Vivaldi Antenna

Vivaldi antenna typically has at least octave bandwidth and thus it can be used in numerous applications. Usually, this antenna is printed on dielectric substrate. Because of its relatively complex shape, it is often considered to be difficult for modeling. Thus the antenna geometry is often provided via CAD files.

The antenna shown in this paper is a balanced antipodal antenna. In November 2000, it was used for EM solvers comparison. Six software vendors has taken part in the benchmarking. WIPL-D did not take part at that moment, so the capabilities for design and simulation of the Vivaldi antenna are presented here.

Theoretical Characteristics

The main characteristics of the Vivaldi antenna are broad band operation and rather complex geometry.

An example of the Vivaldi antenna is designed and analyzed using WIPL-D 3D EM solver. (Fig. 1). The antenna is printed on dielectric substrate, and all metal parts are shown in Fig. 2.

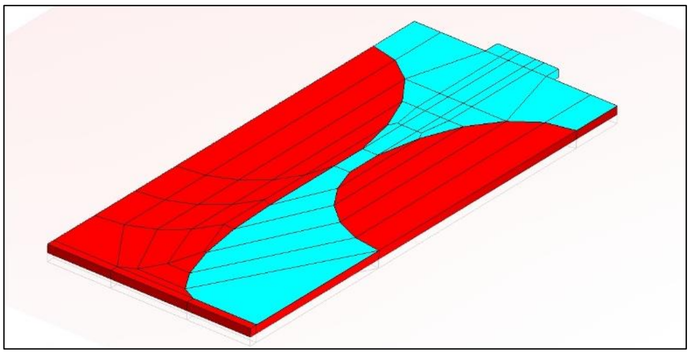

Figure 1. Vivaldi antenna in WIPL-D

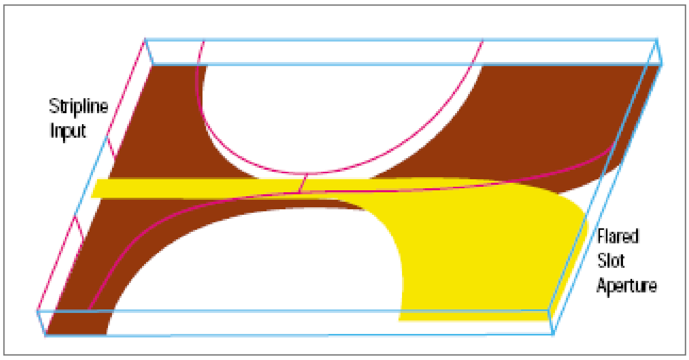

Figure 2. Vivaldi antenna metallic parts

Because of its complex geometry, thorough explanation of antenna parts (including dimensions) is given in Figs 3-4.

