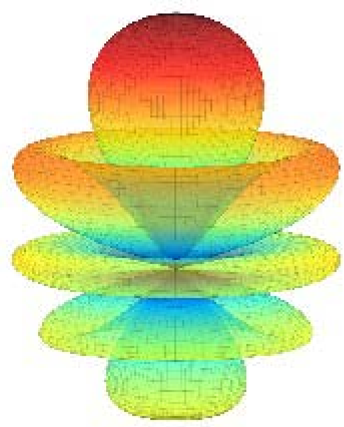

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NEWSLETTER

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In this issue:

Editor's note:

Hello again. By the time that this newsletter hits your inbox, the run-up to the conference will be in its closing stages. It really does look to be a good one.

This newsletter brings an article about an interesting patch antenna design by Taha Imeci and Fadi Khalil gives us a quick view of TLM in a way that explains what the method does rather than how it does it.

Next month's issue will introduce the new Fellows and members of the Board of Directors'.

As I write this, news is developing of the earthquake and tsunami in Japan. Our thoughts and prayers are with our friends and colleagues.

Wishing you all well

Alistair Duffy apd@dmu.ac.uk

A Novel Patch Antenna with Multiple Discontinuities

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***Abstract*—**A novel microstrip patch antenna with multiple discontinuities has been designed, simulated, built and tested. The design process is based on a 2D random optimization technique which uses a 3D commercial planar em simulator repeatedly. Simulated return loss of 24 dB, input impedance of 56 ohms and a gain of 8.97 dB are achieved at the center frequency of 6.22 GHz. Simulated results are in good agreement with the measured data.

***Index Terms*—**Microstrip, patch, antenna, radiation.

I. INTRODUCTION

A microstrip patch antenna with a resonance frequency of 6.22 GHz is designed, simulated, built and tested. The main purpose was to obtain high gain and low return loss by modifying the shape of a conventional rectangular patch. The shape was modified by changing the width of the patch at different locations along the length. This resulted in a random 2-dimensional optimization scheme. At each step, Sonnet Software [1] was used to compute various parameters such as the return loss and the gain. If the results were not satisfactory, the shape of the patch was further modified and the resulting antenna was simulated again. The simulated antenna was on an Agilent FoamClad substrate with very low dielectric constant of 1.25, and thickness of 120 mils. Although the input portion of our optimized antenna is similar to an antenna designed by other researchers [2], our final antenna has no slots. In [3] and [4] there are some patch antenna designs of different shapes. In [5], various techniques are introduced about designing different types of antennas for military applications.

In Section II, the design process is demonstrated by mainly presenting various intermediate simulation results. In Section III, measurement results are presented and compared with the simulated data. The conclusion and final comments are given in Section IV.

II. DESIGN PROCESS

Figure 1 shows the top view of the optimized antenna and Figure 2 has the 3-D view. As mentioned above, the antenna is optimized by computing a parameter, such as return loss, as the width of the patch is changed at certain point along its length. In this section we illustrate this process by presenting simulated results as certain shape parameters are varied.

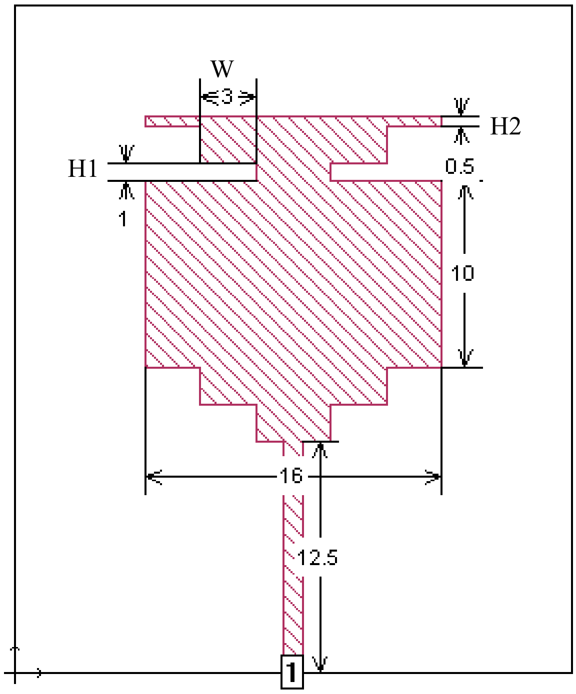

Figure 1. Top view of the antenna. Dimensions are in mm.

