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A Parallel Electromagnetic Genetic-Algorithm Optimal Relevance for Patch Transmitter Design

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Abstract – A current trend in electronics technology is the emphasis on growingly stringent system requirements in both the commercial as well as military sectors, in addition to primary-taining low costs in manufacturing, operations and primary. For the military, the new paradigm shift is toward network-centric warfare, wherein a major emphasis is placed on the com-plex interaction flanked by the various information subsystems that comprise a complete military system. Hence, the desire is to obtain a system that is capable of reconnaissance, data analysis, ordnance control, messages, etc., all in a real-time setting via an ad hoc virtual network.

Keywords: Genetic-Algorithm, Electromagnetic, Patch Transmitter

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INTRODUCTION

Transmitter designs for both ground-and airborne-based subsystems present a unique challenge, in that they should be as simple as possible and low-cost while at the same time satisfying the particular electrical requirements. In the commercial do primary, the expansion of Wireless Fidelity [WiFi] Internet access systems [IEEE 802.11b], 2.5 G and 3 G wireless technology, broadband cellular technology that han-dles high-rate voice and data, etc., has also placed a significant burden on the design of low-cost transmitters that achieve quite re-markable specifications in terms of band size, gain, multiband operation, and physical [e.g., size] constraints.

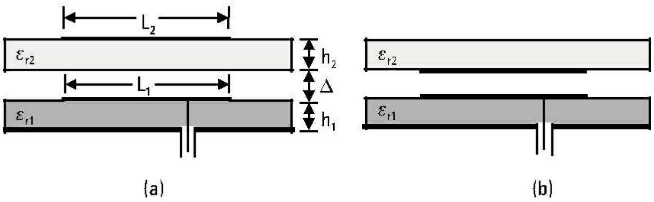
As a result, designers have had to turn to ever-more inge-nious techniques to achieve these goals. A technique that has be-come quite popular over the last several years has been the use of evolutionary optimal strategies for electromagnetic de-sign. In particular, the use of genetic algorithms [GA] has ex-ploded onto the research scene with great success, predomi-nantly due to its particular characteristics that make it an ideal tool that marries quite well with existing EM analysis tech-niques, and typically yields results that satisfy the given requirements in a nonintuitive fashion. A great deal of effort has already been expended in furthering both the computational maturity of GA optimal in electromagnetic, as well as in extending the do primary of relevance's to include quite ingenious designs. Two distinct focus areas in which GA optimal has yielded quite fruitful results are novel pat-tern synthesis [1-2] and broadband [or multiband] opera-tion. Another area in which the use of GA designs shows promise is the expansion of "smart" transmitters.

REVIEW OF LITERATURES:

In this study, we describe an electromagnetic GA optimization [EGO] relevance [introduced in [3]] that has been developed for the cluster supercomputing platform, and is thus quite powerful and apropos for today's tough transmitter design problems. A representative patch transmitter design example for commercial relevance's is detailed, which illustrates the versatility and applicability of the technique. We show that EGO allows us to combine the *accuracy* of full-wave EM analysis with the *robust-ness* of GA optimal and the *speed* of a parallel computing algorithm. In Part II, the EGO relevance software architec-ture proposed in [6] is presented in greater detail, i.e., the EM analysis procedure and parallel infrastructure is fully developed. In particular, we present a more in-depth expansion of the par-allel relevance architecture. The single-program multiple data model is in essence a key feature that allows us to use the more accurate full-wave technique of moments [MoM] simulations in conjunction with the evolutionary optimal approach. We also provide a more detailed treatment of Attribute extraction steps required by the GA's fitness function after the MoM solu-tion has been computed. Although not explicitly made use of in the present study, Part II-A describes a more general func-tionality implicit in EGO for the design of N-port guided-wave and radiating structures. Part III then presents a detailed rep-resentative patch transmitter design case study. We illustrate the use of EGO to design a dual-band linearly polarized transmitter el-ement for wireless message [1.9 and 2.4 GHz] applica-tions. The resulting transmitter exhibits acceptable dual-band op-eration [i.e., better than 10 dB return loss with 5.3% and 7% operating band sizes at 1.9 and 2.4 GHz, and 5 dB rejection flanked by bands] while primarytaining a cross-pol maximum field level at least 11 dB below the co-pol maximum[4-5].

