters of the arrays.[2] The program uses 2 slot modes, 100 waveguide modes in the horizontal direction and 20 even waveguide modes in the vertical direction. To calculate longitudinal and transverse cooling impedances, the program uses even and odd mode (sum and difference) horizontal symmetry. Placing a vertical magnetically conducting plane in the center of the array is used to solve the sum mode. Placing a vertical electrically conducting plane in the center of the array is used to solve the difference mode. The single-ended S-parameters are derived from the sum and difference S-parameters:

$$S_{1,1} = S_{1,1_{\Sigma}} + S_{1,1_{\Delta}} \qquad (3)$$

[1] PBAR Note No. 578, "New Definition of Stochastic Cooling Kicker and Pickup Impedances", Dave McGinnis, March 2, 1998.

[2] PBAR Note No. 560, "Momemt Method Formulation for Beam Excitation of Waveguide Slots", Dave McGinnis, July 27, 1997.

$$S_{2,1} = S_{2,1_\Sigma} + S_{2,1_\Delta} \tag{4}$$

$$S_{3,1} = S_{1,1_\Sigma} - S_{1,1_\Delta} \tag{5}$$

$$S_{4,1} = S_{2,1_\Sigma} - S_{2,1_\Delta} \tag{6}$$

Figures 4 through 11 show the measured and calculated S-parameters.

The "wiggles" in the calculated and measured values of the magnitude response of S_{21} and S_{41} seem to be 180 degrees out of phase. To try to track down this discrepancy between the measured and the calculated responses, the sum and difference mode forward scattering parameters $S_{21\Sigma}$ and $S_{21\Delta}$ are plotted in Figures 12-15. Again the "wiggles" seem to be 180 degrees out of phase between the calculated and the measured values.

The moment method program does not calculate the S-parameters directly but calculates the "scattered" field off the slots. The total field received at the ports is the sum of the "scattered" field plus the "incident" field. The scattered field C_{21} is given as:

$$S_{2,1_\Delta} = C_{2,1_\Delta} + e^{-j\beta(z_2 - z_1)} \tag{7}$$

$$S_{2,1_\Sigma} = C_{2,1_\Sigma} + e^{-j\beta(z_2 - z_1)} \tag{8}$$

where z_1 and z_2 are the reference planes of ports 1 and 2, respectively. The scattered wave, C_{21}, amplitudes and phases are shown in Figures 16 through 23 for the sum and difference modes.

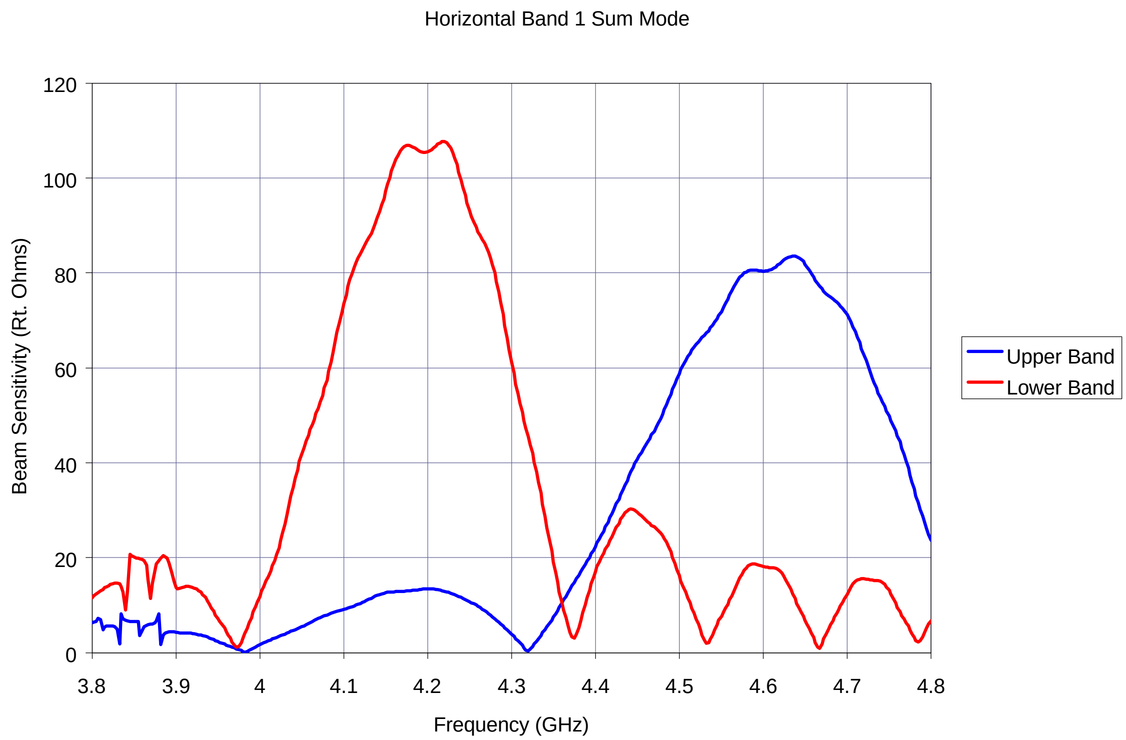

Figure 1. Sum mode pickup impedance for Horizontal Band 1.

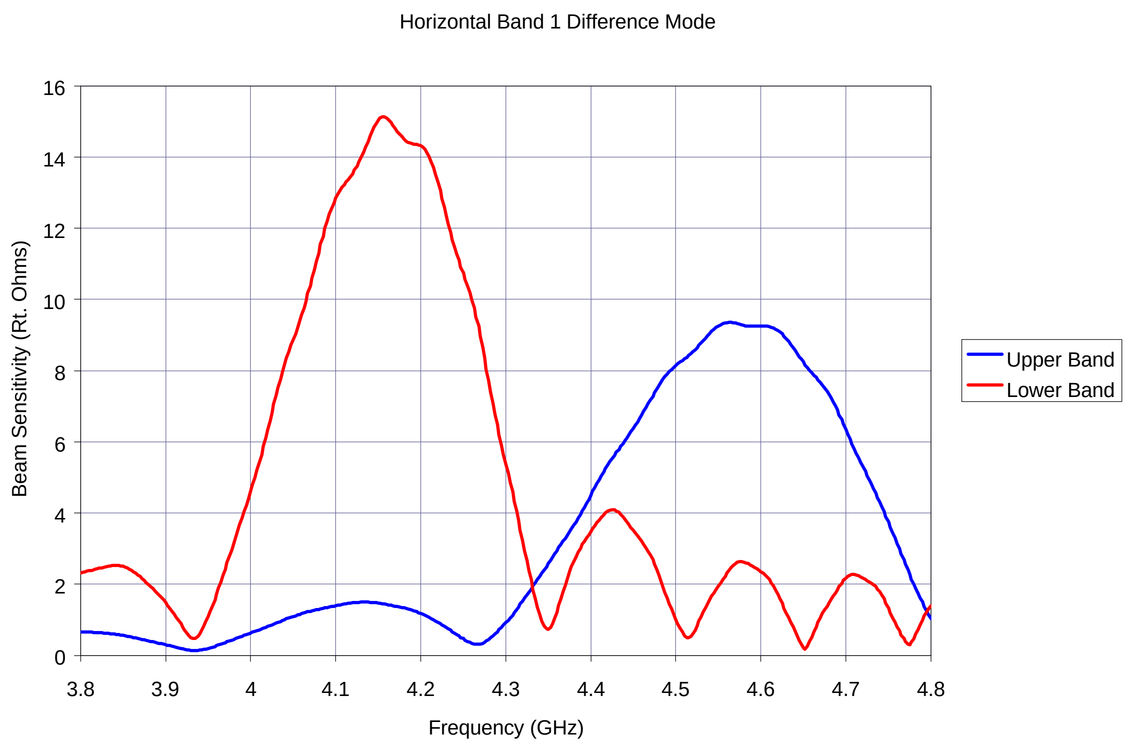

Figure 2. Difference mode pickup impedance for Horizontal Band 1.

