rf & wireless EUROPE

Using AntSyn to Design an Ultra-Wideband Antenna

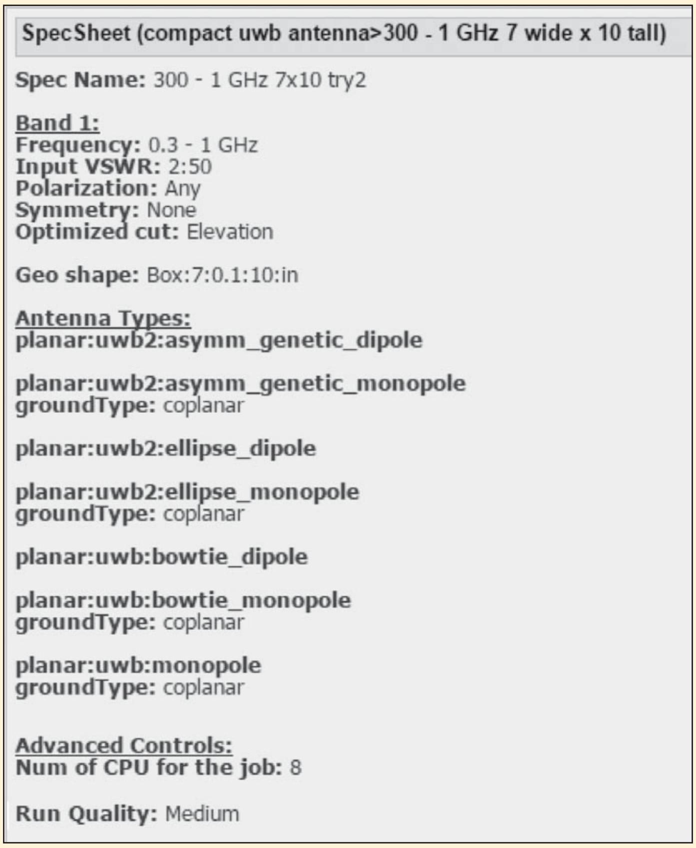

Figure 1: Spec sheet for initial AntSyn design run

Figure 2: Results of this initial design run within AntSyn

Growing demand for wireless connectivity relies on integrated antenna solutions customized for optimal system performance, cost, and size. Achieving multiple performance metrics such as impedance matching, gain, radiation efficiency, and operating bandwidth is a time consuming process involving numerous iterative simulations and a significant amount of design knowledge. Fortunately, research into the use of evolutionary algorithms (EAs), a programmatic method for exploring the design space and automatically locating superior antenna designs, has matured into a viable technology.

EA is proving to be more effective at generating antenna structures with higher performance than would otherwise be developed by traditional methods. This application note demonstrates the use of AntSyn antenna synthesis and optimization technology, which uses a proprietary EA methodology to accelerate the overall antenna development process. The requirement for this design was a wideband planar antenna fitting within a 7” x 10” form factor. The antenna’s operating band needed to start as low in frequency as possible given the size constraint, with the upper frequency range at or above 1 GHz. Frequencies higher than 2.5 GHz were not of interest. The low end of the operating band was initially set at 300 MHz and expected to be difficult to achieve in this size. It was preferable not to extend the size