ELECTROMAGNETICALLY COUPLED MSAS

Two implementations of an ECMSA are shown in below Figure. The bottom patch is fed with a coaxial line, and the top parasitic patch is excited due to electromagnetic coupling with the bottom patch. The patches can be fabricated on different substrates, and an air gap or foam substance can be introduced flanked by these layers to increase the BW.



In the normal implementation, as shown in Figure [a], the parasitic patch is on the upper side of the substrate. In the inverted implementation shown in Figure [b], the top patch is on the bottom side of the upper substrate. In this case, the top dielectric layer also acts as a protective layer from the environment. The transmitter dimensions are optimized so that the resonance frequencies of the two patches are close to each other to yield broad BW. This concept is applicable to any arbitrary shaped patch. The ECMSAs with two to three layers of micro strip patches [rectangular, circular, and triangular] provide an impedance BW of 10–30% for VSWR ≤ 2 [6–9]. The increase in the BW is obtained due to an increase in the overall height of the transmitter, a decrease in the effective dielectric constant e_e [if an air or foam substrate is inserted in flanked by the two patches], and the multiresonator effect.

Instead of feeding the bottom patch, the top patch can be fed by coaxial probe, which passes through the bottom patch. The bottom patch is not directly connected with the probe; instead a small hole is made around the feed. It gets excited through the electromagnetic coupling arising from the probe and the upper patch. This implementation does not offer any benefit as compared to the implementations given in Figure, so it is not discussed in detail.

➢ **Micro strip Line Feed ECMSAs**

Besides the two-layer-stacked ECMSA implementations discussed above, electromagnetic coupling is also used to excite the patch on the top layer through the micro strip line feed in the bottom layer as shown in Figure.

Figure: Electromagnetically coupled MSA with feed connected to top patch.

This implementation has the benefit that the micro strip feed line could be fabricated on a thin high dielectric constant substrate, so that emission from the feed is negligible and the top patch can be fabricated on a thick substrate with a low dielectric constant [or suspended implementation] for a large BW. Also, there is no direct connection flanked by the feed and the patch. A small misalignment flanked by the patch and the feed, unlike in the case of coaxial feed where it is very critical, does not change the characteristics of the transmitter as described below.

CONCLUSION:

An exploded 3-D view of square and circular patches that are electro-magnetically fed with a micro strip. The length of the square patch is *L* and the radius of the circular patch is *a*. The micro strip line is fabricated on a dielectric substrate with a dielectric constant $e_{r\ 1}$ and thickness h_1, and the radiating patch is fabricated on a substrate with a dielectric constant $e_{r\ 2}$ and thickness h_2. Generally, $e_{r\ 1}$ is chosen to be greater than or equal to $e_{r\ 2}$, and h_1 is taken smaller than or equal to h_2, so that the emission from the micro strip line is small. Even for $h_1 = h_2$, the top patch sees the ground plane at a height of $H = h_1$ □ h_2, so the emission from the patch will be more than that from the micro strip line. The theoretical results obtained using the MoM for various patch dimensions and substrate Attributes are summarized below.

For $e_{r\ 1} = e_{r\ 2}$ and $h_1 = h_2$, the variations of percentage BW for VSWR ≤ 2 and efficiency *h* with a normalized total substrate thickness [*H* /*l* , where

$H = [h_1$ □ $h_2]$ and $l = l_0 / \sqrt{e_{r\ 1}}$] for three values of $e_{r\ 1}$ [1.1, 2.55, and 10.5] are elaborated. These curves are valid for both square and circular ECMSA, because both percentage BW and *h* of the transmitter depend on the substrate Attributes. As e_r or *H* /*l* increases, percentage BW increases but *h* decreases. A BW of 20% is obtained for $e_{r\ 1} = e_{r\ 2} =$ 1.1 and $H / l = 0.13$.

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