Design and Analysis of Partitioned Square Loop Antennas

[1]R. Hasse, [2]V. Demir, [1]W. Hunsicker, [1]D. Kajfez, and [1]A. Elsherbeni

[1] Department of Electrical Engineering
The University of Mississippi, University, MS 38677, USA
rhasse@olemiss.edu, wfhunsic@olemiss.edu, eedarko@olemiss.edu, atef@olemiss.edu

[2] Department of Electrical Engineering
Northern Illinois University, DeKalb, IL 60115, USA
demir@ceet.niu.edu

Abstract – A novel antenna design is presented for operation at 5.8 GHz with omni-directional pattern characteristics. The antenna employs square loop geometry of one wavelength perimeter. The loop is partitioned with capacitive elements in order to minimize phase variations in the current flow and thereby enhance the radiation efficiency. Five capacitive elements are used to achieve optimal loop current flow, resulting in phase variations smaller than ± 6°. The performance of the antenna is first analyzed with a thin-wire antenna using method of moments (MoM) solver and later validated using a custom finite difference time domain (FDTD) package. The calculated radiation pattern in the plane of the loop is close to omni-directional with directive gain of 1.5 dBi. A printed circuit antenna is manufactured with alternating top- and bottom-layer conductors, with the overlapped regions acting as physical capacitors. The measured radiation patterns of the printed antenna confirm the predicted omni-directional behavior in the equatorial plane, while the input impedance demonstrates a close match to 50 Ω. The mean value of the gain is 2.15 dB at 5.869 GHz. A second printed antenna, having top-layer conductors only and gap capacitors, is simulated using finite element (FEM) software, and the performance is nearly omni-directional with a directive gain of 1.66 dBi. Both designs are very sensitive to the dimensions of the physical capacitors and require a highly accurate method of fabrication.

Keywords: Loop antenna, partitioned, and omni-directional.

I. INTRODUCTION

The loop antenna has proven to be one of the most practical and adaptable types of antennas [1], with circular and rectangular geometries representing the most popular configurations. This popularity stems primarily from their inherent low cost, simplicity of fabrication, and ease of implementation as front-end elements in RF and communication systems. However, their performance in comparison with other antenna designs is limited with respect to gain, bandwidth, and directionality of radiation. For example, when the perimeter of the loop antenna is small with respect to wavelength, its radiation impedance is extremely small and thus inconvenient for matching to a 50 Ω transmission line. Conversely, when the loop perimeter is of the order of one wavelength or larger, the current flowing in the loop exhibits large phase variations that ultimately degrade the radiation efficiency [2]. This results in a poor radiator and a shift of the radiation pattern maximum from in the plane of the loop to a plane normal to the loop, which may not be desirable for the intended application.

It is possible to minimize the phase variation of the loop current by partitioning the loop into several sections that are small in comparison to wavelength, and then inserting lumped capacitive elements in a series configuration [3, 4]. The resulting antenna structure is simple and can be investigated using a thin-wire model radiating into free space. The physical dimensions are then converted to an equivalent printed model with overlapping conductors on a low-loss dielectric substrate. A second printed loop antenna is designed using top-layer conductors only with gap capacitors. The procedure used to design both the wire and printed antennas is discussed, while simulation results using custom finite difference time domain (FDTD) software and a commercial finite element (FEM) package are presented which validate the final printed designs. Measurements of the return loss and radiation patterns for the overlapped design are also presented to compare the performance of this partitioned loop antenna with the simulation results.

II. WIRE ANTENNA MODEL

A thin-wire square loop antenna of radius a = 0.5 mm and side $s = \lambda/4$ was designed and simulated using the commercial software package entitled Analysis of Wire Antennas and Scatterers (AWAS) [5]. The loop antenna was centered in the *xy* plane at $z = 0$ and modeled with copper wire segments ($\sigma = 5.81\times10^7$ S/m). A total of 6 wire segments comprise the antenna geometry, as shown in Fig. 1. Since the aspect ratio $s/a \cong 26$ (relatively thick antenna), three polynomial coefficients per λ were used to model the current and charge distributions along segments 1, 3, 4, and 6, respectively, while five coefficients were used for segments 2 and 5 in the numerical solution of the two-potential equation [6].

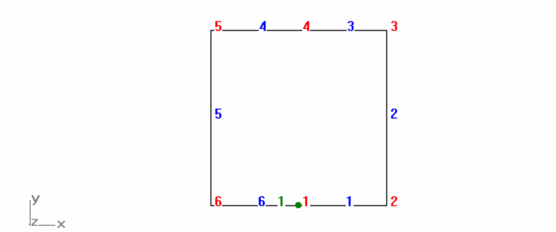


Fig. 1. Thin-wire model for partitioned loop antenna with source, nodes and wire segments indicated.

An ideal voltage generator of 1.0 V was fixed between segments 1 and 6 (node 1) with a port impedance of 50 Ω. Concentrated capacitive loadings were positioned at the four corners and between segments 3 and 4 (node 4) directly opposite to the source. Five capacitive elements ranging in value from 0.046-0.069 pF were used to minimize the current phase variations.
The antenna was simulated in transmission mode in free space from 1 GHz to 10 GHz using a total of 450 points, and optimization of the capacitor values yielded an input impedance of 50.64 – *j* 1.96 Ω, a corresponding input admittance of 19.72 + *j* 0.0076 mS, and a return loss of -34 dB at 5.8 GHz, as shown in Fig. 2. The simulated current magnitude and phase variations on each wire

