High Gain Circular Microstrip Antennas using TM_{1m} Modes

Prateek Juyal* and Lotfollah Shafai
Department of Electrical & Computer Engineering, University of Manitoba,
Winnipeg, Manitoba, Canada R3T 5V6

High gain patch antennas are desirable for many applications. For patch antennas printed on common material substrate and operating in the fundamental mode, the gain is limited to a maximum of about 7.5dBi. High gain is achieved via array configurations or by superstrate loading. Array design involves complicated feed network, which introduces losses. Superstrates, which usually uses high dielectric constant material or more recently partially reflective surfaces (PRS), can be used for gain enhancement but at the cost of increased antenna height. Also, moderately high gain values limited to a maximum of 11-12dBi can be achieved via stacked patch configurations. Among the basic patch shapes, solid circular disc has been extensively studied in the past. Its low gain is inherently due to the fundamental mode (TM_{11}) of operation. By operating the disc in higher zeros of order 1 mode i.e. TM_{1m} modes, where m is the electric field variation along the radial direction, higher broadside gain is expected, due to increase in electrical size of the radiating patch. But, TM_{1m} ($m \neq 1$) modes are avoided in literature, due to the high sidelobelevel in the E-plane of radiation patterns, which make them unfit for various applications. As m increases, the number of sidelobes increases and the main beam contracts.

In this paper we propose a novel method to design high gain circular disc antennas, which involves the use of TM_{1m} modes. This method is based upon the radiated far field superposition of TM_{1m} modes to achieve higher gain, with reduced sidelobe level. The method uses the stacked configuration, in which the circular discs are designed to operate in one of the TM_{1m} modes. Circular discs, either having odd or even value of m are stacked for different antenna configurations. For example, TM_{11} and TM_{13} discs are stacked to have one antenna or another with TM_{12} and TM_{14} stacked. The higher gain is due to the in phase radiation in the main beam, and the side-lobe cancellation is due to out of phase radiation. To validate the method, two probe fed stacked antenna configurations, having a broadside gain of 13.8dBi (TM_{11} & TM_{13}) and 14.8dBi (TM_{12} & TM_{14}) are designed. Both antenna configurations have different impedance and radiation properties. The detail of the study and the effect of all parameters, such as the dielectric constant and the effect of the substrate thicknesses will be provided in the presentation. The issues related to proper mode excitation will also be discussed.