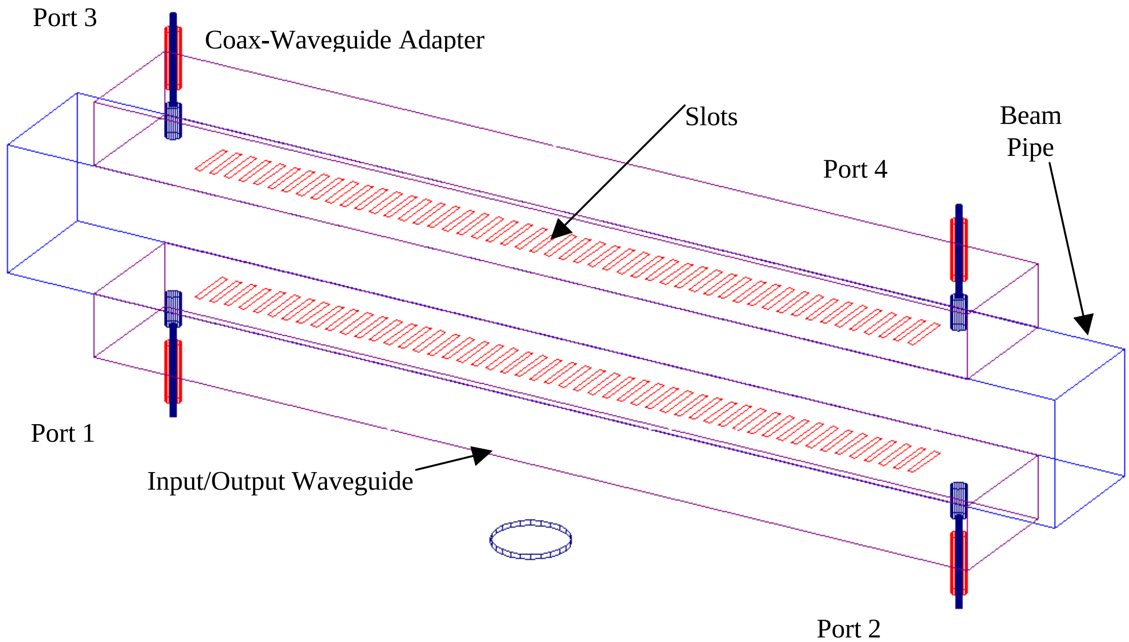

Figure 3 Port setup for S-Parameter measurements.

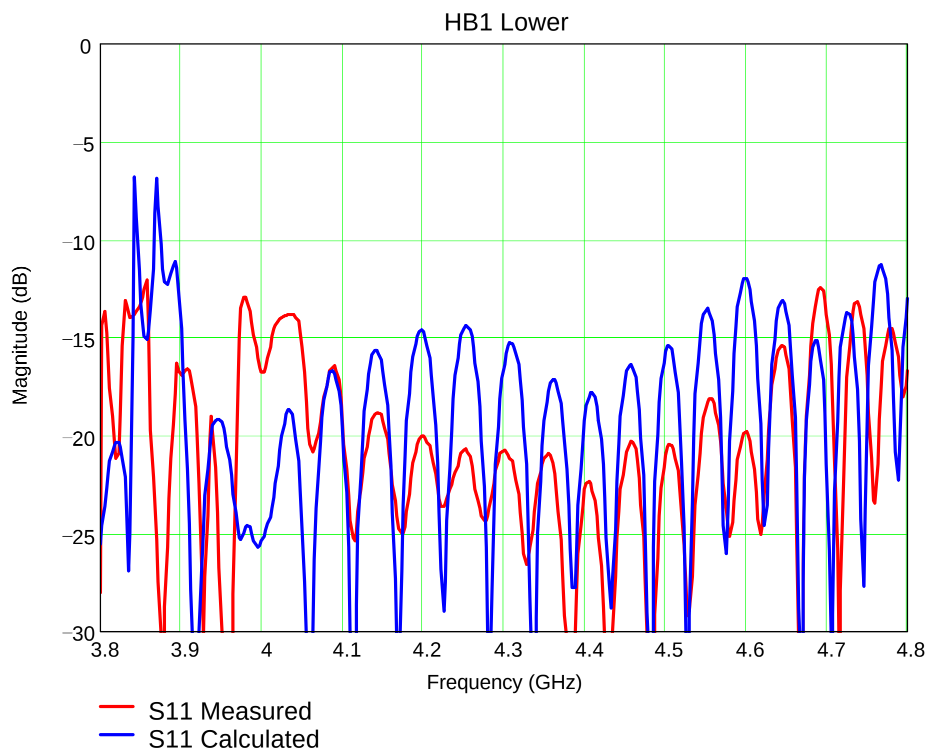

Figure 4. S11 for the lower sub-band of HB1.