Figure 3 shows the simulated result for the return loss of the optimized antenna. The parameter H1 for this antenna was 1 mm.

Table 1 shows variation of simulated results with the parameter H1, when all other parameters are fixed as shown in Figure 1. Note that, since all other parameters are fixed, changing H1, will change the total length of the antenna. Figure 4 shows the resulting antenna when H1 is set to zero. From Table 1, we observe that the return loss is better when H1 is 2, but the center frequency has changed.

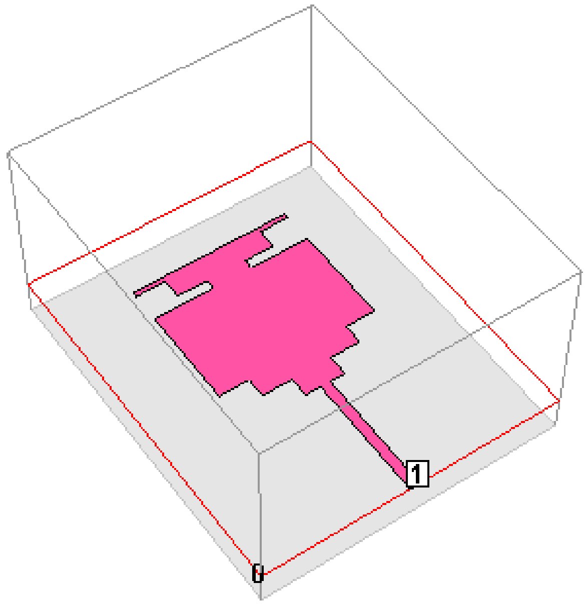

Figure 2. 3-D view of the antenna.

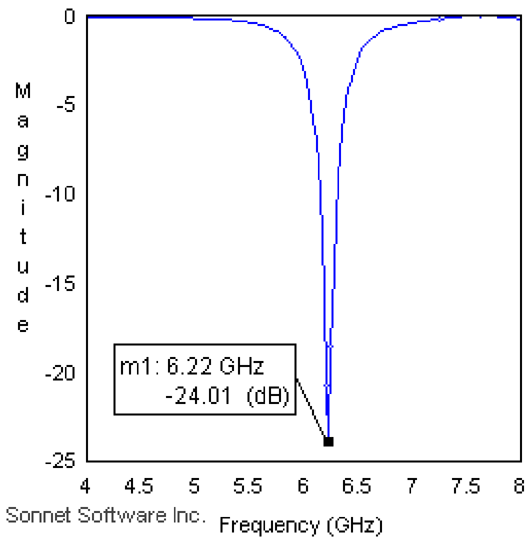

Figure 3. Return loss of the antenna.

Table1: Variations with the parameter H1.

H1	Zin	Fc	Gain	RL
0	73	6,94	7,4	14
0,5	60	6,46	8,5	20
1	**56**	**6,22**	**8,97**	**24**
1,5	53.5	6	9.05	26,5
2	50	5,78	9,17	35
2,5	47	5,58	9,2	26

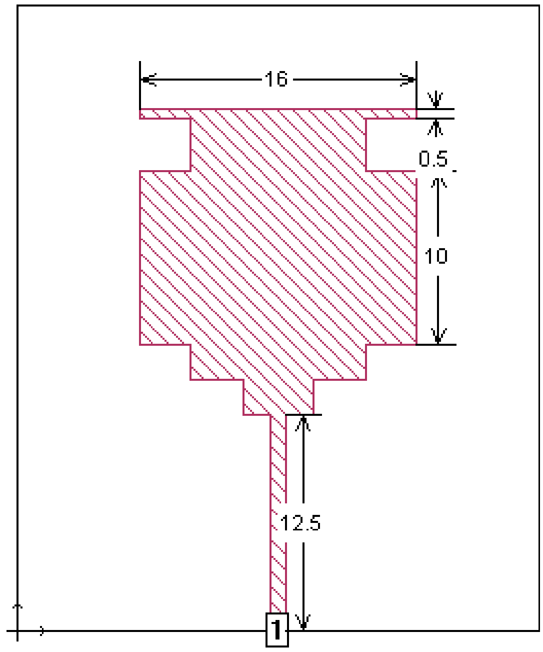

Figure 4. Shape of the patch when H1 = 0.

