

## Left-handed wire antennas over ground plane with wideband tuning

F.J. Herraiz-Martínez, P.S. Hall, Q. Liu, D. Segovia-Vargas

**Abstract**— Tunable left-handed (LH) wire antennas over a ground plane are presented in this paper. These antennas are small and have a wide tuning bandwidth and are matched to  $50 \Omega$  within the operation range. Two kinds of antennas have been developed: the monopole antenna and the half-loop antenna over ground plane. In both cases, the antennas are designed, manufactured and measured at fixed frequencies as a first step. After that, a study to replace some LH components with variable capacitors has been carried out for each antenna. Tunability over a wide bandwidth has been achieved. Finally, some prototypes of both antennas have been manufactured and measured. The tunable LH monopole antenna has been measured showing a monopolar radiation pattern with a 28% tuning bandwidth (695-924 MHz). Its radiation efficiency takes values between 50% and 70% within all the tuning bandwidth and the maximum dimension varies only between  $0.11\lambda_0$  at 695 MHz and  $0.15\lambda_0$  at 924 MHz. The tunable LH half-loop antenna over a ground plane has a radiation pattern with maximum radiation orthogonal to the ground plane. It has a 1.64:1 measured tuning bandwidth properly matched to  $50 \Omega$  (considering  $|s_{11}| < -10$  dB). Its measured radiation efficiency is always above 54% within the working bandwidth.

**Index Terms**— Left-handed materials, loop antenna, monopole antenna, reconfigurable antennas, tunable antennas.

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