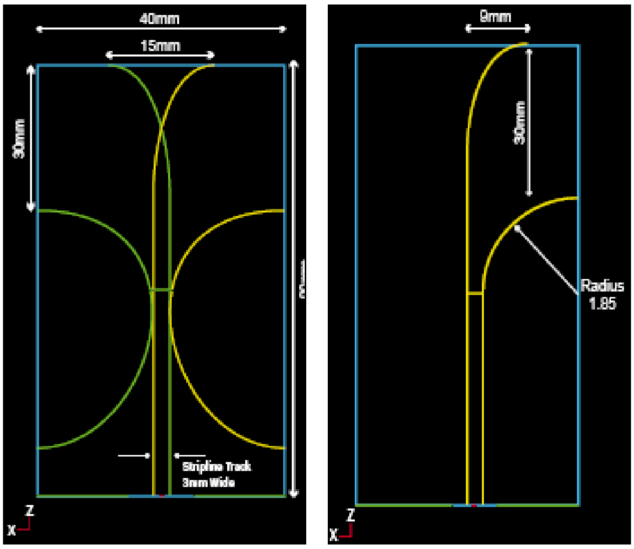

Figure 3. Vivaldi antenna. Dimensions

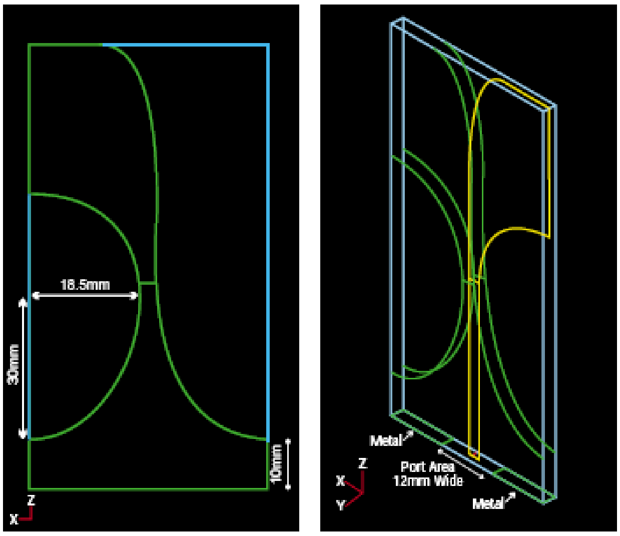

Figure 4. Dimensions and parts of Vivaldi antenna

Specific shape of the Vivaldi antenna enables operating band to be very wide. This particular antenna involves microstrip line and its ground plane both gradually flaring out. Thus, the lowest operating frequency is determined by the cut-off mechanism of the flare. The skew in the electric field across the slot makes poor cross-polar polarization performance which degrades with frequency rising. Antenna is considered as a triplate based structure (done by adding additional dielectric and metallization layer, which is provided for balancing the E-field distribution in the flared slot). The antenna configuration with arcs and elliptically tapered geometry is challenging test for EM software in terms of providing suitable mesh and accurate far field results.

The paper reports simulation times, radiation pattern and near field for two operating frequencies, as well as s11 from 1 GHz up to 20 GHz. The two operating frequencies are chosen according s11 (3 GHz and 15 GHz).

WIPL-D Simulations

Computer used for these calculations is Intel® i7® CPU 7700K @ 3.60 GHz, a standard desktop quad core configuration.

Dielectric properties for the simulated model are given in Tab. 1.

Table 1. Dielectric characteristics

Parameter	Value [Unit]
Er	2.32
H	3.15 [mm]

Parameter s11 is shown in Fig. 5.

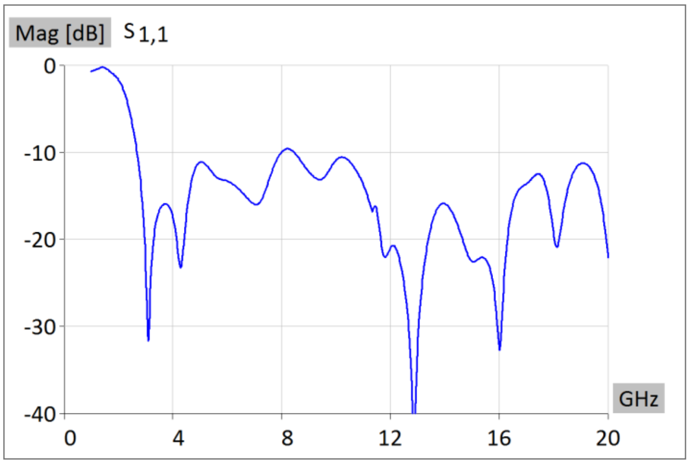

Figure 5. S11 parameter for Vivaldi antenna

Radiation pattern and distribution of near field for 3 GHz and 15 GHz are given in Figs 6-9 (all figures showing total electric field).