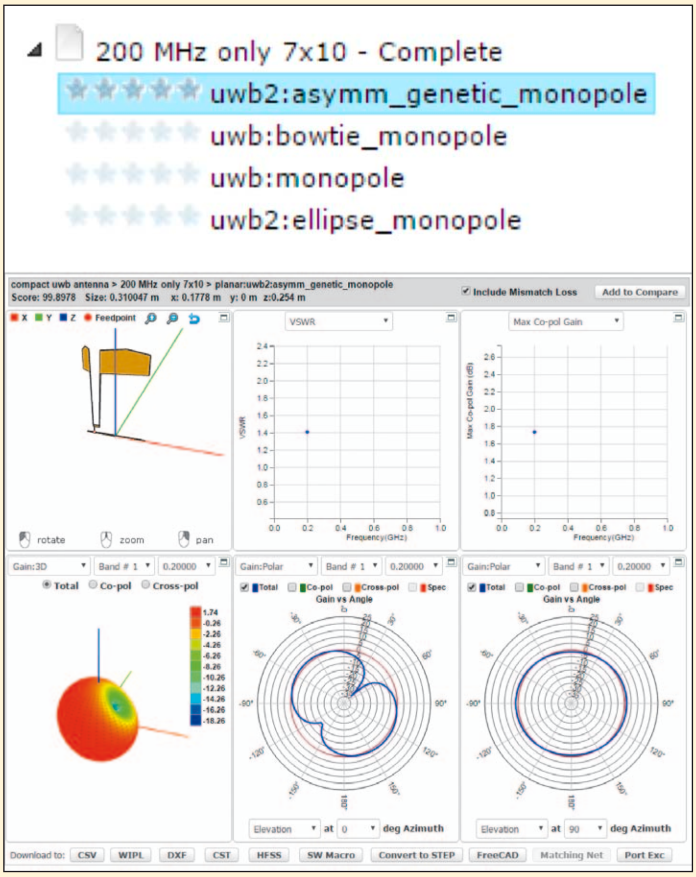

Figure 3: Results for 7” x 10” form factor

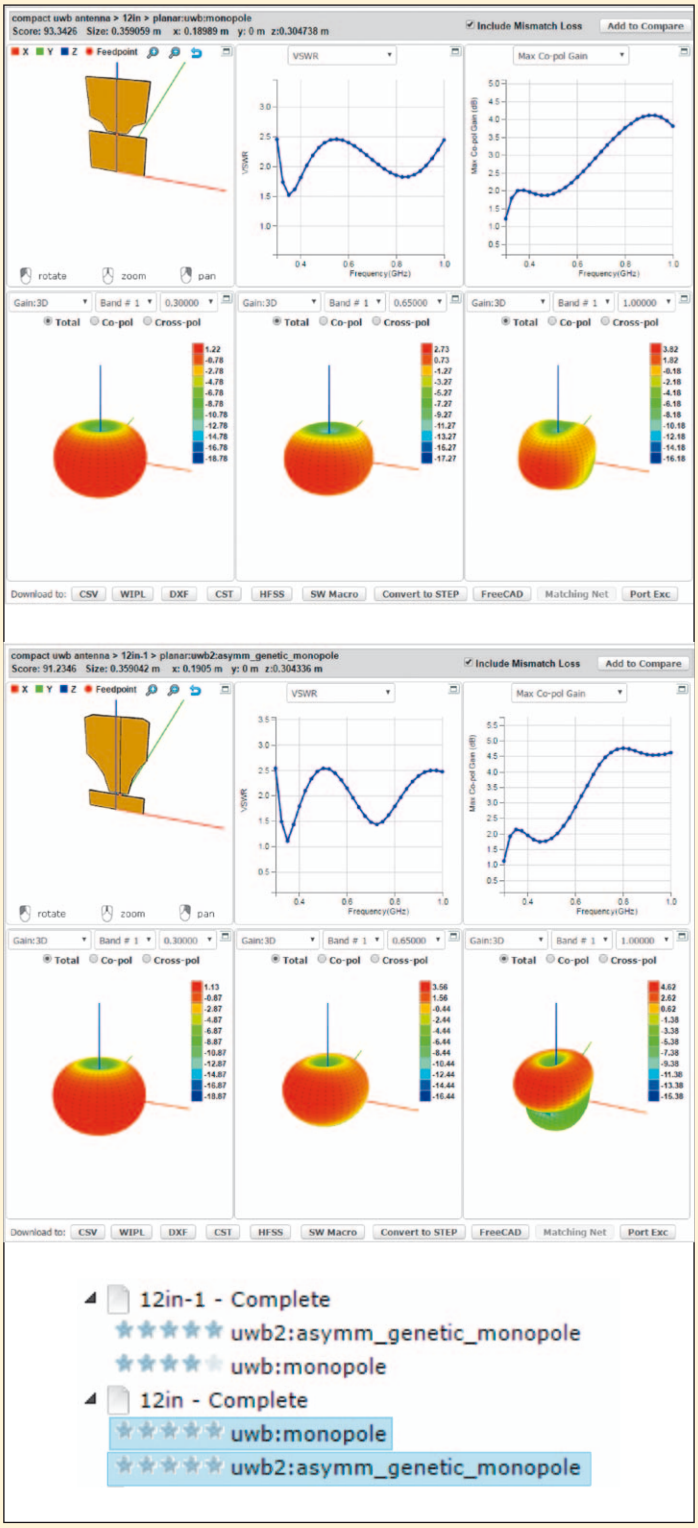

Figure 4: Results using 12" tall form factor: UWB monopole (top) and asymmetric monopole (bottom)

SpecSheet (compact uwb antenna>10in 350-2o5 ghz)

Spec Name: 10in 350-2o5 ghz

Band 1:
Frequency: 0.35 - 2.5 GHz
Input VSWR: 2:50
Polarization: Any
Symmetry: None
Optimized cut: Elevation

Geo shape: Box:7.5:0.1:10:in

Antenna Types:
planar:uwb2:asymm_genetic_monopole
groundType: coplanar