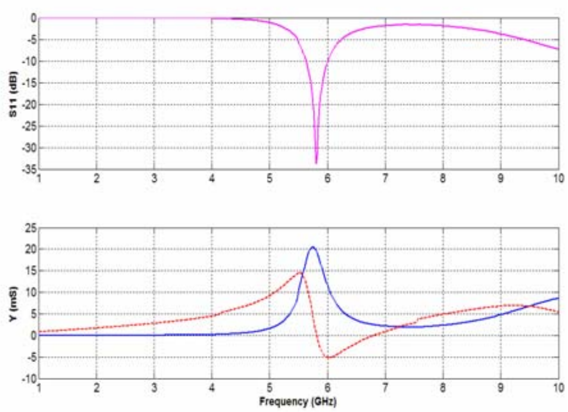


Fig. 2. Return loss and input admittance for wire partitioned loop antenna at 5.8 GHz.

segment of the antenna with lumped capacitors are plotted in Fig. 3, with phase variations on the order of ± 6°, indicating good stability of the current phase over the entire loop length. For comparison, the current magnitude and phase on each wire segment of the loop antenna without lumped capacitors is shown in Fig. 4, where the current phase varies approximately 180°.

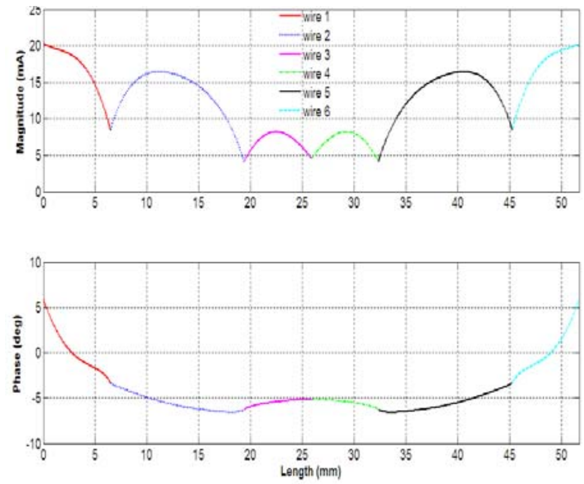


Fig. 3. Current magnitude and phase for thin-wire loop antenna with lumped capacitors at 5.8 GHz.

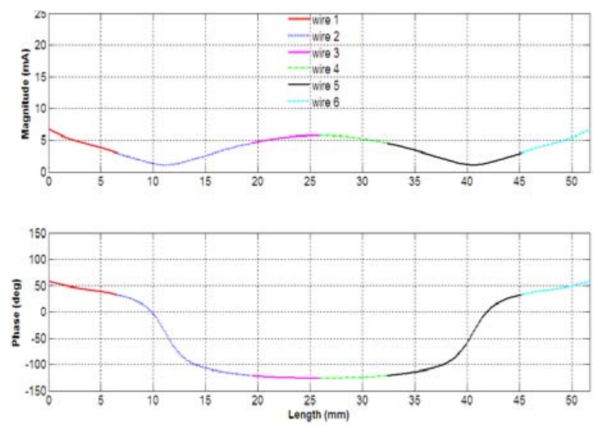


Fig. 4. Current magnitude and phase for thin-wire loop antenna without lumped capacitors at 5.8 GHz.

The simulated E_ϕ component of the far-field, in three principle planes, is shown in Fig. 5. The radiation pattern is omni-directional to within 0.5 dB in the loop antenna plane. The cross-polarization components are negligible due to the symmetry of the loop and therefore are not visible on the patterns in Fig. 5. The far-field directive gain is equivalent to 1.5 dBi.

III. OVERLAPPED PRINTED LOOP ANTENNA MODEL

A printed square loop antenna, as illustrated in Fig. 6, was designed by converting the loop wire conductors using a cylinder-to-ribbon current equivalence approximation $w \cong 2d$ [7], to a strip width of 2.0 mm. The antenna is realized on a substrate with alternating top and bottom layer conductors using Rogers RT/Duroid 5880 with $\varepsilon_r = 2.2$, substrate height h = 0.787 mm (31 mil), tan $\delta = 0.0004$, and conductor thickness t = 0.035 mm. The capacitances are realized by overlapping the end sections of strips on opposite sides of the substrate. The areas of overlap for the five physical capacitors were computed as,

$$A = \frac{h\,C}{\varepsilon_0\ \varepsilon_r} \qquad (1)$$

where A is the required overlapped area, h is the substrate height, and C is the required capacitance. The corresponding areas are 1.84 μm^2 (0.046 pF), 2.63 μm^2 (0.065 pF), and 2.80 μm^2 (0.069 pF), respectively.

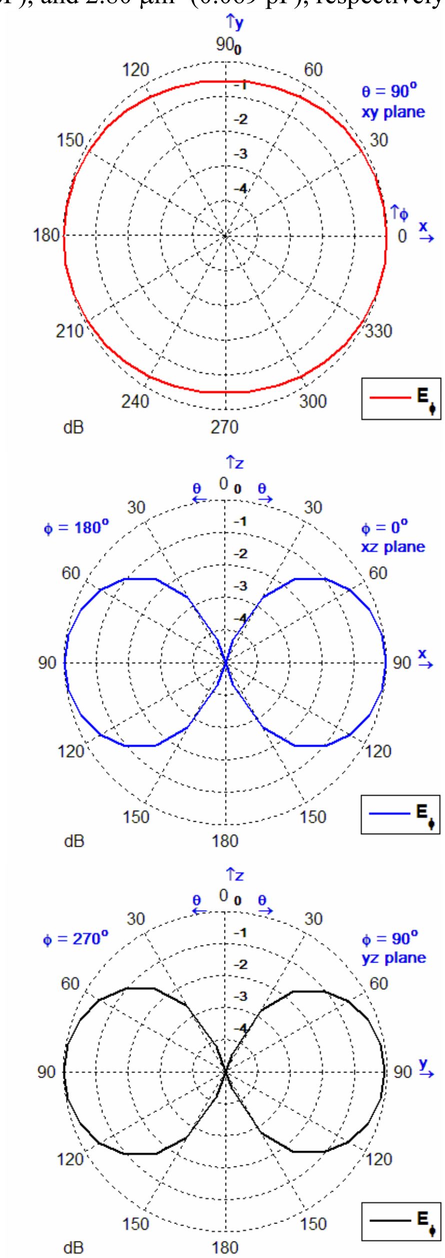


Fig. 5. Simulated far-field radiation patterns for thin-wire partitioned loop antenna at 5.8 GHz.

