MINIATURIZED EMBEDDED-CIRCUIT METAMATERIALS FOR ANTENNA ARRAYS DESIGN: CONCEPT AND CHARACTERIZATION

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Patch antennas have found numerous applications in wireless systems for their simplicity in fabrication, compatibility with planar circuitry, low profile and planar structures, and unidirectional radiation capability. Despite many nice electrical and mechanical features of microstrip antennas, their use for a number of applications has been limited due to the limitation in bandwidth and/or size. The size of a patch antenna can be miniaturized by printing the antenna on a high dielectric substrate, however the high permittivity material increases the coupling between the antenna and its ground plane and reduces the antenna bandwidth. The bandwidth can be increased with the use of a thicker substrate, but the high dielectric-thick substrate generates surface wave that drastically degrades the antenna performance. This effect is more dominant when the patch is used as an element of a compact antenna array design.

To improve the bandwidth of patch array antennas without increasing the element size or array spacing an approach must be developed that should allow substrate thickness increase at the same time suppress the mode transition to surface waves. To accomplish this we propose using of resonant Embedded-Circuit Metamaterials (ECM) as the isolators printed between the array elements in order to remarkably suppress the surface waves. The resonant ECM are constructed of miniaturized loop circuits terminated to the loading capacitors. Above the resonance frequency of the loops the metamaterial shows a negative effective permeability which is responsible for determining the stop-band characteristic. Note that compared to the previously proposed structures for suppression the surface waves, designed based on the dielectric and metallo-dielectric band-gaps, the ECM has a much smaller size and one can use only one layer to significantly stop the surface waves.

A Finite Difference Time Domain (FDTD) technique with Periodic Boundary Conditions/Perfectly Matched Layers (PBC/PML) walls is applied to comprehensively characterize the ECM and highlight their superior advantages for the design of high performance antenna arrays.

Abstract Submission Form

2004 National Radio Science Meeting

Abstract: mosallaei8227

Date Received: September 22, 2004

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