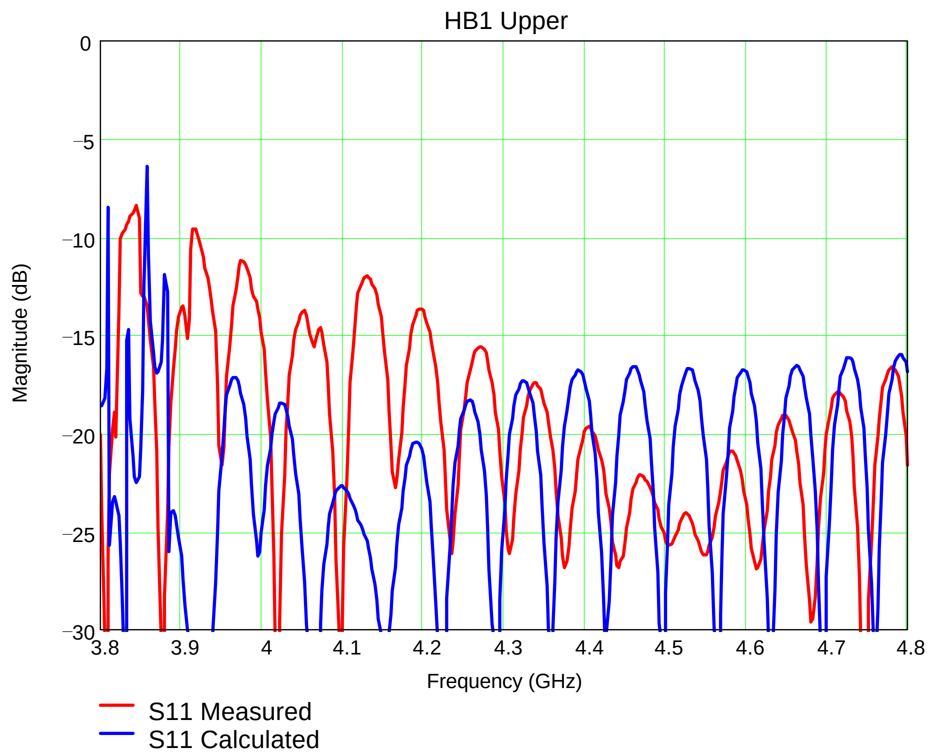

Figure 5. S11 for the upper sub-band of HB1

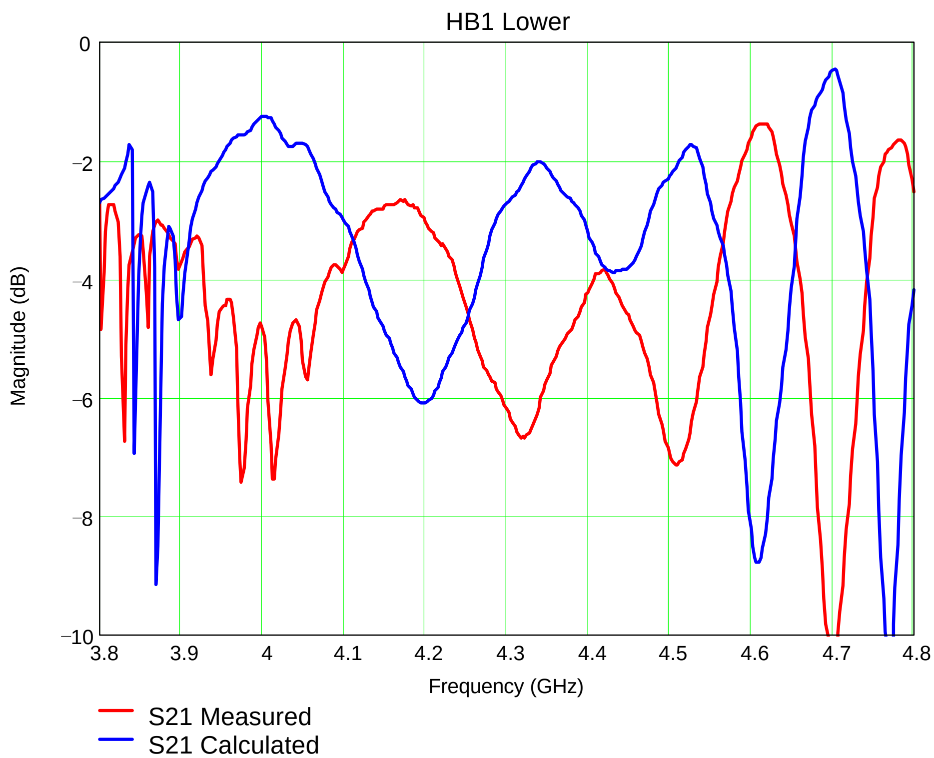

Figure 6. S21 for the lower sub-band of HB1.

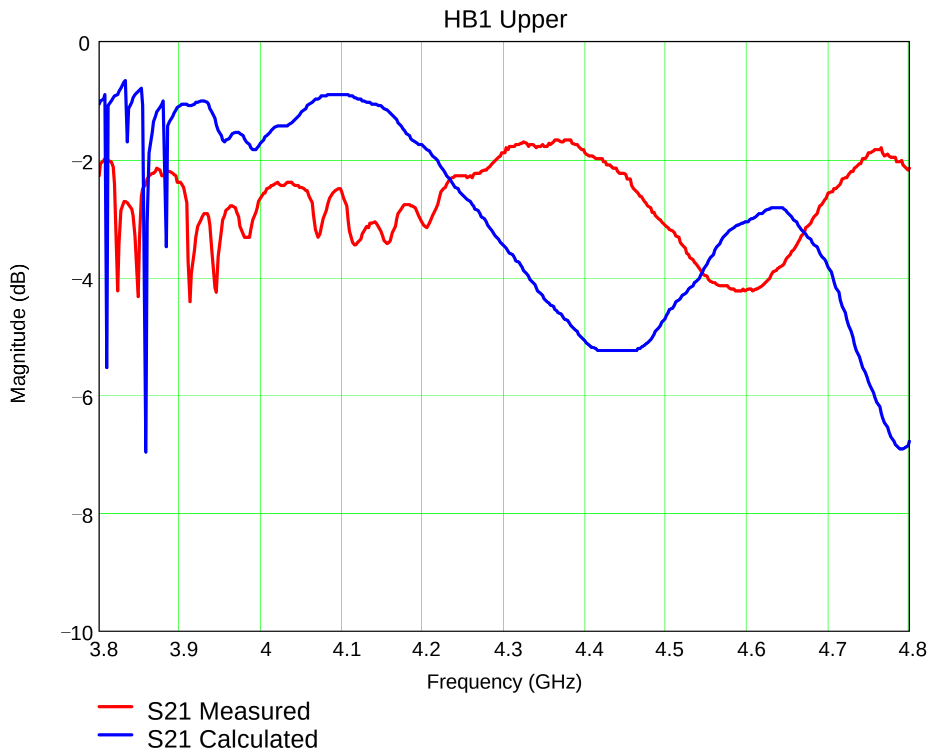

Figure 7. S21 for the upper sub-band of HB1.

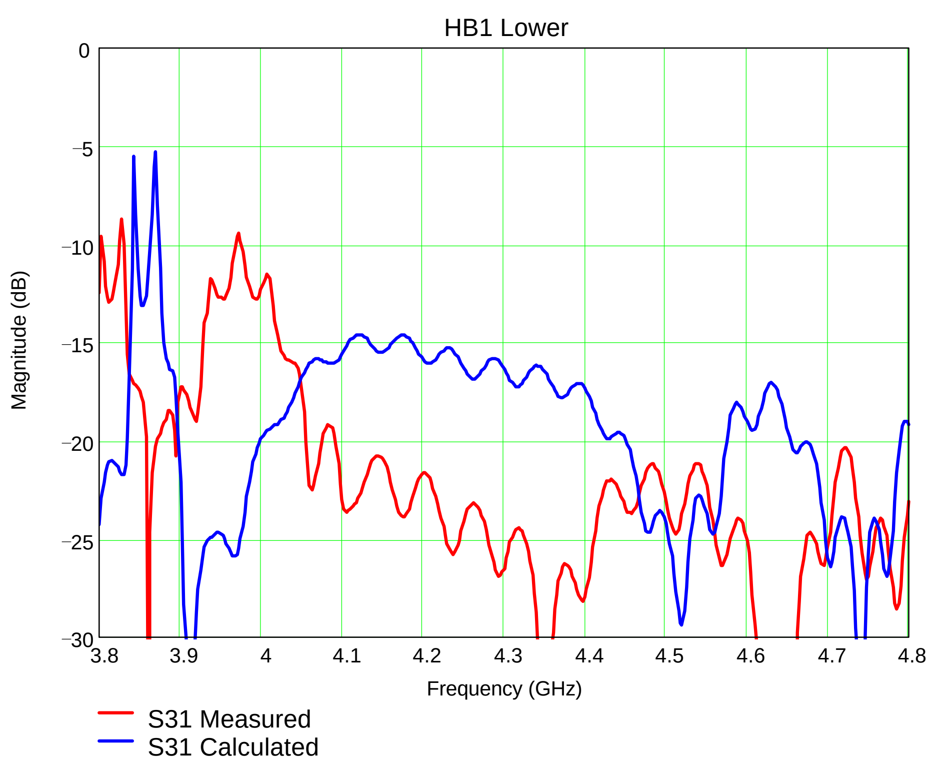

Figure 8. S31 for the lower sub-band of HB1.

