Analysis of Dimensional Invariance in U-Slot Microstrip Patch via Segmentation Method

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Extended Abstract

Frequency independent or self complementary antennas have constant input impedance, independent of their geometrical configuration [1],[2]. For symmetrically located U-Slot microstrip patch, the dimensional invariance method (DI) has been shown to produce wideband designs [3] for symmetrically located U-Slots. This unique feature of the DI technique remains unexplored.

Segmentation method can be effectively used to analyse DI method because it divides the U-Slot patch into simpler regular rectangular segments for which the Green’s functions are known [4]–[6]. It provides flexibility to analyze symmetrically and asymmetrically located U-Slots by varying the dimensions of the rectangular segments. The quantity $Z_{pq}$ for a U-Slot’s rectangular segment of sides $(a,b)$ and with ports $p$ and $q$ on the same side reads as [5]

$$Z_{pq} = j\omega\mu\varepsilon \left[ -\cot(\alpha k) + \frac{2ab}{W_p W_q} \sum_{n=1}^{\infty} \left( \frac{\sin(n\theta_1) - \sin(n\theta_2)}{n^2 - n^2} \sin(n\theta_3) - \sin(n\theta_4) \right) \right],$$

(1)

where $\theta_1 = \pi b(y_p + W_p^2)$, $\theta_2 = \pi b(y_p - W_p^2)$, $\theta_3 = \pi (y_q + W_q^2)$, $\theta_4 = \pi (y_q + W_q^2)$, $B = \frac{bk}{\pi}$, and the wavenumber in the dielectric is defined as

$$k^2 = \omega^2 \mu\varepsilon (1 - j\frac{Q}{Q_T}).$$

(2)

The terms in (1) and (2) are all defined explicitly in [5] and are omitted here for brevity. The total quality factor $Q_T$ in (2) is given by [7, p. 280, Eq. (4.64)]:

$$\frac{1}{Q_T} = \frac{1}{Q_{sp}} + \frac{1}{Q_c} + \frac{1}{Q_{sw}} + \frac{1}{Q_d}.$$  

(3)

In [6] the surface wave power and hence $Q_{sw}$ in (3) was omitted, implying that the results are valid for electrically thin substrates. Since wideband behavior in microstrip antennas is observed for electrically thicker substrates [7, p. 288, Fig. 4-16], the input impedance of the probe-fed U-Slot needs to be recalculated considering both surface ($Q_{sw}$) and space ($Q_{sp}$) wave powers in (1)–(3).

Parametric study of both symmetric and asymmetric U-Slots via the segmentation technique, followed by a full-wave characteristic mode analysis [3], is expected to reveal the nature of the dimensional invariance method. The results are currently in progress for future presentation.

References