Figure 7 (a) shows the dimensions of a partitioned loop antenna with a feeding line in which the overlapping areas of strips are approximated to these calculated values. Simulation of this antenna using a custom 3-D FDTD solver verified that it operates at 5.8 GHz. The antenna has been fabricated using a LPKF ProtoMat C100/HF milling machine, and the return loss was measured using an Agilent Technologies model E8363B PNA network analyzer with 801 frequency points. The measurement shows that the antenna operates at a center frequency of 6.02 GHz with –19.6 dB return loss.

This result demonstrates that the center frequency has shifted from the desired value of 5.8 GHz. During fabrication the milling tool removed part of the substrate while rubbing out the extraneous copper, resulting in a substrate thickness of 0.55 mm (except for regions covered by copper), which is less than the nominal 0.787 mm. Such a change in substrate thickness likely altered the physical capacitors and their associated fringing fields. Additional FDTD simulations including the actual substrate thickness after fabrication demonstrated that this thinning effect increases the frequency. Thus the exact values of the individual capacitances proved to be very critical in achieving the desired center frequency, and the printed loop antenna dimensions had to be modified slightly in order to lower the center frequency of operation.

The modified dimensions are illustrated in Fig. 7 (b) and include increasing the area of overlap for the physical capacitor opposite to the source, as well as for the capacitors in the upper left- and right-hand corners of the loop layout. A new antenna was then fabricated using these modified dimensions. Figure 8 shows the back and front views of this antenna. The return loss measurement is compared to the FDTD simulated results as shown in Fig. 9. The fabricated antenna resonates at 5.869 GHz with a bandwidth of 6%, while the simulated curve shows a peak return loss at 5.78 GHz. The substrate of this new antenna is measured to be 0.5 mm and is thinner than the simulated thickness, and this produces the discrepancy between the simulated and measured results, but the measurement still shows good performance at 5.8 GHz (-18 dB).

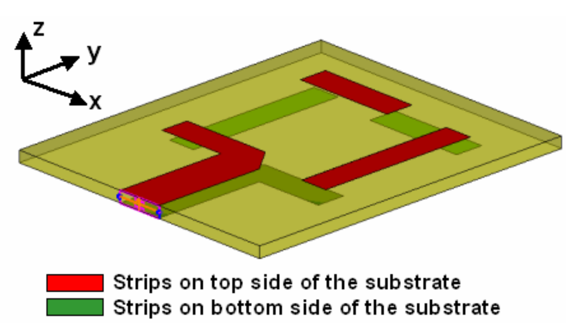
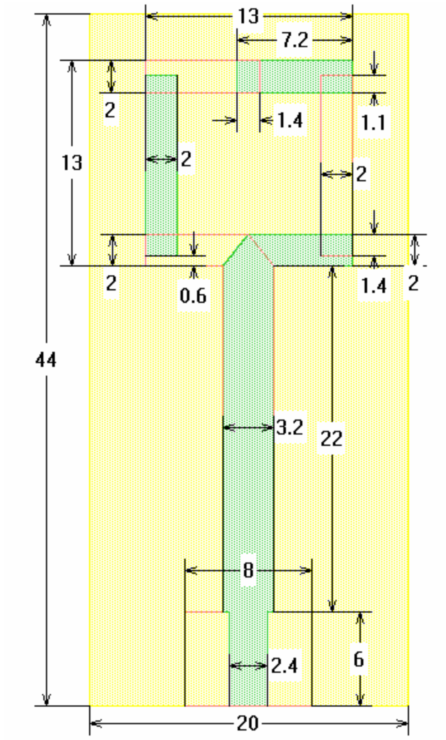
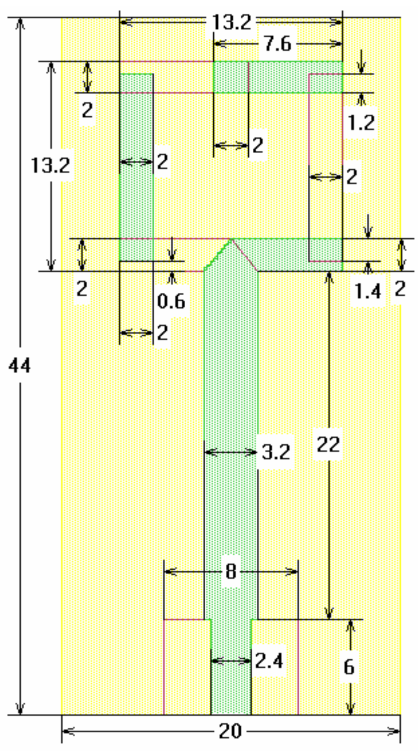


Fig. 6. Schematic of the overlap printed partitioned loop antenna on a substrate material.