Table 2 shows, the variations of simulated results with the parameter W, when all other parameters are fixed as in Figure 1. Note that, although changing W changes the shape of the antenna significantly, it does not change the overall length or the width of the antenna. Figure 5 shows the patch when W is set to zero. Again, from Table 2, we observe that the return loss is better when W is 4, but the desired center frequency has changed.

Table2: Variations with the parameter W.

W	Zin	Fc	Gain	RL
0	65	6,62	8,33	16
2	61	6,42	8,67	19,4
3	**56**	**6,22**	**8,97**	**24**
4	48	5,88	9,1	33,5
5 (max.)	60	7,82	7,05	20

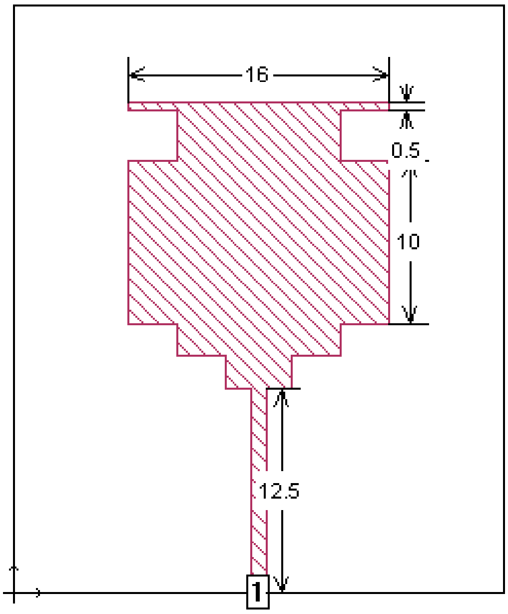

Figure 5. Shape of the patch when W = 0.

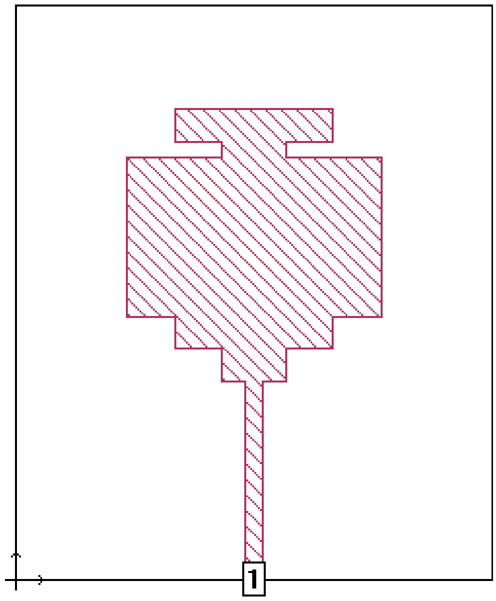

Figure 6. Shape of the patch when H2 = 0.

Table 3 shows variation of simulated results with the parameter H2, when all other parameters are fixed as shown in Figure 1. Note that, since all other parameters are fixed, changing H2, will change the total length of the antenna. Figure 6 shows the resulting antenna when H2 is set to zero. From Table 3, even though we observe that the return loss and the gain are better when H2 is 1, but the desired operating frequency has changed.

Table3: Variations with the parameter H2

H2	Zin	Fc	Gain	RL
0	84	6,8	7,6	14
0,5	**56**	**6,22**	**8,97**	**24**
1	50,1	5,96	9,15	31,5
1,5	46	5,74	9,28	27
2	43	5,56	9,33	21

Figure 7 shows the imaginary part of the input impedance. It is almost zero (0,53 Ω). The real part of the input impedance is 56.7 Ω, and shown on Figure 8.

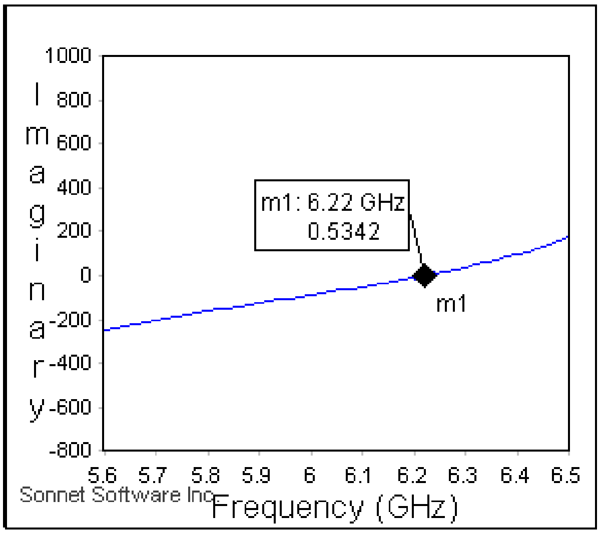

Figure 7. Imaginary part of the input impedance.