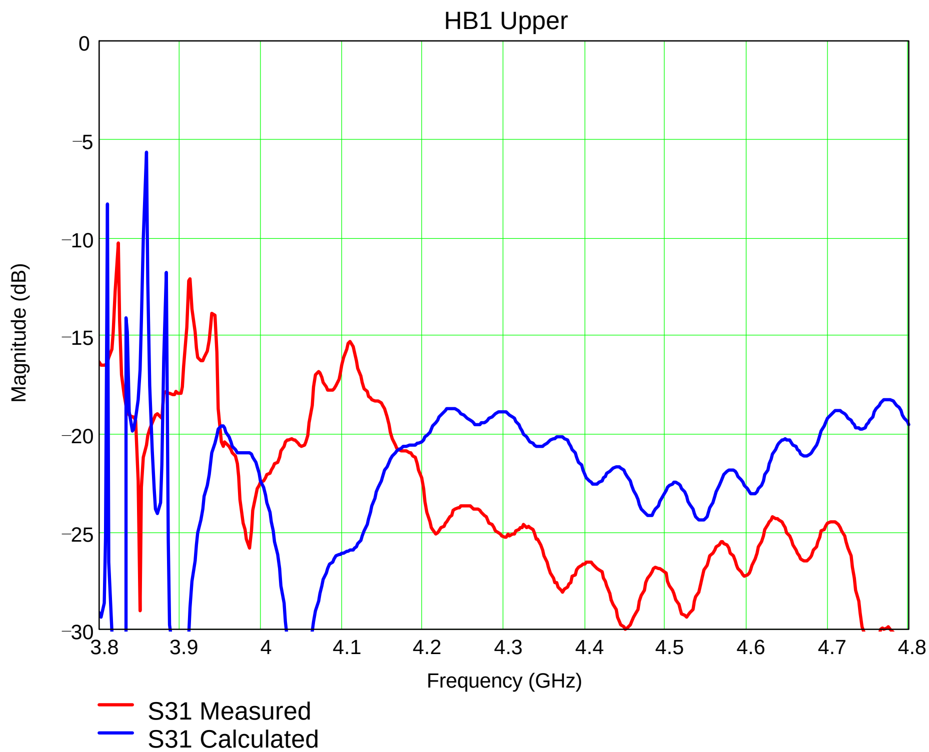

Figure 9. S31 for the upper sub-band of HB1.

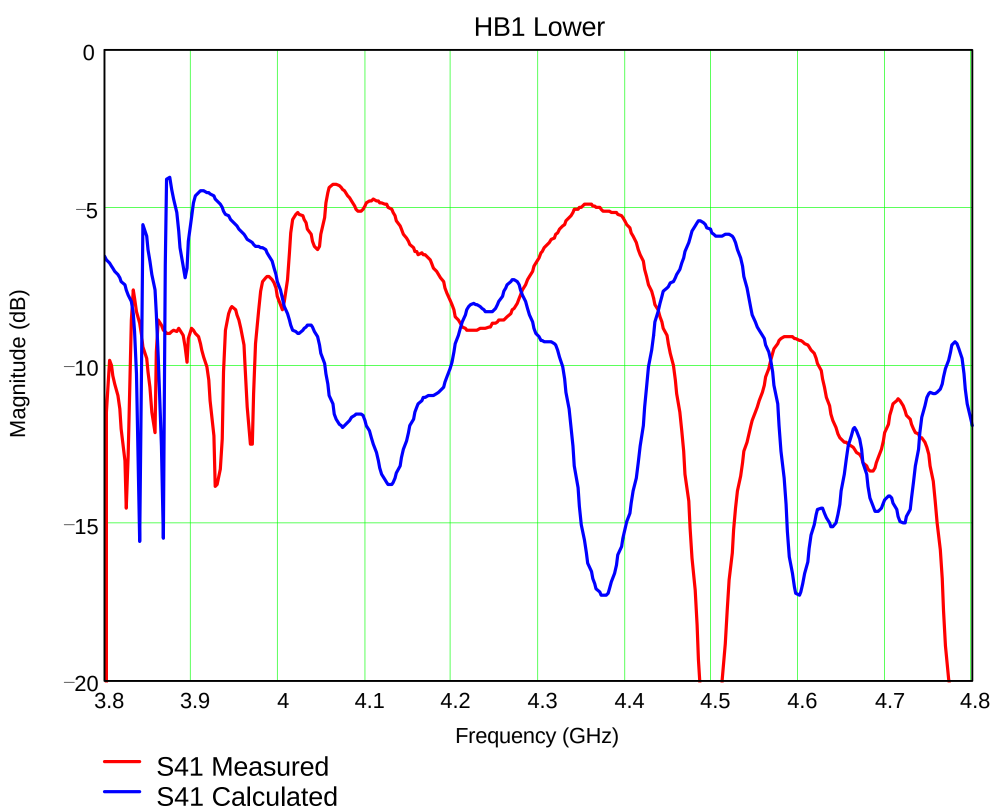

Figure 10. S41 for the lower sub-band of HB1.

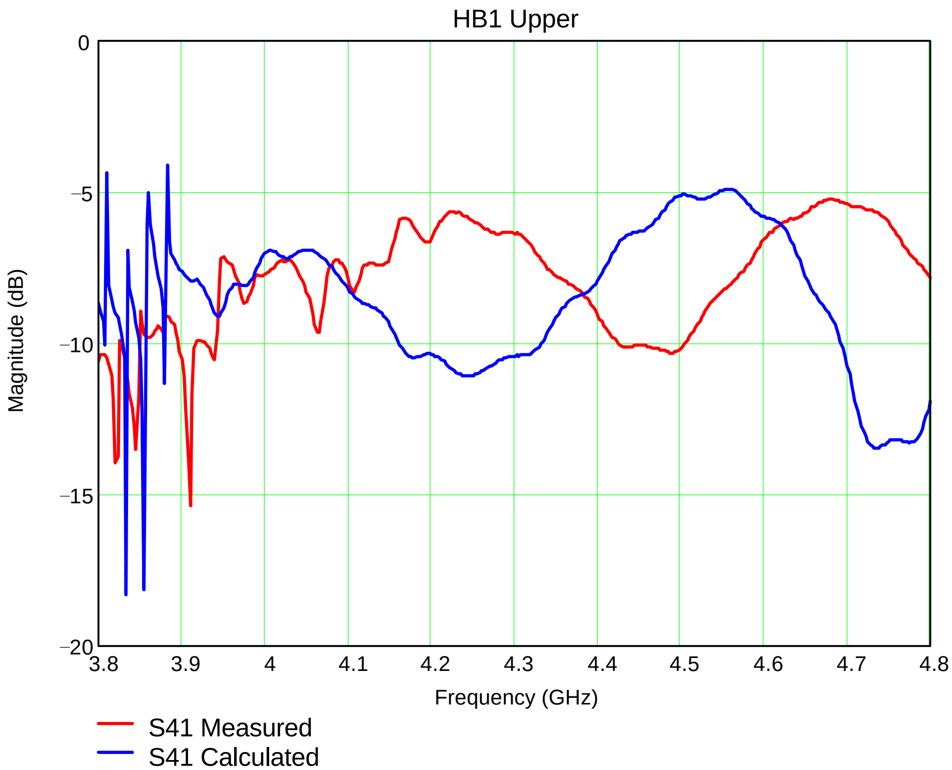

Figure 11. S41 for the upper sub-band of HB1.