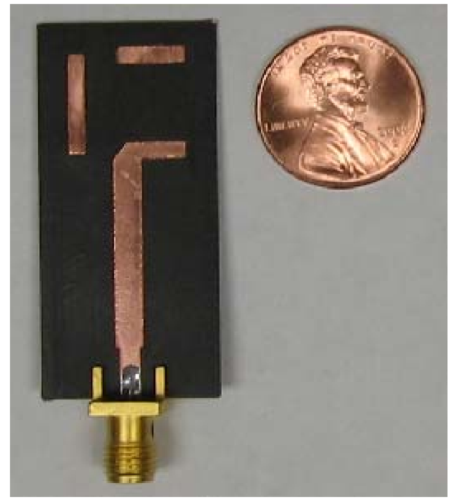


(a)

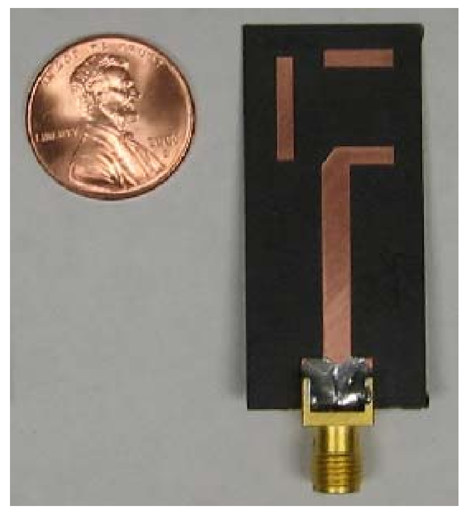


(b)

Fig. 7. (a) Initial design dimensions of the overlap partitioned loop antenna in mm. (b) Modified design dimensions of the overlap partitioned loop antenna in mm.



(a)



(b)

Fig. 8. Overlap partitioned loop antenna: a) front view and b) back view.

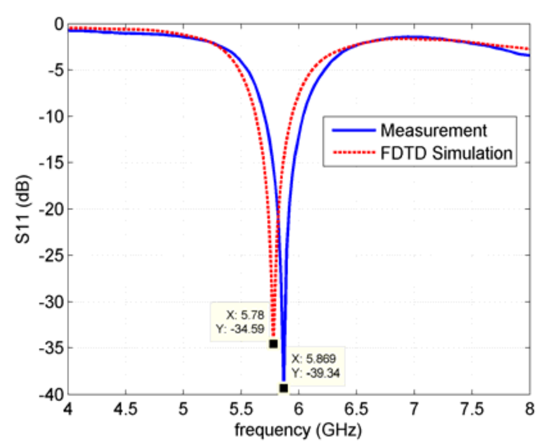


Fig. 9. Measured and simulated return losses for overlap partitioned loop antenna.

Radiation patterns of the fabricated antenna were measured inside a rectangular anechoic chamber using a ETS-Lindgren model 3117 double-ridged waveguide horn (1-18 GHz) as the excitation source, with a source-to-receiver distance of 3.65 m. An automated measurement system, comprised of an HP 8350B sweep oscillator, HP8514B S-parameter test set, HP8530A microwave receiver, and motorized rotator, was calibrated at 5.869 GHz using a Narda model 642 (5.4-8.20 GHz) standard gain horn (SGH) [8].

Simulated directivity patterns calculated by FDTD in three principal planes at 5.8 GHz are shown in Fig. 10, while Fig. 11 shows the corresponding radiation patterns measured at 5.869 GHz for comparison. Good agreement is observed between the simulated and measured patterns. Radiation is omni-directional in the *xy* plane with ϕ-polarization. The slightly higher cross-polarization levels (E_ϕ) seen in each plane in Fig. 11, as compared to the simulation results, are likely caused by the presence of surface currents on the receiver cable in the anechoic chamber due to the absence of a balun transformer in the antenna feed path during measurement.

The gain comparison method was used to measure the absolute gain of the printed loop antenna using the relation [2],

$$(G_T)_{dB} = (G_S)_{dB} + 10\log_{10}\left(\frac{P_T}{P_S}\right) \qquad (2)$$

where G_S = 15.42 dB at 5.869 GHz for the SGH. As seen in Fig. 11, the gain of the loop antenna in the *xy* plane is not uniform, with a maximum of 4.64 dB (135°), a minimum of -1.27 dB (45°), and a mean value of 2.15 dB, which is in good agreement with the directivity simulation. By improving the accuracy of fabrication using high resolution techniques, such as chemical etching or laser milling, it is possible that a more uniform radiation pattern in the plane of the loop antenna would result. More importantly, the overlap design represents a natural implementation of physical capacitors in the partitioned antenna structure without the need for incorporating SMT chip capacitors, which will add additional costs into the manufacturing process.

IV. TOP LAYER PRINTED LOOP ANTENNA MODEL

A second printed square loop antenna was designed with top layer conductors only in order to minimize engineering design and fabrication costs, and this partitioned structure is realized by using straight-edge gap capacitances at the same strategic locations as for the overlap printed loop antenna, as shown in Fig. 12. A fully parameterized model was developed using the High Frequency Structure Simulator (HFSS) [9] software package in order to independently vary the gap widths for the capacitors, conductor widths, and loop size. A feed port with nominal impedance of 50 Ω excited the antenna across a source feed gap of 3.0 mm using an interpolating frequency sweep from 4 GHz to 8 GHz with 12 adaptive passes and a delta S convergence level of 0.005 to ensure accurate meshing of the minute gap capacitances.