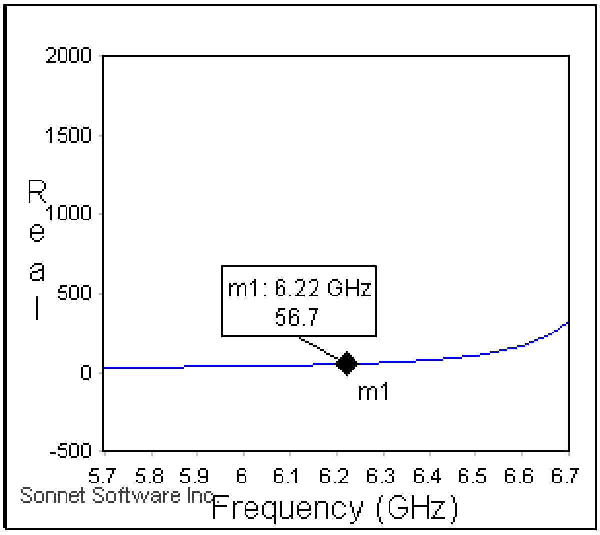

Figure 8. Real part of the input impedance.

Radiation pattern is seen on Figure 6. Main principal plane, E_{φ}, has almost 9 dB maximum gain.

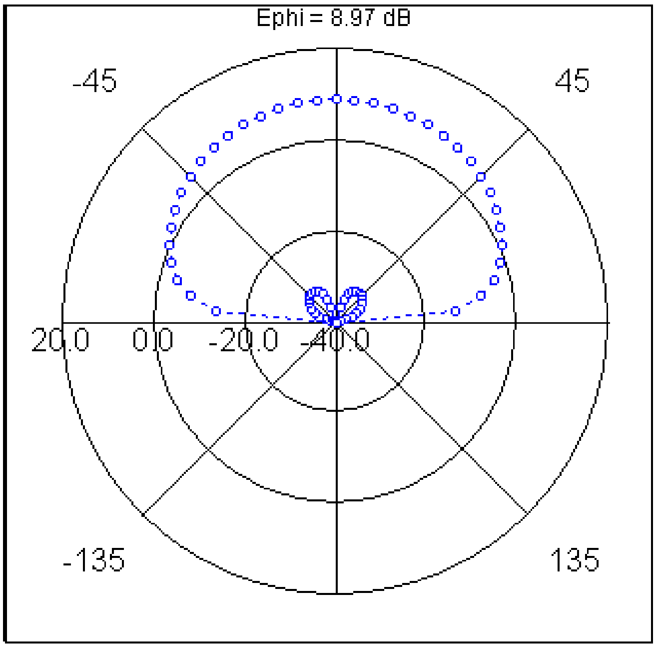

Figure 6. Radiation pattern.

Figure 7 shows that current on the antenna. It is clearly seen that the current is mostly crowded at the input feeding line and, at the edges of end sections, of the patch, where the multiple discontinuities are located.

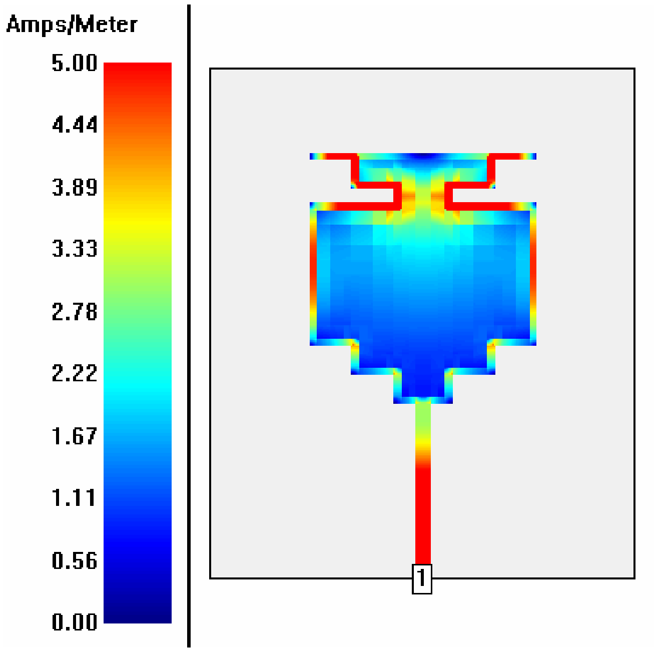

Figure 7. Current distribution on the antenna.