planar:uwb:monopole
groundType: coplanar

Advanced Controls:
Num of CPU for the job: 8

Run Quality: High

Figure 5: Spec sheet for the 10" form factor at low frequency

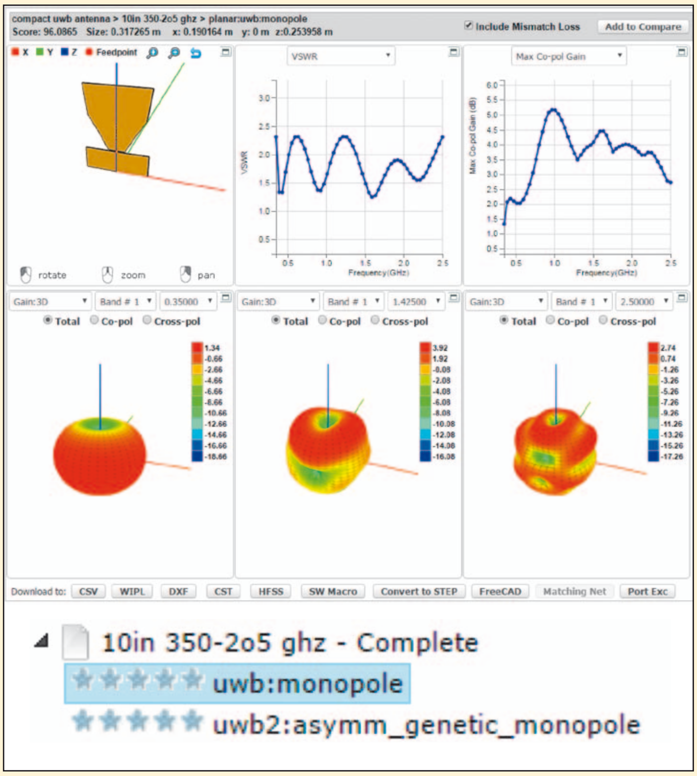

Figure 6: Results for the 10" form factor at low frequency

unless there was dramatic improvement in frequency coverage. A series of AntSyn evaluations were conducted to explore this design space. The final design was optimized to cover 325 MHz to 2.5 GHz and was 7.5" wide x 10" tall.