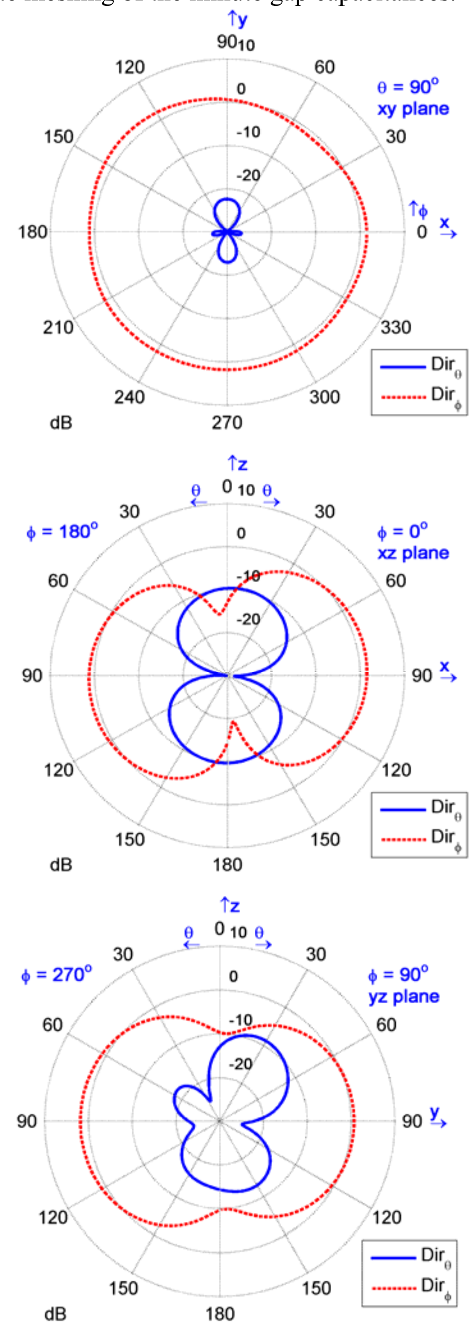


Fig. 10. Simulated directivity patterns for overlap printed loop antenna at 5.8 GHz (FDTD).

A perfectly matched layer acting as the absorbing boundary was applied to the outer faces of the solution space in order to create an open model. The simulated gap widths for the capacitors were optimized to the values of 0.10 mm (top corners), 0.13 mm (bottom corners), and 0.11 mm (opposite the source). The simulated electric surface current distribution at 5.8 GHz is shown in Fig. 13, where the highest currents are found near the lumped source and along the inner edges of the conductors. It was necessary to increase the side length *s* to 15 mm for this design in order to achieve good radiation resistance, with a return loss of -21.5 dB at the meshed solution frequency of 5.8 GHz (see Fig. 14).

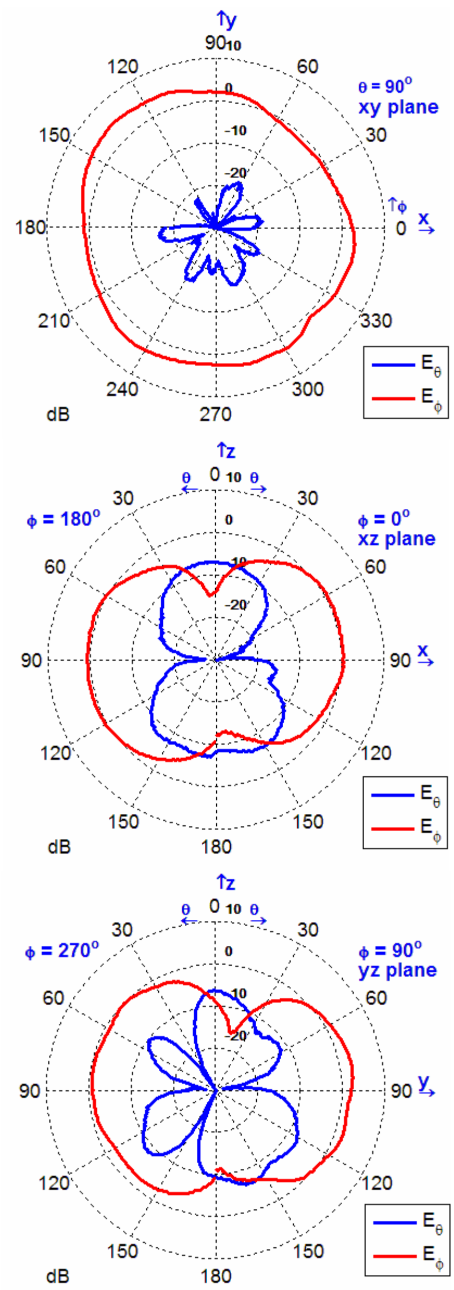


Fig. 11. Measured radiation patterns for overlap printed loop antenna at 5.869 GHz.

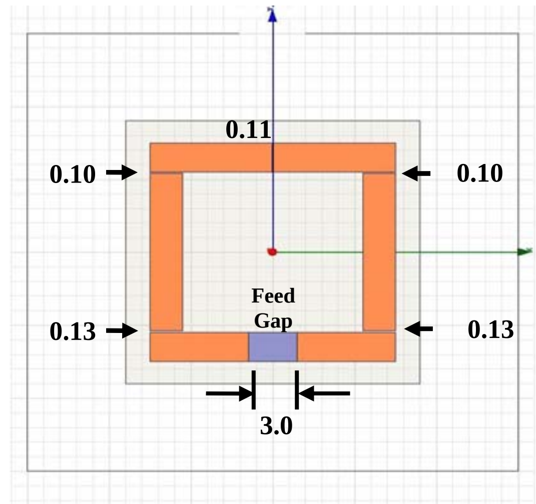


Fig. 12. Schematic of top layer printed loop antenna with gap capacitor dimensions in mm.