IV. EXPERIMENTAL RESULTS

Figure 8 has the return loss comparison of the measured and the simulated results. It proves the good agreement of the two results. Figure 9 shows the good agreement of simulated and the measured results of the radiation pattern of E_{φ}.

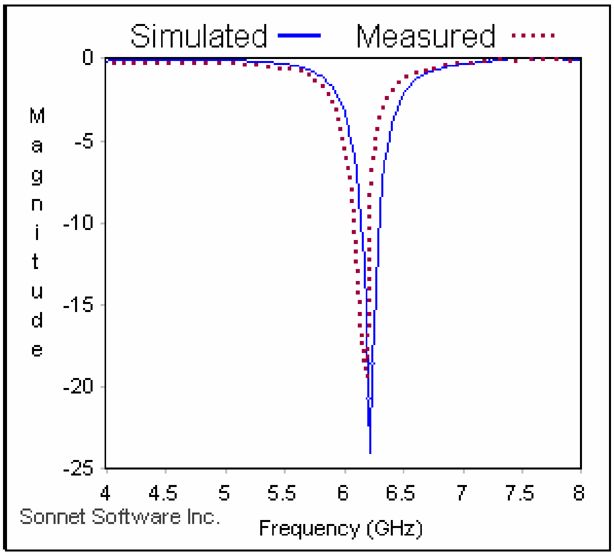

Figure 8. Return Loss of simulated and measured results.

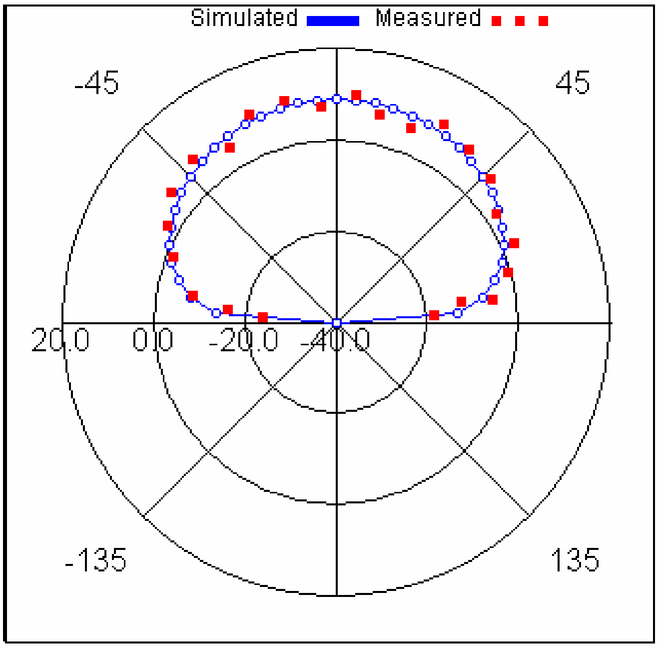

Figure 9. Simulated and measured results of E_{φ} .

V. CONCLUSION

In this work, a novel high frequency microstrip patch antenna is designed, simulated, built and tested. Design process is explained in detail. A parametric study of changing the shape of the patch is conducted. The essential contribution of the paper could be considered as forming multiple discontinuities on a conventional rectangular patch antenna such that, maintaining a symmetric, relatively high gain microstrip patch antenna. Experimental results verify the simulated results.

ACKNOWLEDGEMENT

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A quick view of the TLM Method

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The Transmission Line Matrix (TLM) method has become a widely used tool for full wave electromagnetic analysis. This efficient method belongs to the general class of differential time-domain (TD) numerical modeling methods. It has emerged as a key numerical method in computational electromagnetics for the modeling of complex electromagnetic structures (microstrip lines, RF MEMS, multi-layered planar active antenna …).

