Design of dual-band slot antenna with double T-match stubs

Y.-C. Lin and K.-J. Hung

A simple and compact design of dual-band slot antenna is presented. Fed by a CPW, the antenna is printed on a single-layer PCB with extremely low manufacturing cost. A pair of T-match stubs is employed to generate the dual resonances in the 2.4–2.5 and 5–6 GHz bands. The antenna of small radiating area $11 \times 28 \text{ mm}^2$ is demonstrated on an FR4 PCB with ground plane size of $31 \times 35 \text{ mm}^2$. Robust radiation performances are achieved, including in-band gain flatness within $\pm 0.5 \text{ dB}$ and polarisation isolation better than 15 dB. Consistent radiation patterns for both bands are obtained with peak gains about 3 and 4 dBi in the lower and upper bands, respectively.

Introduction: Design of dual-band and multi-band antennas has gained increasing demands in modern wireless communication systems in which the backward compatibility and the roaming capability among multi-standards are required. For instance, the antenna is preferably designed in 2.4–2.5 and 5–6 GHz bands to meet the standards of IEEE 802.11a/b/g in WLAN systems.

Compared to other transmission line structures, antennas designed with CPW feed have many advantages, including the simple configuration of a single metallic layer, the elimination of complex inter-connection with via and solder pads, less coupling with nearby RF components, and ease of integration with active MMIC devices. Hence, the CPW-fed structure is selected and incorporated in the design of the proposed antenna.

In general, the design goals of dual-band antennas in wireless consumer products include low cost, compact size, sufficient impedance bandwidth, high efficiency, omnidirectional patterns, flat gain in the band, low cross-polarisation of radiation patterns, and consistent performances for both bands. Several types of dual-band antenna have been presented in the recent literature, including the monopole with notch [1], the folded monopole [2], and the rectangular aperture [3] and slot loop [4]. However, these antenna designs may satisfy only some of the aforementioned goals while experiencing trade-offs of the others. In this Letter, a robust design of a dual-band slot antenna using double T-match stubs is proposed, aiming to achieve these goals simultaneously.

Fig. 1 Antenna geometry

Antenna design: Fig. 1 shows the geometry and configuration of the proposed dual-band slot antenna. The antenna is designed on a single-layer PCB substrate with dielectric constant ϵ_r , loss tangent $\tan \delta$ and thickness h . A 50Ω CPW transmission line of strip width S and gap G is employed as a feed to the antenna. The open-ended T-match stub of length T and width W_s is devised to perform sufficient bandwidth for the input impedance matching [5, 6]. By adding an extra T-match stub connected to the upper ground, the dual-band resonances of the antenna are generated while keeping good impedance bandwidths and stable radiation characteristics. The effective length of the slot loop is then divided by the T-match pair with the inner circumference designed as λ_g for the lower-band resonances and the outer circumference about $2\lambda_g$ for the upper-band resonances.

The design of the proposed antenna is performed with a commercial electromagnetic tool [7]. The prototype antenna is illustrated on a low-cost FR4 substrate with dielectric constant $\epsilon_r = 4.3$, loss $\tan \delta = 0.02$ and thickness $h = 1.6 \text{ mm}$. The overall ground plane size of the prototype antenna is $31 \times 35 \text{ mm}^2$. The dimensions of other parameters are determined with the optimal performances in terms of the impedance bandwidths and radiation characteristics. The final dimensions are obtained as follows: $S = 3.6 \text{ mm}$, $G = 0.4 \text{ mm}$, $G_{in} = 1 \text{ mm}$, $G_{out} = 1.25 \text{ mm}$, $W_s = 0.5 \text{ mm}$, $T = 19 \text{ mm}$, $L = 28 \text{ mm}$, and $W = 11 \text{ mm}$.

Fig. 2 Measured and simulated return loss of proposed antenna

Fig. 3 Measured radiation patterns at 2.45 GHz

a E-plane (y-z plane) b H-plane (x-z plane)
----- co-polarisation
— cross-polarisation

Fig. 4 Measured radiation patterns at 5.2 GHz

a E-plane (y-z plane) b H-plane (x-z plane)
----- co-polarisation
— cross-polarisation

Fig. 5 Measured gain spectrum of proposed antenna

a 2.35–2.55 GHz b 5.0–6.0 GHz

Results and discussion: Fig. 2 shows the simulated and measured input return losses. Good agreement between simulation and measurement results is achieved. The 10 dB return loss bandwidths are measured from 2.32 to 2.50 GHz in the lower band and 4.78 to 6.85 GHz in the upper band, both exceeding the requirements of IEEE 802.11a/b/g spec. Figs. 3a and b show the normalised radiation patterns of E-plane (y - z plane) and H-plane (x - z plane), respectively, measured at 2.45 GHz. As expected, the E-plane patterns are bidirectional like a dipole and the H-plane patterns are nearly omnidirectional. It is emphasised that cross-polarisation is significantly suppressed down to the level below 15 dB in this design, which mainly results from the symmetry of the antenna geometry. Fig. 4 shows the measured radiation patterns at 5.2 GHz. Similar to the lower-band performances, the dipole-like patterns and low cross-polarised patterns are achieved, meaning good consistency for both bands. The spectrum of the peak gain is measured as around 3 dB in the lower band (2.35–2.55 GHz) and 4 dB in the upper band (5.0–6.0 GHz), as shown in Figs. 5a and b, respectively. The Figures show that the antenna gain is stable and in-band gain flatness is only within ± 0.5 dB for both bands. In practice, the stable in-band antenna gain and consistent gain patterns in the two operation bands are desired in real applications of dual-band WLAN systems.

Conclusions: A dual-band CPW-fed slot antenna has been designed, built and measured. The proposed antenna performs the exceeding impedance bandwidths and stable antenna gains in both bands. Using the symmetric double T-match stubs as feeding structures, the design may significantly suppress the cross-polarisation level, a common problem existing in dual-band antenna design. The proposed antenna is cost-effective, simple, compact, and the dual-band design has stable gain and low cross-polarisation in both bands. These features make the proposed antenna robust and suitable for applications of any dual-band wireless communication system.

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