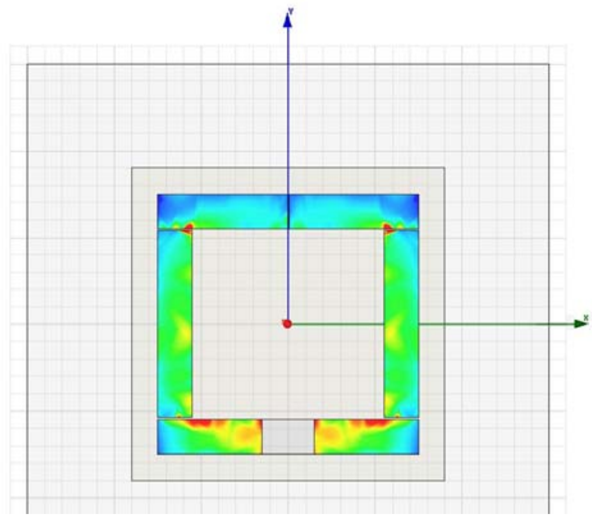


Fig. 13. Simulated electric surface currents for top layer printed loop antenna at 5.8 GHz (HFSS).

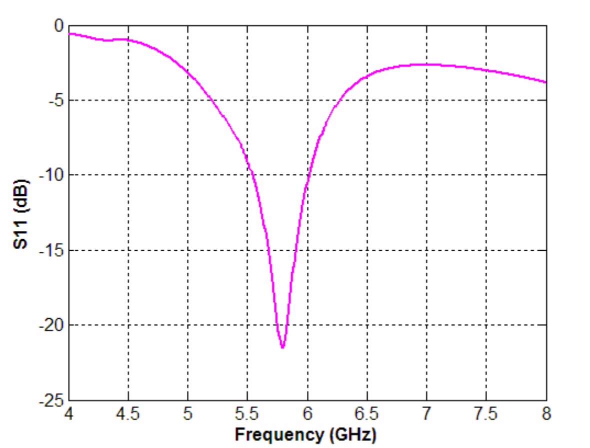


Fig. 14. Simulated return loss for top layer printed loop antenna using HFSS.

The calculated directive gain is 1.66 dBi with a radiation efficiency of 0.989 and corresponding bandwidth of 8 %. The calculated co-polarized and cross-polarized far-field radiation patterns in three principal planes are shown in Fig. 15, with nearly omni-directional radiation in the loop antenna plane as desired. For this design the electric field lines in the capacitive regions extend primarily into the air dielectric, as there is little confinement of the electric field in the substrate dielectric without the presence of conductors on the bottom layer, and the sensitivity of the gap capacitors to environmental factors is thereby increased.

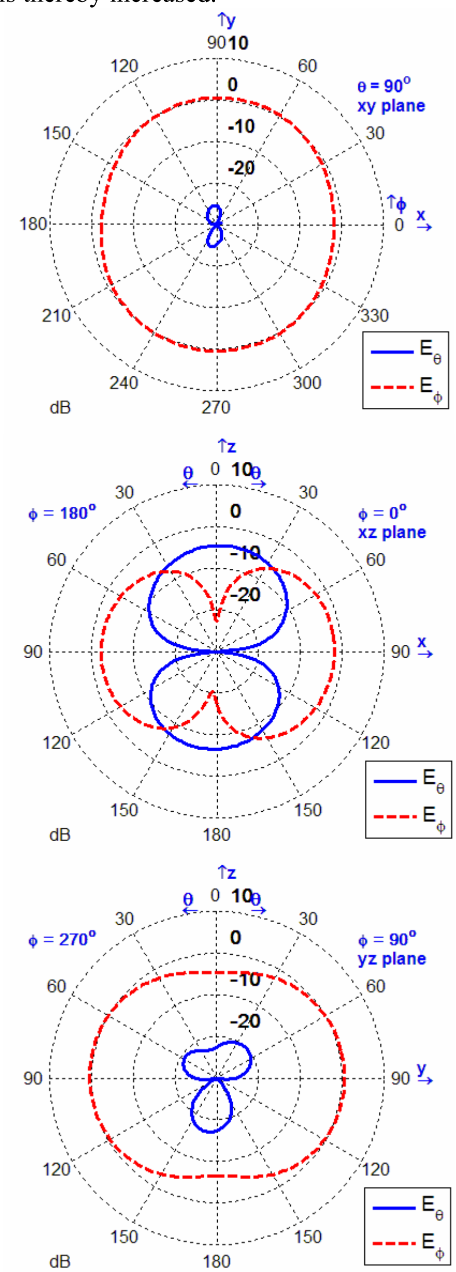


Fig. 15. Simulated far-field radiation patterns for top layer printed loop antenna at 5.8 GHz (HFSS).

Several attempts were made at fabricating the top-layer design using the LPKF milling machine with a 0.1 mm universal cutting tool, but visual inspection of the cuts using an optical eye piece revealed that the accuracy of the milled gap dimensions was poor and non-reproducible. Alternative fabrication processes (e.g. chemical etching) are currently being explored in order to minimize the design sensitivity to fabrication tolerances. Note that the source gap dimension of 3.0 mm is intended to excite the antenna with a balun transformer. A sample of a commercial balun transformer at 5.8 GHz was obtained from a preferred manufacturer, however, the device dimensions are sub-miniature and not practical for use with this antenna, therefore, a custom split tube balun transformer of diameter 3.5 mm and length λ_g = 35 mm is currently being fabricated with symmetrical slot lengths of $\lambda_g/4$ = 8.75 mm, in order to balance any surface currents and achieve a good match to the input impedance of the antenna.

