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An Ultrawideband Patch Antenna for UHF Detection of Partial Discharge

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The location of partial discharge (PD) sources by free-space UHF detection is an attractive approach for condition monitoring of high voltage equipment in substations. A low-cost, radiometric, PD wireless sensor network (WSN) has been proposed to provide continuous real-time coverage for an entire substation (J.M. Neto, Y. Zhang, A. Jaber, M. Zhu, M. Judd, R. Atkinson, J. Soraghan, J.S. Neto, M.F. Vieira, I.A. Glover, *2014 XXXIth URSI General Assembly and Scientific Symposium* (URSI GASS), Beijing, 16 - 23 Aug. 2014, pp.1-4). A suggested band for UHF PD detection is 0.3 - 1.5 GHz (Z. Tang, C. Li, X. Cheng, W. Wang, J. Li, *IEEE Trans. Dielectr. Electr. Insul.*, 6, 2006, pp. 1193–1199). A novel ultrawideband (UWB) printed monopole antenna is presented here for PD WSN applications.

Fig. 1 shows the configuration of the proposed antenna and a constructed prototype. It is constructed on FR4 substrate with thickness 1.6 mm and relative dielectric constant of 4.4. The width of the 50 Ω microstrip feed (W_2) is 3 mm. The antenna is compact (dimensions 24 cm × 20 cm). The optimised parameters are L_1 = 50 mm, L_2 = 6 mm, L_3 = 2 mm, L_4 = 43 mm, L_5 = 90 mm, W_1 = 64 mm, W_2 = 3 mm, W_3 = 16 mm, W_4 = 50 mm, W_5 = 68 mm, h = 1.6 mm. The impedance bandwidth is enhanced by the two steps (L_4×W_3) and bevelled shoulders (W_4). The slotted ground plane with a rectangular notch, (L_2-L_3) ×W_1, and the offset L3 between the radiating patch and ground plane are for impedance matching. Adjusting the latter controls coupling between the lower edge of the patch and ground plane. The low frequency limit is determined by the total effective length of the antenna current which includes the patch and ground plane.

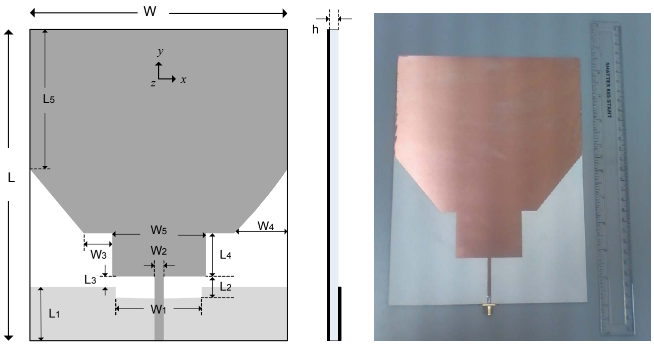

Fig. 1 *Antenna configuration and constructed prototype*

The bandwidth of a UWB antenna can be achieved by overlapping several adjacent resonances, each one represented by a parallel equivalent circuit. The proposed antenna structure is simulated using CST Microwave Studio. Fig. 2 shows the measured and simulated return loss. -10 dB return loss (S11) is achieved from 0.35 to 1.37 GHz. The three resonances (most obvious in the simulated S11) are due to the three serial discontinuities moving from the feed line along the antenna. Fig. 3 shows the simulated far-field radiation pattern at 0.75 GHz. The peak directivity is 4.3 dBi. At this frequency the antenna has an approximately omnidirectional H-plane pattern but with maximum gain directed approximately 24 degrees offset from the x-z plane. The E-plane pattern is similar to that of a monopole antenna but with slightly greater gain in the y-z plane compared to the x-y plane.

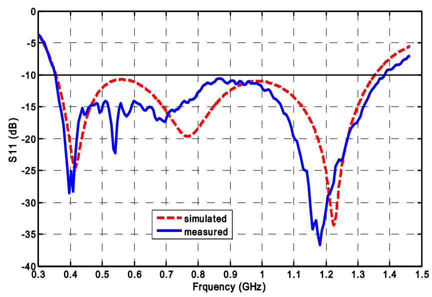

Fig. 2 *Simulated and measured return loss*

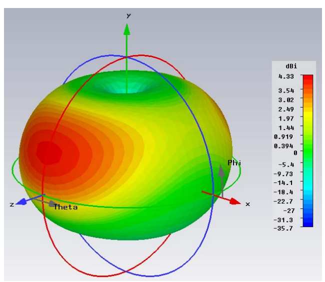

Fig. 3 *Radiation pattern at 0.75 GHz*