Configurations for DPS-DNG Loading in Rectangular Microstrip Patch Antenna for size reduction

Aparna Limaye*, Jayanti Venkataraman, **Rochester Institute of Technology, NY**

Double positive and double negative materials, as a combination (DPS-DNG), are being investigated to utilize their promising properties like phase compensation, infinite bandwidths and zeroth order resonance, in various devices. Of these devices, a size reduction for the microstrip patch antenna with a DPS-DNG substrate is of considerable interest. However, there have been concerns about the radiation efficiency of such a microstrip antenna. The DPS-DNG substrate rectangular patch antenna has been recently analyzed using a transmission line (TL) model and theoretical formulations for a circular patch antenna using a cavity model has been established. The 1-D cavity resonator with DPS-DNG media has been investigated previously (N. Engheta, IEEE AWPL, 1, 10-13, 2002) and is used as basis for the present investigation.

The present work investigates the rectangular microstrip patch antenna with DPS-DNG substrate for two configurations where the DPS-DNG interface is parallel to the radiating edge (Fig 1a) and the DPS-DNG interface is normal to the radiating edge (Fig 1b). The cavity model with two electric walls (PEC) and four magnetic walls (PMC) is used and the modes that can exist are derived for each configuration. In addition, the work proceeds to investigate the effect of feed locations and types, to determine the feasibility of creating an effective radiator. Also, the phase compensation phenomenon in the DPS-DNG substrate is investigated in order to satisfy the condition of π-phase reversal between the radiating edges of the rectangular patch.

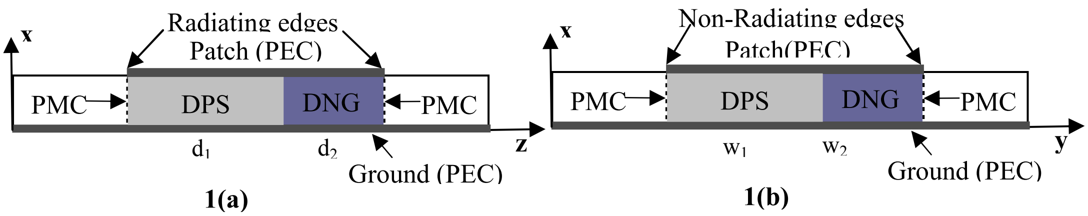

Figure 1: DPS-DNG substrate for a rectangular patch antenna
(a) DPS-DNG interface parallel to radiating edge (b) DPS-DNG interface normal to radiating edge

In both configurations, the set of TE and TM modes that can exist have been obtained. Unlike the conventional microstrip patch antenna, the modes in the above configurations are TE/TM oriented normal to the substrate interface. In the first configuration the mode that satisfies the transcendental equation for the 'electrically-small size condition' is TM^z, while in the second configuration it is TM^y. This leads to a size reduction in the non-radiating edge length $(d_1+d_2) << \lambda/2$ in Fig.1a and a size reduction in the radiating edge length $(w_1+w_2) << \lambda/2$ in Fig.1b. This is consistent with the DPS-DNG microstrip antenna analysis using the TL model done by other researchers. The following transcendental equations have been derived for the two configurations:

Interface parallel to the radiating edges (Fig.1a): $$\frac{\beta_{z1}}{|\varepsilon_1|}\tan\beta_{z2}d_2 = \frac{\beta_{z2}}{|\varepsilon_2|}\tan\beta_{z1}d_1$$

Interface normal to the radiating edges (Fig.1b): $$\frac{\beta_{y1}}{|\varepsilon_1|}\tan\beta_{y2}W_2 = \frac{\beta_{y2}}{|\varepsilon_2|}\tan\beta_{y1}W_1$$

Where, β_{y1}, β_{y2} and β_{z1}, β_{z2} are the propagation constants in the y and z directions respectively for the two regions and $\varepsilon_2 = -|\varepsilon_2|$. In both cases, the transcendental equation, for electrically small dimensions, simplifies to the ratio of the permittivities for the two media:

$$\frac{d_1}{d_2} = \frac{|\varepsilon_2|}{|\varepsilon_1|} \quad \text{and} \quad \frac{w_1}{w_2} = \frac{|\varepsilon_2|}{|\varepsilon_1|}$$

Resonant frequency, feed locations and input impedance for such a patch are also investigated.