V. CONCLUSIONS

A novel loop antenna design is presented which utilizes capacitive elements at strategic locations in order to minimize phase variations in the current flow and thereby enhance the radiation efficiency. Initial design parameters are obtained using AWAS, a thin-wire antenna MoM solver, and then an overlap partitioned loop antenna is designed on a planar substrate and optimized using a custom FDTD solver. The design is fabricated and return loss and radiation pattern measurements are performed. The radiation pattern measurements reveal that the antenna provides the desired omni-directional radiation characteristics, with an input impedance close to 50 Ω and a mean value for the gain of 2.15 dB at 5.869 GHz. A second printed loop antenna is also designed with top layer conductors and straight-edge gap capacitors and optimized for performance at 5.8 GHz using HFSS. The simulated radiation pattern is nearly omni-directional in the antenna plane. The return loss simulation yields a result of -21.5 dB at a center frequency of 5.8 GHz. Attempts at fabricating this antenna demonstrated that it is extremely sensitive to fabrication imperfections, and alternative fabrication processes such as chemical etching or laser milling are currently being explored in order to minimize the sensitivity of both printed designs to fabrication tolerances.

REFERENCES

[1] G. S. Smith, "Loop antennas," in *Antenna Engineering Handbook*, Third Edition, Chapter 5, McGraw-Hill, Inc., New York, 1993.

[2] C. A. Balanis, *Antenna Theory: Analysis and Design*, Second Edition, Chapter 5, John Wiley & Sons, Inc., New York, 1982.

[3] V. Demir, R. Hasse, D. Kajfez, and A. Z. Elsherbeni, "Partitioned square loop antenna," *The 23rd Annual Review of Progress in Applied Computational Electromagnetics Society, ACES'07*, Verona, Italy, March 2007.

[4] D. M. Dobkin, S. M. Weigand, and N. Iyer, "Segmented magnetic antennas for near-field UHF RFID," *Microwave Journal*, pp. 96-102, June 2007.

[5] A. R. Djordjević, M. B. Dragović, V. V. Petrović, D. I. Olćan, T. K. Sarkar, and R. F. Harrington, *Analysis of Wire Antennas and Scatterers (ver. 2.0), Software and User's Manual, Chapter 8*, Artech House, Norwood, MA, 2002.

[6] B. D. Popović, M. B. Dragović, and A. R. Djordjević, *Analysis and Synthesis of Wire Antennas*, John Wiley & Sons, Inc., 1982.

[7] R. F. Harrington, *Time-Harmonic Electromagnetic Fields*, Chapter 5, McGraw-Hill, Inc., New York, 1961.

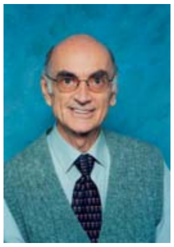
[8] Narda Company, 435 Moreland Road, Hauppauge, NY, 11787, www.nardamicrowave.com, 2006.

[9] High Frequency Structure Simulator (HFSS), Ver.10, Ansoft Corporation, Pittsburgh, PA, 2006.

Roger Hasse received a Bachelor of Science degree in physics from Oakland University, Rochester, Michigan, in 1991. He was awarded a U.S Department of Energy SERS fellowship from January 1994 to December 1994 at the Pacific Northwest National Laboratory, Richland, Washington, where he applied pulse echo and swept frequency acoustic techniques in the nondestructive testing of materials. From April 1995 to November 1997, he was awarded a Graduate Research Assistant fellowship at the Los Alamos National Laboratory, Los Alamos, New Mexico, where he conducted acoustic interferometry experiments in support of chemical weapons verification technology. He later joined the staff at Cornell University from November 1997 to January 2001 as a Research Support Specialist, where he provided hardware development and software maintenance support for visiting scientists, technical staff, and graduate students at the Cornell High Energy Synchrotron Source (CHESS). He joined the National Center for Physical Acoustics (NCPA), Oxford, Mississippi, as a Research and Development Engineer from February 2001 to January 2005. He conducted acoustic experiments and developed hardware and software in support of USDA-sponsored research in New Orleans, Louisiana. He also conducted research in nonlinear acoustics at the NCPA using the Schlieren imaging technique. He is currently pursuing his Master of Science degree in Electrical Engineering, with a concentration in electromagnetics, in the Department of Electrical Engineering at the University of Mississippi. In addition, he is presently a Systems Engineer with the Raytheon Company, working on low-power and high-power near field measurements and data analysis in support of the F/A-18 Active Electronically Steered Array (AESA) APG-79 radar antenna, both on-site in Forest, Mississippi, and off-site in El Segundo, California. Mr. Hasse is a member of The Applied Computational Electromagnetic Society (ACES), and a member of the Acoustical Society of America (ASA).

Veysel Demir was born in Batman, Turkey, in 1974. He received his Bachelor of Science degree in electrical engineering from the Middle East Technical University, Ankara, Turkey, in 1997. He received a scholarship award from the Renaissance Scholarship Program for graduate study in the United States (2000-2004). He studied at Syracuse University, Syracuse, New York, where he received both the Master of Science and Doctor of Philosophy degrees in Electrical Engineering in 2002 and 2004, respectively. During his graduate studies, he worked as a Research Assistant for Sonnet Software, Inc., Liverpool, New York. He worked as a Visiting Research Scholar in the Department of Electrical Engineering at the University of Mississippi from 2004 to 2007. He joined the Department of Electrical Engineering at Northern Illinois University as an Assistant Professor in August 2007. His research interests include numerical analysis techniques (FDTD, FDFD, and MoM), as well as microwave and RF circuit analysis and design. Dr. Demir is a member of the IEEE and ACES, and he has coauthored more than 20 technical journal and conference papers. He has been serving as a reviewer for both the Applied Computational Electromagnetics (ACES) Journal and the Transactions on Microwave Theory and Techniques (MTT) Journal.