What Antenna Types Work Best? (Initial spec sheet definition)

The initial evaluation explored various antenna types to determine if any could perform as required at the low end (300 MHz) of the frequency band while not exceeding the specified maximum form factor. Given the AntSyn user's prior experience with antenna design, a select set of antenna types of interest was specified as a starting point for the optimization, rather than allowing AntSyn to automatically select antenna types. The

Figure 7: Spec sheet settings for UWB dipole

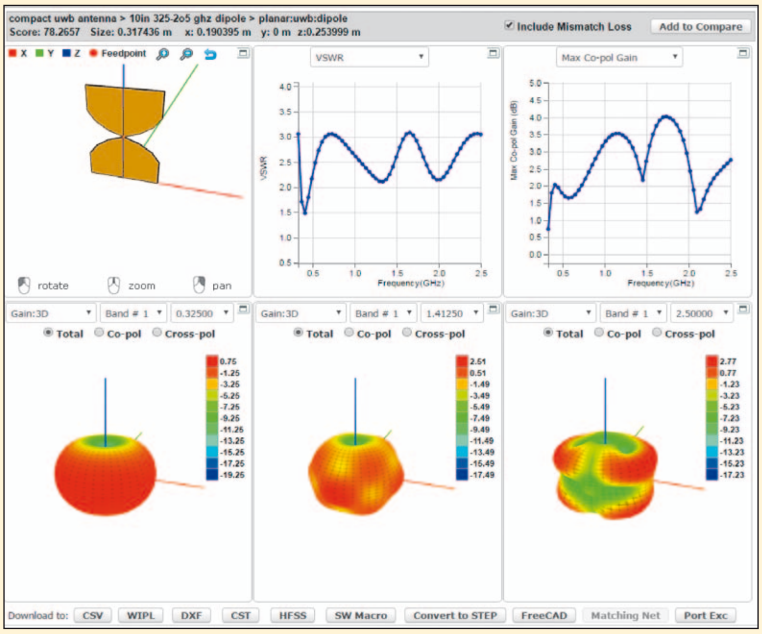

Figure 8: Dipole results

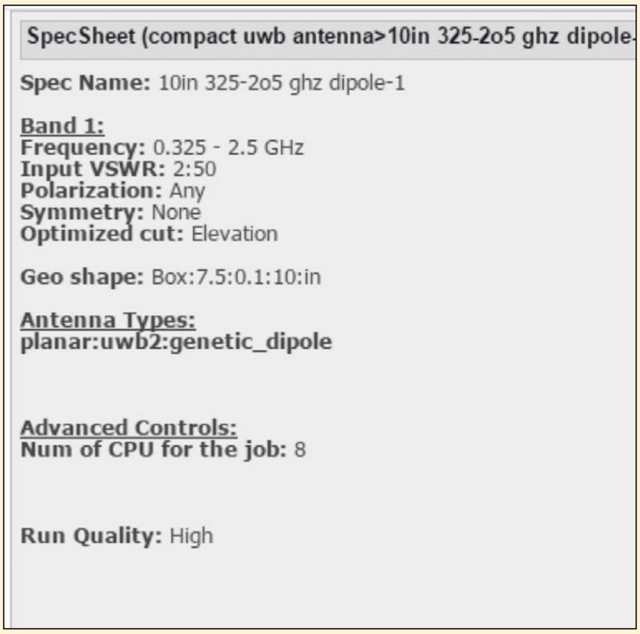

Figure 9: Spec sheet for genetic dipole

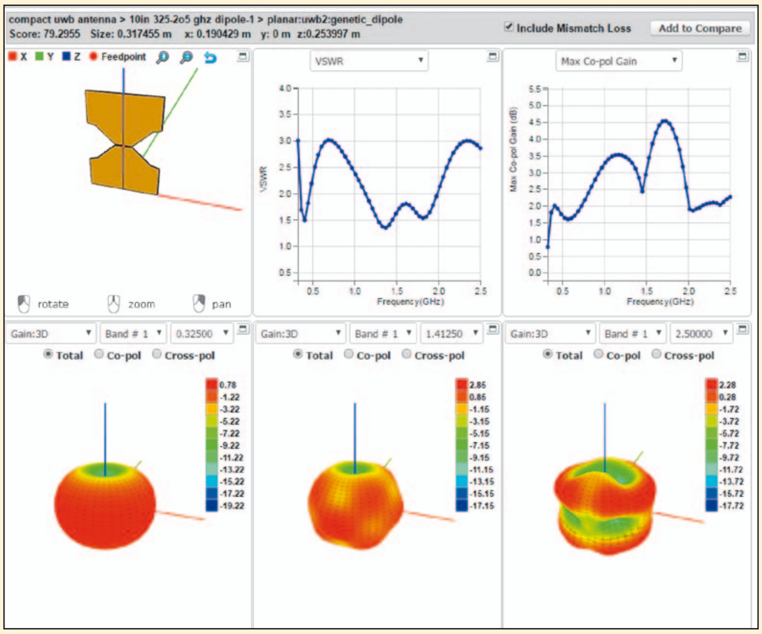

Figure 10: Best result for genetic dipole

specification sheet for the initial evaluation is shown in Figure 1.

AntSyn allows the user to specify a run quality (RQ) based on how much time and computation AntSyn will spend optimizing each design. AntSyn completes runs much faster at low RQ than it does at medium RQ, which in turn runs much faster than high RQ. However, the higher quality setting performs more computations, which often leads to better antenna performance required for difficult design challenges. For this initial evaluation, medium RQ was selected since the wide bandwidth and relatively small form factor made this specification more difficult, yet the limited number of antennas to screen would solve relatively