Measurement, simulation and optimisation of wideband log-periodic antennas

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Introduction

Log-periodic antennas or Log-Periodic Dipole Arrays (LPDAs) have a unique characteristic to present a nearly constant gain and good directivity over a wide frequency range and this is the main reason of their success. They were invented by D. Isbell and R. DuHamel at University of Illinois in 1958, and are extensively used in EMC (Electromagnetic Compatibility) measurements and TV reception. A lot of research is being conducted in order to study and optimise log-periodic antennas. Log-periodic antennas are made up of dipoles that are fitted on a boom and are arranged in such a way that two consecutive ones are fed in phase-opposition. The length of the dipoles and the spacing between them decreases gradually. In this study an LPDA is measured, simulated, and then optimised in the 450-900 MHz UHF frequency band.

Keywords—Boom, dipoles, directivity, electromagnetic compatibility, frequency, gain, log-periodic antenna, LPDA, measurements, optimisation, TV reception.

LPDA measurements

This study presents the results of a ten-element log-periodic antenna measurement campaign conducted in open field measurement conditions in the UHF frequency range of 450-900 MHz. The measurements were performed using a Rohde & Schwartz FSH8 portable spectrum analyser. The gain of the antenna was measured using the reference antenna method with the help of two calibrated biconical dipole antennas. A model of this antenna was developed in CST Studio Suite 2016, so that the simulation results could be compared with the measured results and the datasheet of the antenna. The simulated results of the model obtained from CST include the VSWR and gain plots versus frequency. Furthermore, the optimisation of this antenna has been performed in CST using the Trusted Region Framework algorithm included in this simulator. Fig. 1 shows the antenna field measurement arrangement conducted on the campus of the University of Huddersfield.

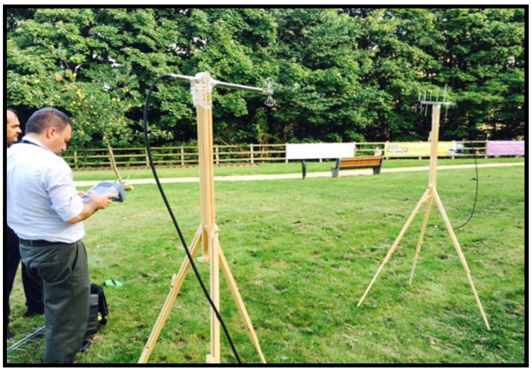

Fig. 1. Reference antenna method used to measure the LPDA gain using a calibrated biconical antenna.

Fig. 2 shows the antenna model designed in CST whereas Fig. 3 shows the actual ten-element LPDA. Fig. 4 and Fig. 5 show the measured gain and the simulated gain of the antenna.

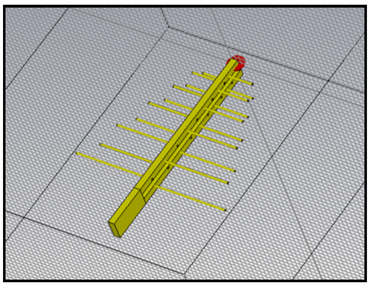

Fig. 2. Ten-element LPDA designed in CST.

Fig. 3. Actual ten-element LPDA.

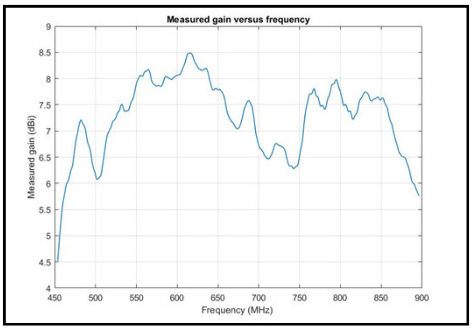

Fig. 4. Measured antenna gain.

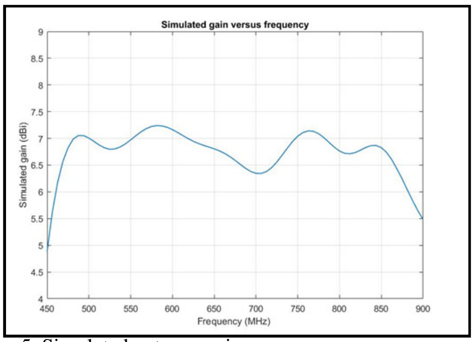

Fig. 5. Simulated antenna gain.

After this preliminary check of the antenna model, there was confidence that simulation results are correct and that they accurately model antenna performance. The optimisation of this antenna was then performed.

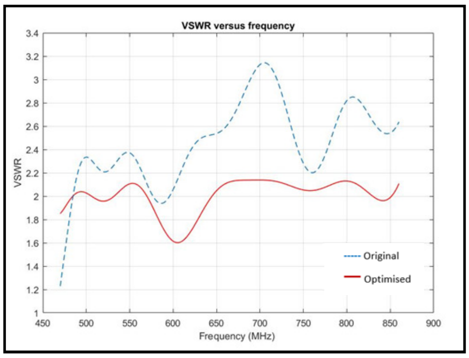

Fig. 6. Comparison between original and optimised antenna VSWR.

Fig. 6 and Fig. 7 present a comparison of the original and the optimised antenna VSWR and gain, respectively.

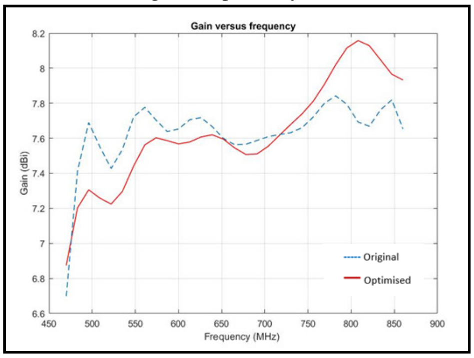

Fig. 7. Comparison between original and optimised antenna gain.

Conclusion

The above results show that there is a good agreement between the simulated and the measured gain. Moreover, an optimised LPDA antenna design has been obtained using the Trusted Region Framework algorithm providing improved VSWR and gain over the original design.