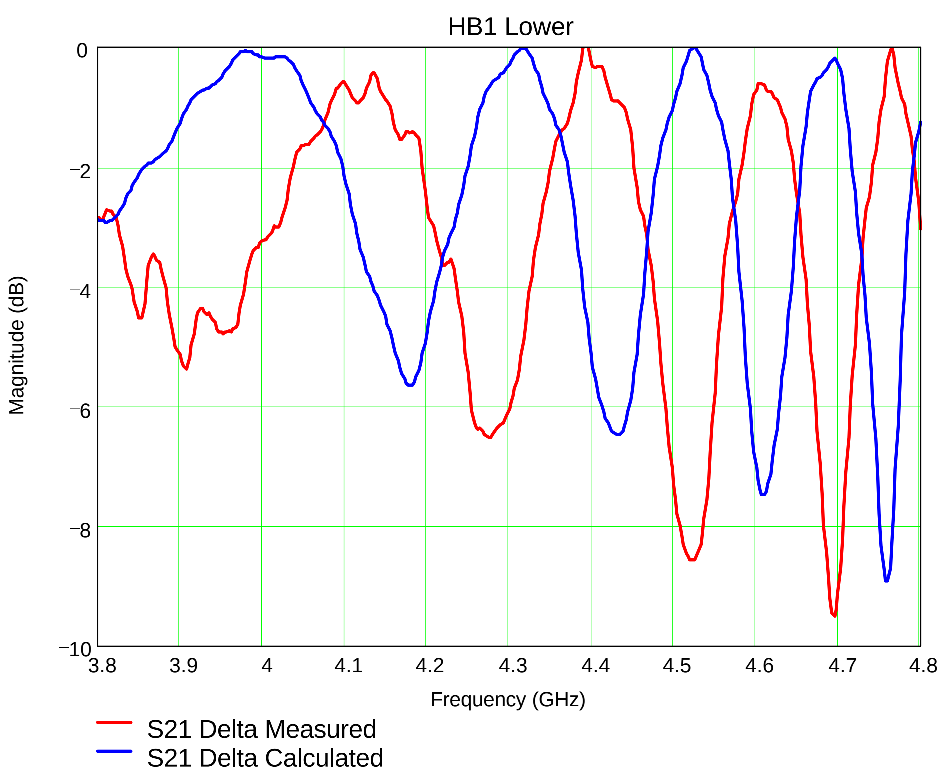

Figure 12. S21D for the lower sub-band of HB1.

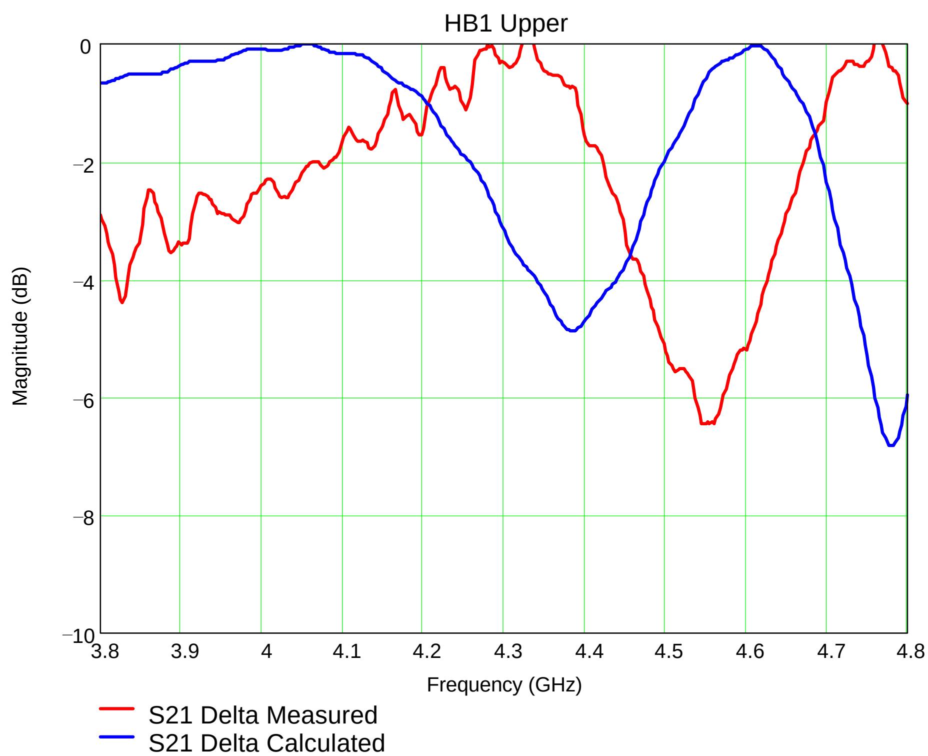

Figure 13. S21D for the upper sub-band of HB1.

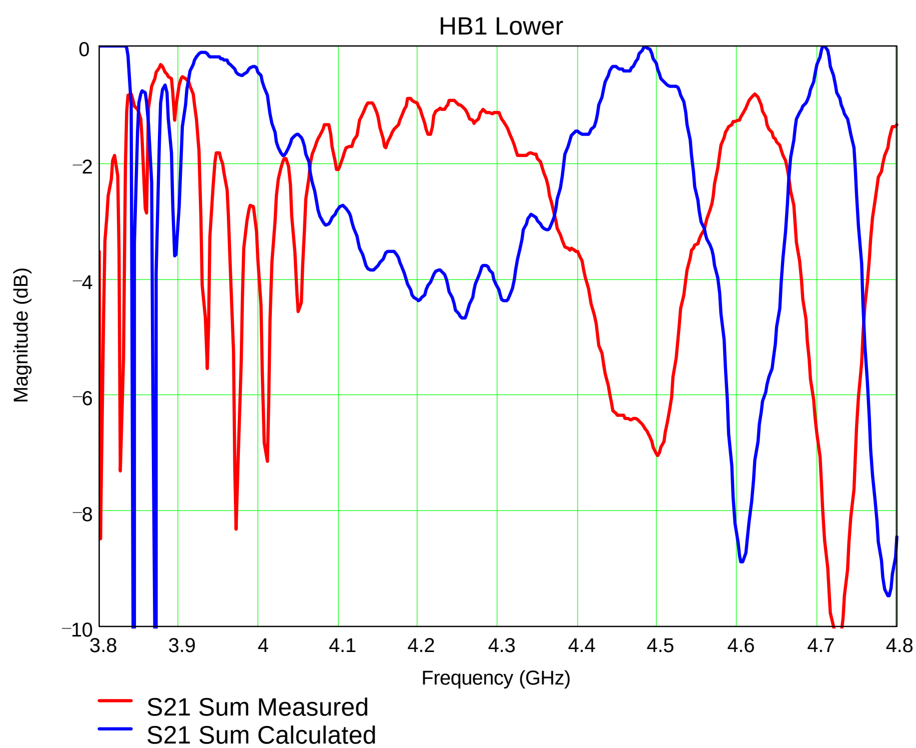

Figure 14. S21S for the lower sub-band of HB1.