quickly. High RQ was not selected because the primary purpose of the initial exploration was to become familiar with the problem quickly and not to create the final highest-performance design. The results of this initial evaluation for the various antenna types along with the quality of results (QoR) indicator (star rating system) are shown in Figure 2. The QoR provides a qualitative rating of how well each design performed compared with the entered specifications.

The best of the results returned by AntSyn did not achieve the required return loss at 300 MHz. The voltage standing wave ratio (VSWR) exceeded 4.0 at 300 MHz, 1 GHz, and the middle frequencies, indicating more design effort and a possible trade off were required.

Exploring the Effect of Aspect Ratio

The designer then set up a new spec sheet to investigate the impact of the orientation of the antenna on performance. The overall dimensions were maintained, but now with a 7”

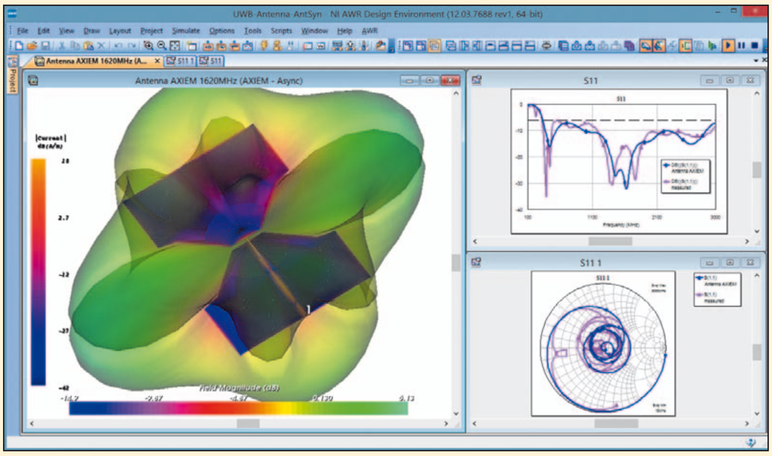

Figure 11: Currents and radiation pattern shown in AXIEM simulation, as well as good agreement with simulation and measurement results

Figure 12: The fabricated UWB antenna prototype

width and 10” height, replacing the 10” wide x 7” high initial version. The original frequency band definition was kept at 300 MHz to 1 GHz and the antenna types were pre-selected as before. The taller antenna form factor worked much better, though the desired outcome was still not achieved.