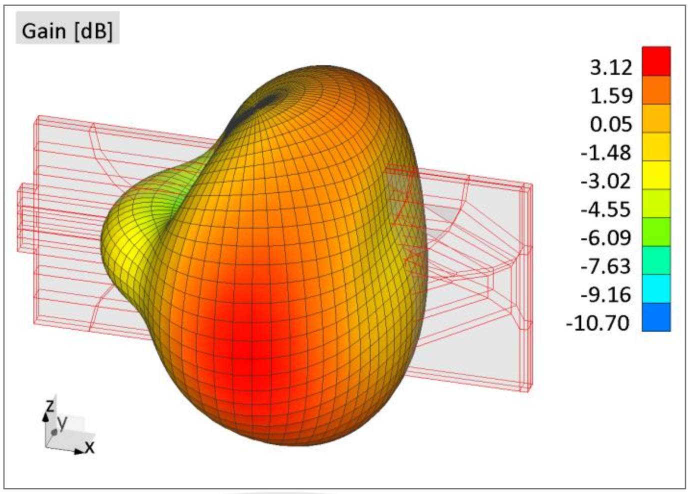

Figure 6. Radiation pattern at 3 GHz

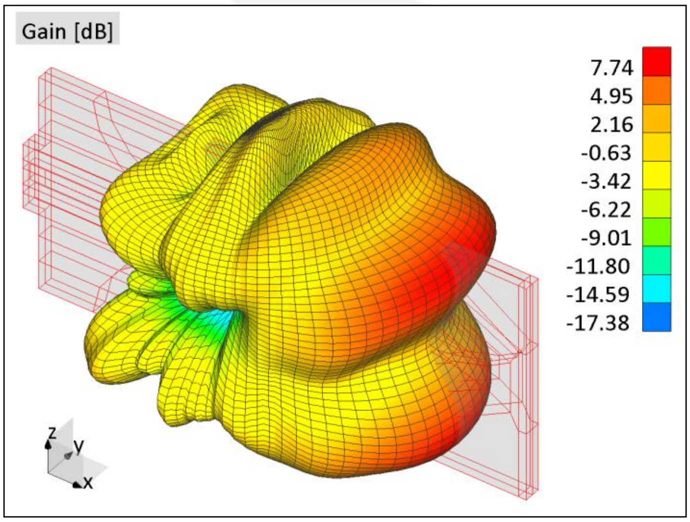

Figure 7. Radiation pattern at 15 GHz

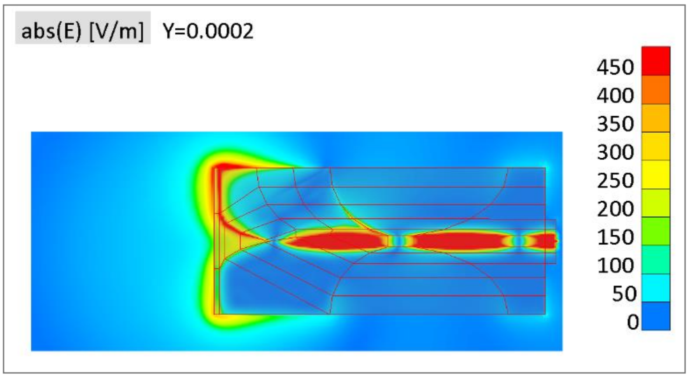

Figure 8. Near field at 3 GHz

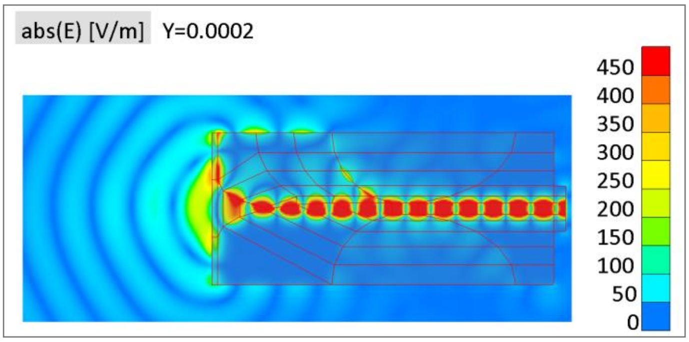

Figure 9. Near field at 15 GHz

Number of unknowns and simulation times per frequency are given in Tab. 2.

Table 2. Number of unknowns and simulation times

Model	Number of unknowns	Time [sec]
3 GHz	495	0.6
15 GHz	2 907	2.5
20 GHz	4 003	3.1

Conclusion

Vivaldi antenna is a commonly used antenna in broadband applications. Advantages of using the Vivaldi antenna are: it is suitable for ultra-wideband signals, easy-manufacturing component and impedance matching is relatively easy.

As in this case, it is usually printed at the dielectric substrate. This is necessary since, for on-board production, the dielectric increases structure solidity (i.e. metallic conductors are placed on dielectric). Dielectric also inserts losses, which are most often insignificant.

The results, among other conclusions, show extremely wide band in which the return loss is under -10 dB. The simulation can be performed in low number of frequency points due to the powerful built-in interpolation method. This is the most obvious drawback for using Method of Moments in simulation of ultra wide band antennas (each frequency point is simulated separately).

In MoM EM simulations, the simulation is quite fast at the lowest operating frequency, but more demanding at the end of the frequency band. As one of the solutions, WIPL-D offers built-in features where each frequency point is simulated according to the current referent frequency, and not according to the stop frequency. In that sense, the overall simulation time in a wide frequency band is decreased several times.

However, here the simulation is performed by using a regular desktop quad core CPU. All simulation times are extremely low. In case the EM simulation is more challenging (the number of unknowns is increased further), the simulation can be dramatically speeded up by using inexpensive low end GPU cards.

The near field simulations clearly show that near field distribution around antenna depends of operating frequency.