The TLM method is based on the analogy between the electromagnetic field and a mesh of transmission lines. In fact, the basic approach of the TLM method is to obtain a discrete model which is then solved exactly by numerical means. Approximations are only introduced at the discretization stage. This is to be contrasted with the traditional approach in which an idealized continuous model is first obtained and then this model is solved approximately.

As a network model of Maxwell’s equations formulated in terms of the scattering of impulses, it possesses exceptional versatility, numerical stability, robustness and isotropic wave properties.

Based on the accuracy and complexity of the modeling medium, one can use one-, two- or three-dimensional TLM modeling. Two dimensional TLM modeling is the most popular one as it can model most of the problems and is more efficient compared to three-dimensional TLM modeling.

For electromagnetic systems, the discrete model is formed by conceptually filling space with a network of transmission-lines in such a way that the voltage and current give information on the electric and magnetic fields. Space and time are discretized. The (three dimensional) space is subdivided in cells. Every TLM cell is represented by a twelve port node. At the faces of every cell the tangential electric and magnetic field components are sampled. The electromagnetic field is modeled by wave pulses propagating between adjacent cells and scattered within the cells. This yields in a simple case a total of twelve electric and twelve magnetic field components per cell. The discretized field state is represented by a state vector summarizing the states of all TLM cells.

The point at which the transmission-lines intersect is referred to as a node and the most commonly used node for 3D work is the symmetrical condensed node (SCN). The TLM algorithm consists of the propagation of the wave amplitudes from the mesh nodes to the neighboring nodes and the scattering of the wave amplitudes in the mesh nodes. At each timestep, voltage pulses are incident upon the node from each of the transmission-lines. These pulses are then scattered to produce a new set of pulses which become incident on adjacent nodes at the next timestep.

The relationship between the incident pulses and the scattered pulses is determined by the scattering matrix, which is set to be consistent with Maxwell's equations. Additional elements, such as transmission-line stubs, can be added to the node so that different material properties can be represented.

By one single computation of a pulse response a large amount of information is obtained. The versatility of the TLM method allows straight-forward calculation of complex structures.

The TLM method has been evolving for approximately forty years. Hybrid methods like one combining time-domain integral equations have been presented for the efficient modeling of shielding problems. Other papers discuss correction techniques, i.e. based on modification of cell impedance.

Originally developed to model electromagnetic systems, the TLM method, based on Huygens principle, has proven efficiency in modeling any phenomena which obeys this principle. Researchers showed that TLM can be used to model several types of physical systems and solve among others, diffusion problem, vibration, heat transfer, radar and electromagnetic compatibility (EMC).

Actually, most electromagnetic problems are complex and require large memory and computational time. Research work has shown that the TLM method may be parallelized to speed-up the computation and to distribute the memory requirements. Due to its time-domain intrinsic nature, domain decomposition can be applied here by splitting the TLM computational region into subregions, to perform the TLM algorithm inside each subregion independently of other subregions and to exchange the values on the boundaries common to the subregions.

The distributed TLM algorithm can be then implemented on Grid computing facilities. As recent advances in computing technology have brought massively parallel computing power to desktop PCs, massively parallel GPU based TLM algorithm has been reported also.

Fadi Khalil was born in Beirut, Lebanon, on March 1983. He received his BS degree in Electrical Engineering from the Lebanese University, Lebanon in 2005, and the MS degree in Modeling, Information and Systems, in 2006 from Toulouse University, France.
From November 2006 to November 2009, Fadi was working toward the PhD degree in Micro- and Nano-systems for wireless Communications Research Group at the Laboratory of Analysis and Architecture of Systems (LAAS-CNRS) in Toulouse, France, and where is actually working as a research scientist. His research interests include Computational Electromagnetics, modeling of complex (multi-scale) structures and reconfigurable circuits for RF and microwave applications, High Performance Computing, and Wireless Sensors Networks. Dr. Khalil is affiliated to ACES applied society, IEEE MTT (Microwave Theory and Techniques) Society and the IEEE AP (Antennas and Propagation). He is a regular review for the ACES Journal, PIER Journals, CLCAR Conferences and IJCIS Journal.

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The last word

In Science, it is when we take some interest in the great discoverers and their lives that it becomes endurable, and only when we begin to trace the development of ideas that it becomes fascinating.

James Clerk Maxwell