Exploring the Low-Frequency Limit

With the low end VSWR results still out of spec, AntSyn was used to explore what was possible at the lower end of the frequency range. The designer knew that AntSyn could design an antenna at a single frequency much faster than over a wide band and that if a match to a single frequency cannot be obtained for a given form factor, it is unlikely that a wide band antenna can. So, the target frequency was changed to a single, lower value (200 MHz) while maintaining the 7” wide x 10” tall form factor (Figure 3). While the VSWR result at 200 MHz for the asymmetric genetic monopole was acceptable, its appearance suggested that it would be unlikely to achieve broadband performance while maintaining the low desired frequency response. The other antennas showed poor performance at 200 MHz, illustrating the difficultly of achieving this frequency within this size limit. This experiment established that the 200 MHz low end would be difficult to achieve with a broadband antenna. To fully understand the impact of size on performance, the form factor constraint was also relaxed to investigate structures within a 12” height limit. While two antenna types (Figure 4) showed improvement in the VSWR performance, the increased form factor was undesirable to the overall system requirements. It remained to be seen if the additional performance would be worth the expansion in the form factor.

Zeroing in on the Final Specs

In this phase, AntSyn was used to set the final values for the frequency and dimensional limits. AntSyn was used to see if the upper frequency range could be expanded to 2.5 GHz, as a higher frequency limit is usually much easier to achieve than extending the lower frequency range. Results showed that doing so was indeed relatively easy.

The form factor width was also expanded to 7.5” after re-evaluating the maximum limits of the form factor for the application. However, results showed that expanding the height to 12” did not sufficiently improve the lower frequency performance to warrant the extra size.

Various low frequency values (250, 300, 325, 350 MHz) were attempted, with 325 MHz determined as the final low-frequency spec to meet (Figures 5 and 6).

Finalizing the Design

Now that the specifications were finalized, the AntSyn spec sheet was set to high RQ in order to create the design best able to meet those specifications. Monopoles and dipoles were explored. While the results were good for the monopoles, the antenna layout was not ideal for the application, so dipoles were examined more thoroughly. The designer explored the UWB dipole type antenna with spec sheet settings as shown in Figure 7. The results are shown in Figure 8. Since the results were nearly symmetric for the asymmetric dipole, the genetic dipole (which has enforced symmetry) was optimized further. Figure 9 is the spec sheet for this trial and Figure 10 reveals the best result.

This genetic dipole antenna was selected for fabrication because the VSWR was lower for 1.1–2.1 GHz and the areas of higher VSWR were determined not to be an issue. In addition, the form factor was determined to be better for the application.

AXIEM EM Verification

After achieving satisfactory results, the antenna data was transferred to NI AWR Design Environment in planar DXF format for verification using AXIEM 3D planar EM simulator (Figure 11). There were several ways to feed the antenna and for this prototype an edge SubMiniature version A (SMA) connector and a microstrip feed were chosen. The radiators were placed on different sides of a 20 mil Rogers 4003C substrate. The simulations in AXIEM confirmed that the feed line, radiator arrangement, and substrate did not significantly affect antenna performance.

Prototype and Measurement

In order to fabricate the antenna, the AXIEM layout was exported in Gerber format and a prototype manufactured. The prototype was measured with a 1-port vector network analyzer (VNA) (Figure 12). The measured VSWR <3.0 band was 321–3123 MHz, while the simulated band was 330–3464 MHz. Special note: The more challenging low edge of the band agreed very well with the simulation and the nearly decade bandwidth was also accurately captured by the simulation.

Conclusion

AntSyn enables human judgment to be a factor in antenna design selection by providing many different solutions and insight with little effort. Additional links to EM tools such as AXIEM further extend design capabilities and assurance of optimum results.

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