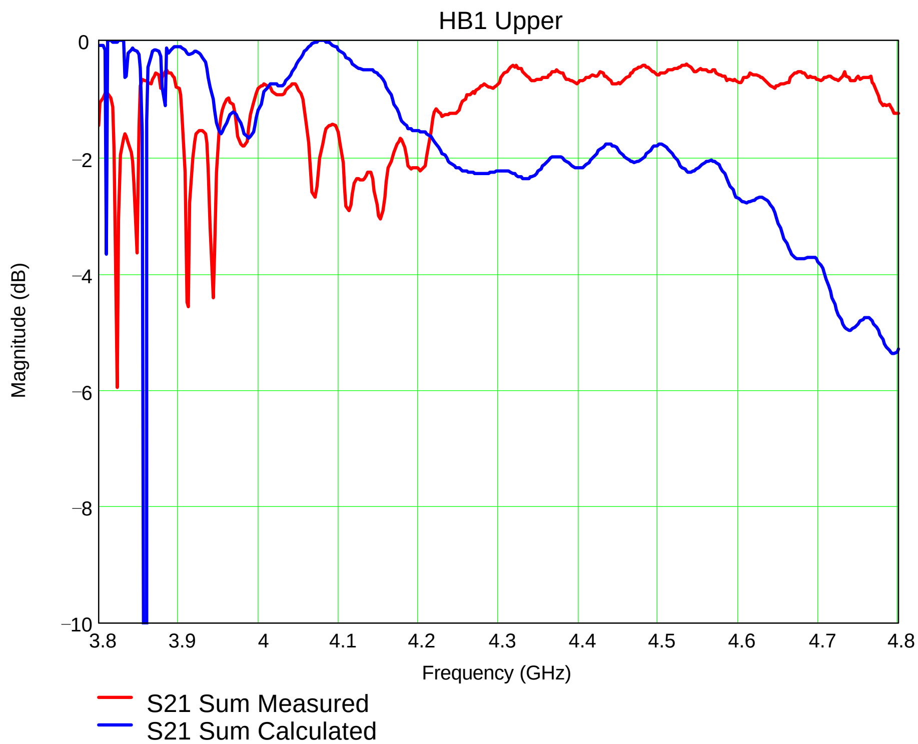

Figure 15. S21S for the upper sub-band of HB1.

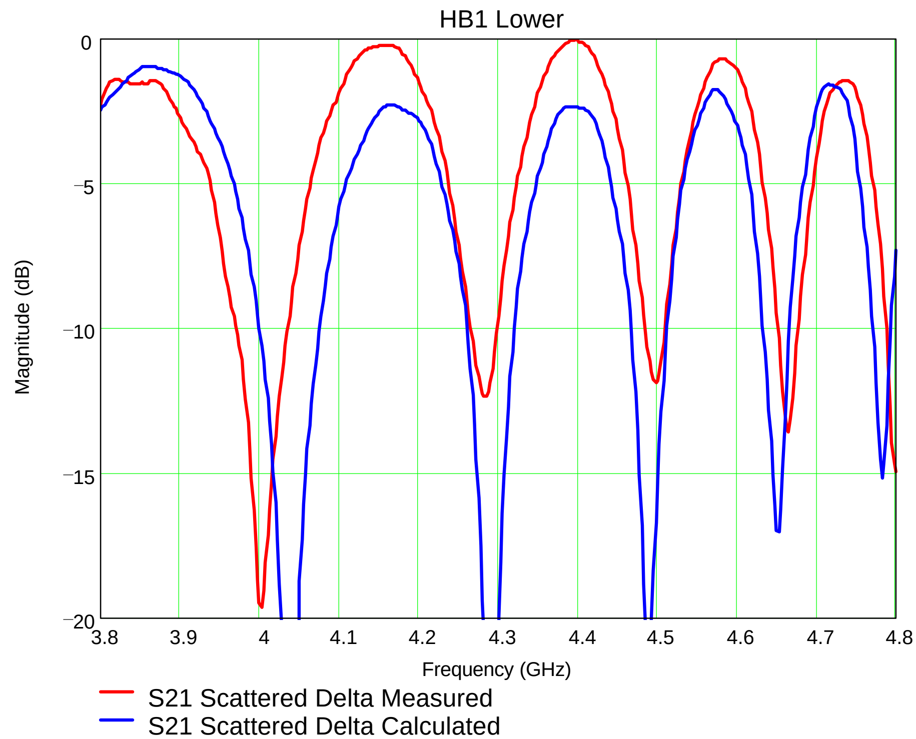

Figure 16. Difference mode magnitude of the forward scattered wave for the lower sub-band of HB1

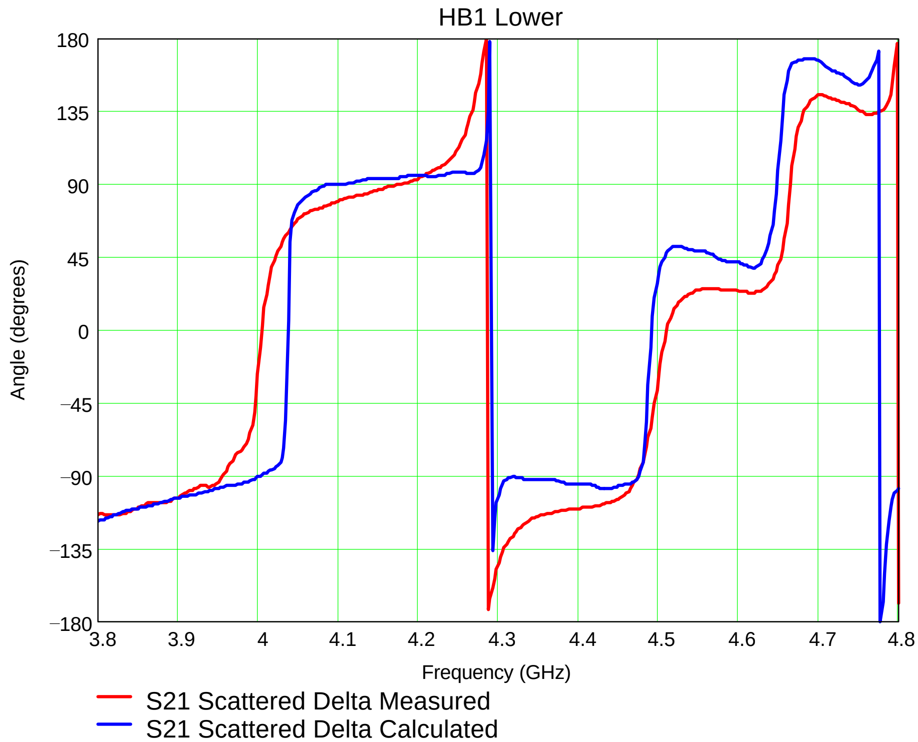

Figure 17. Difference mode phase of the forward scattered wave for the lower sub-band of HB1