Walker Hunsicker was born in Tupelo, Mississippi, in 1978. He received his Bachelor of Science degree in electrical engineering from the University of Mississippi, Oxford, Mississippi, in 2000. In 2002 he worked as a Research Engineer at the Naval Air Warfare Center, Aircraft Division, at Naval Air Station, Patuxent River, Maryland, where he performed analysis on spatial power combiners using the Method of Moments (MoM) technique. He is presently working as an Antenna Design Engineer with Radiance Technologies, Inc., Oxford, Mississippi, since 2004, and will complete his Master of Science degree in electrical engineering, with a concentration in electromagnetics, in December 2007. He plans on pursuing graduate studies towards a PhD degree in electrical engineering in 2008. His research interests include wideband antennas, array synthesis techniques, and computational electromagnetics.



Darko Kajfez is Emeritus Professor of Electrical Engineering at the University of Mississippi. He obtained the electrical engineer's degree (Dipl. Ing.) from the University of Ljubljana, Slovenia, in 1953, and the PhD degree from the University of California Berkeley, in 1967. He co-edited the book entitled *Dielectric Resonators*, and authored the books *Notes on Microwave Circuits* and *Q Factor*. His research interests include RF and microwave measurement techniques and analysis. He can be contacted by email at eedarko@olemiss.edu.

Atef Elsherbeni received an honor B.Sc. degree in Electronics and Communications, an honor B.Sc. degree in Applied Physics, and a M.Eng. degree in Electrical Engineering, all from Cairo University, Cairo, Egypt, in 1976, 1979, and 1982, respectively, and a Ph.D. degree in Electrical Engineering from Manitoba University, Winnipeg, Manitoba, Canada, in 1987. He was a part time Software and System Design Engineer from March 1980 to December 1982 at the Automated Data System Center, Cairo, Egypt. From January to August 1987, he was a Post Doctoral Fellow at Manitoba University. Dr. Elsherbeni joined the faculty at the University of Mississippi in August 1987 as an Assistant Professor of Electrical Engineering. He advanced to the rank of Associate Professor on July 1991, and to the rank of Professor on July 1997. On August 2002 he became the director of The School of Engineering CAD Lab, and the associate director of The Center for Applied Electromagnetic Systems Research (CAESR) at The University of Mississippi. He was appointed as Adjunct Professor, at The Department of Electrical Engineering and Computer Science of the L.C. Smith College of Engineering and Computer Science at Syracuse University on January 2004. He spent a sabbatical term in 1996 at the Electrical Engineering Department, University of California at Los Angeles (UCLA) and was a visiting Professor at Magdeburg University during the summer of 2005. Dr. Elsherbeni received the 2006 School of Engineering Senior Faculty Research Award for Outstanding Performance in research, the 2005 School of Engineering Faculty Service Award for Outstanding Performance in Service, The 2004 Valued Service Award from the Applied Computational Electromagnetics Society (ACES) for Outstanding Service as 2003 ACES Symposium Chair, the Mississippi Academy of Science 2003 Outstanding Contribution to Science Award, the 2002 IEEE Region 3 Outstanding Engineering Educator Award, the 2002 School of Engineering Outstanding Engineering Faculty Member of the Year Award, the 2001 ACES Exemplary Service Award for leadership and contributions as Electronic Publishing Managing Editor 1999-2001, the 2001 Researcher/Scholar of the year award in the Department of Electrical Engineering, The University of Mississippi, and the 1996 Outstanding Engineering Educator of the IEEE Memphis Section. Dr. Elsherbeni has conducted research dealing with scattering and diffraction by dielectric and metal objects, finite difference time domain analysis of passive and active microwave devices including planar transmission lines, field visualization and software development for EM education, interactions of electromagnetic waves with human body, sensors development for monitoring soil moisture, airports noise levels, air quality including haze and humidity, reflector and printed antennas and antenna arrays for radars, UAV, and personal communication systems, antennas for wideband applications, and antenna and material properties measurements. He has co-authored 94 technical journal articles, 24 book chapters, and contributed to 266 professional presentations, offered 17 short courses and 18 invited seminars. He is the coauthor of the book entitled "*Antenna Design and Visualization Using Matlab*", Scitech, 2006, the book entitled "*MATLAB Simulations for Radar Systems Design*", CRC Press, 2003, the book entitled *"Electromagnetic Scattering Using the Iterative Multiregion Technique"*, Morgan & Claypool, 2007, the book entitled *"Electromagnetics and Antenna Optimization using Taguchi's Method"*, Morgan & Claypool, 2007, and the main author of the chapters "*Handheld Antennas"* and *"The Finite Difference Time Domain Technique for Microstrip Antennas"* in Handbook of Antennas in Wireless Communications, CRC Press, 2001. He was the main advisor for 31 MS and 8 PhD students. Dr. Elsherbeni is a Fellow member of the Institute of Electrical and Electronics Engineers (IEEE) and a fellow member of The Applied Computational Electromagnetic Society (ACES). He is the Editor-in-Chief for ACES Journal, and an Associate Editor to the Radio Science Journal. He serves on the editorial board of the Book Series on Progress in Electromagnetic Research, the Electromagnetic Waves and Applications Journal, and the Computer Applications in Engineering Education Journal. He was the Chair of the Engineering and Physics Division of the Mississippi Academy of Science and was the Chair of the Educational Activity Committee for the IEEE Region 3 Section. Dr. Elsherbeni's home page can be found at http://www.ee.olemiss.edu/atef and his email address is Elsherbeni@ieee.org.