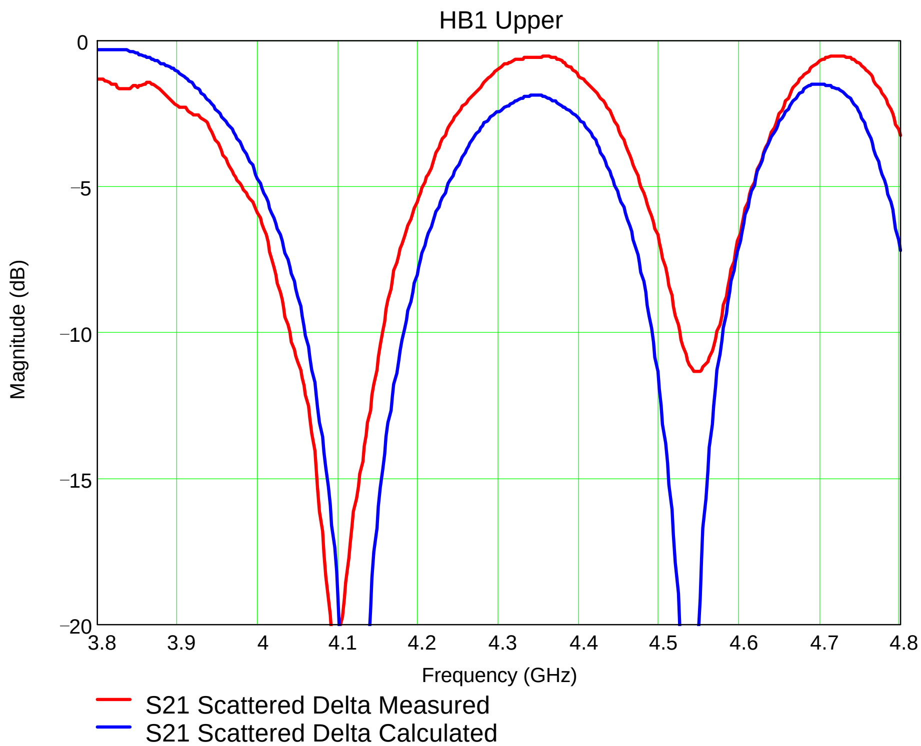

Figure 18. Difference mode magnitude of the forward scattered wave for the upper sub-band of HB1

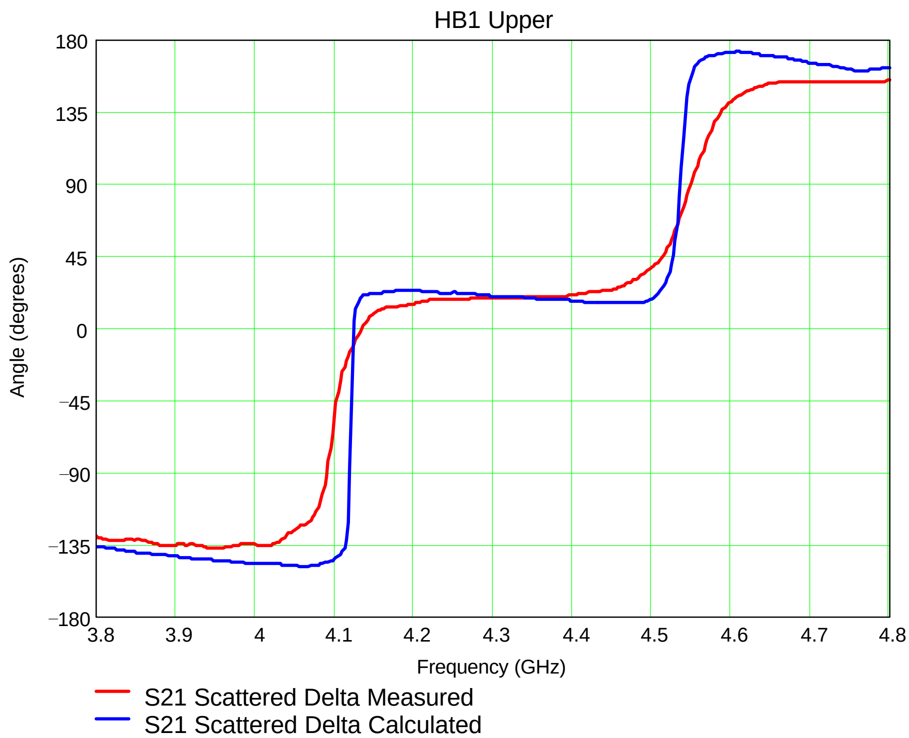

Figure 19. Difference mode phase of the forward scattered wave for the upper sub-band of HB1

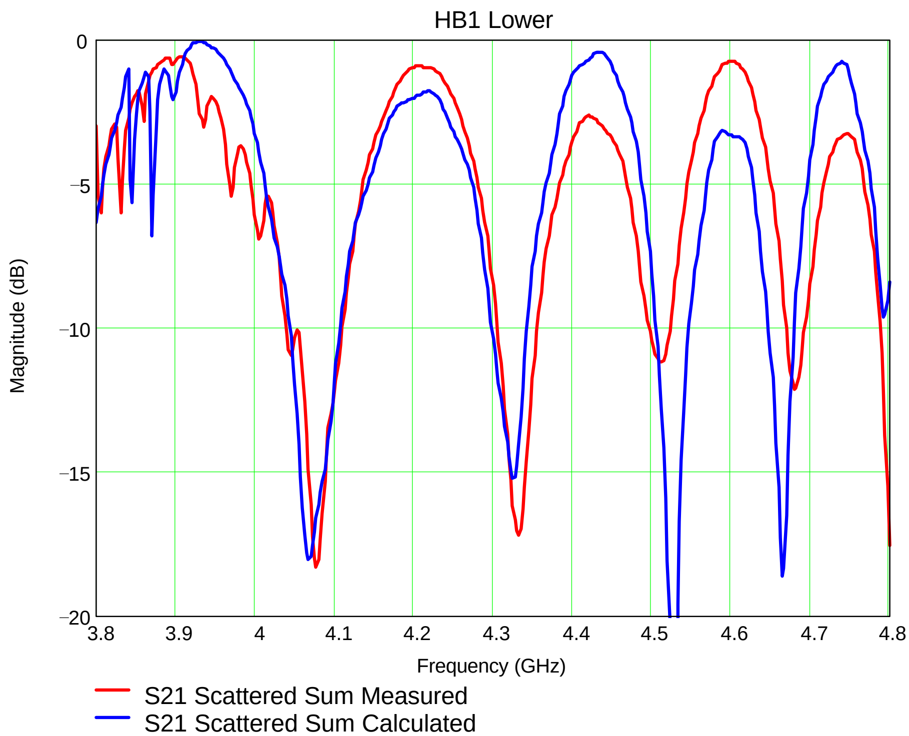

Figure 20. Sum mode magnitude of the forward scattered wave for the lower sub-band of HB1

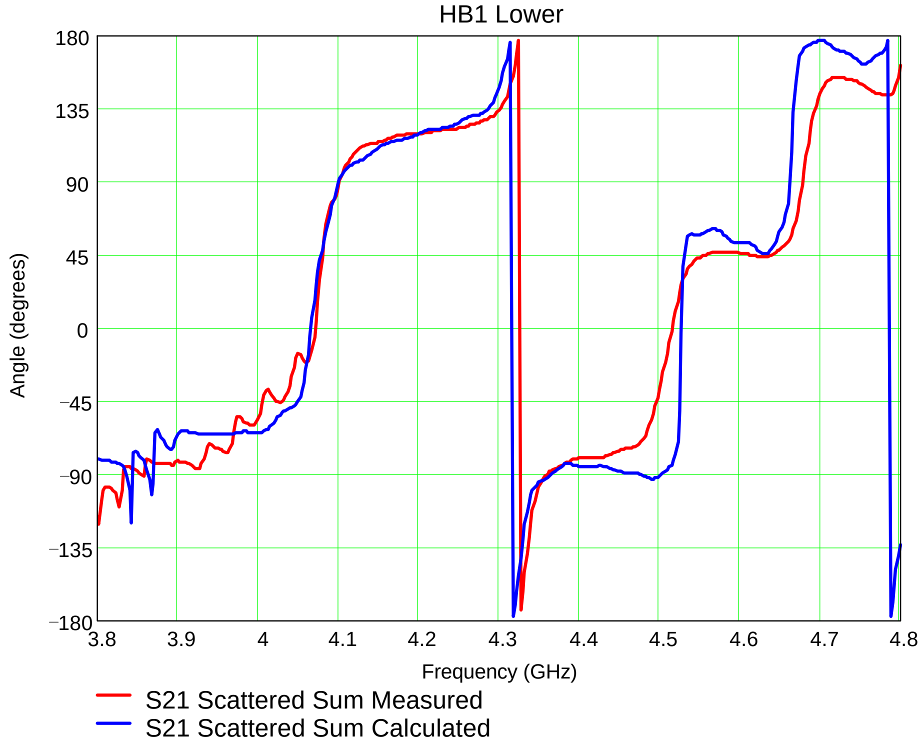

Figure 21. Sum mode phase of the forward scattered wave for the lower sub-band of HB1

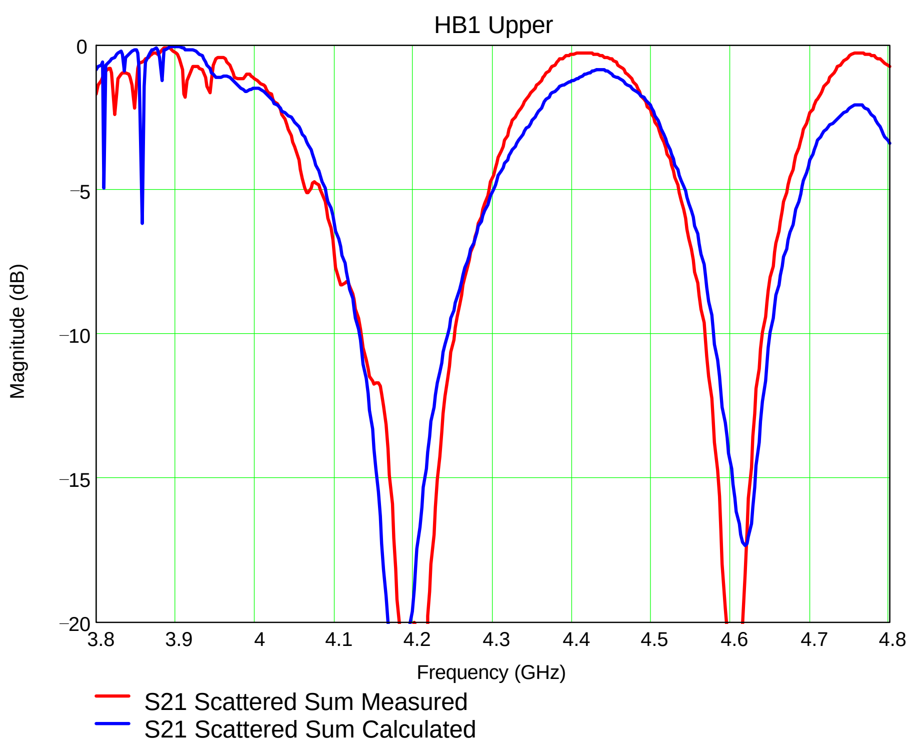

Figure 22. Sum mode magnitude of the forward scattered wave for the upper sub-band of HB1

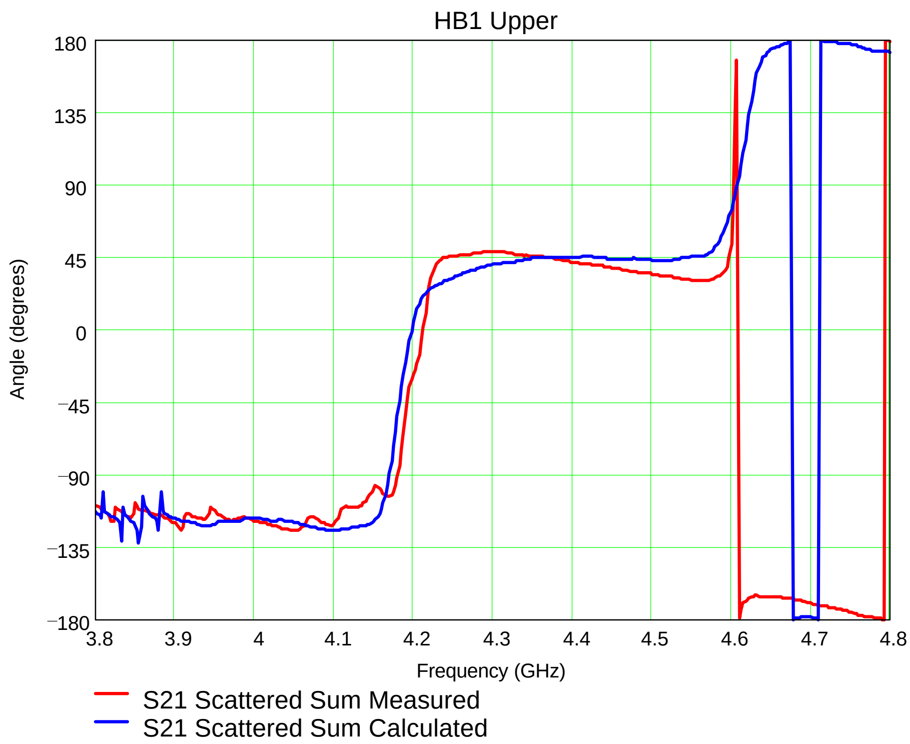

Figure 23. sum mode phase of the forward scattered wave for the upper sub-band of HB1