Quasi-Isotropic X-Band Inverted-F Antenna for Active RFID Tags

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Abstract—An X-band (10.5 GHz) inverted-F antenna (IFA) for an active radio frequency identification (RFID) tag is presented. The antenna consists of two parts. One part comprises a driven monopole and a ground plane. The second part is a metal casing mounted on the ground plane to provide enclosed space for housing the electronics of the tag. The antenna was studied by means of both numerical simulations and measurements. The numerical simulations reveal that the radiation pattern of the antenna is quasi-isotropic. They also show that the −10-dB return loss bandwidth of the antenna is nearly 15%. This predicted antenna bandwidth value has been confirmed by experimental measurement.

Index Terms—Active radio frequency identification (RFID) tag, active tag antenna, directive gain, inverted-F antenna (IFA), quasi-isotropic radiation pattern.

I. INTRODUCTION

Radio frequency identification (RFID) is a rapidly developing wireless technology that uses radio frequencies, from low ones up to millimeter waves, for automatic identification of objects [1]–[4]. In some applications, the tag antenna should not only be compact and inexpensive, but also quasi-isotropic so as to ensure communications between the reader and the tag (tags) for all positions of the target object (objects). The tag antenna must also be sufficiently wideband to help avoid the influence of the environmental changes. In this letter, we propose a quasi-isotropic inverted-F antenna (IFA) for an active tag of a long-range X-band (10.5 GHz) RFID system in which the orientation of the reader antenna on the tag (tags) mounted on the identifiable object (objects) may be arbitrary.

The antenna consists of two parts. One part comprises a driven monopole and a ground plane, which are printed on a dielectric substrate. The second part is a metal casing mounted on the ground plane to provide enclosed space for housing the electronics of the tag. Like the radiated fields of other IFAs [5], the field radiated by the proposed antenna possesses two orthogonally polarized components. By changing the dimensions of the antenna, these components can be adjusted, as was done in the case of wire antennas in [6]–[8], to yield not only omnidirectional but also quasi-isotropic radiation pattern. Having a quasi-isotropic radiation pattern is highly desirable, especially in applications in which the orientation of the tag relative to the reader antenna may be arbitrary.

The antenna was simulated by using the commercial CST Microwave Studio software. The antenna has also been fabricated, and its return loss was measured by using an Agilent N5230A network analyzer. The results of the simulation and measurement were found to be in good agreement.

II. ANTENNA STRUCTURE

The geometry of the proposed 10.5-GHz IFA is shown in Fig. 1. The antenna consists of two parts. One part comprises a driven monopole and a ground plane, which are printed on a Taconic TLY-5-0620 substrate (with the metal surface beneath the substrate etched away) of size 52 × 37 mm², relative permittivity εr = 2.2, and thickness of 1.6 mm. The second part is a metal casing mounted on the ground plane to provide enclosed space for housing the electronics of the tag. In the considered design, the driven monopole is of length l and is connected to a wide ledge in the upper edge of the ground plane. The width of the monopole is w, and the width of the slot between the monopole and the upper end of the ground plane is s. The casing mounted on the ground plane is made of thin brass sheet. As shown in Fig. 1, this casing is protruding from the plane of the printed antenna part.

The antenna is assumed to be fed by a 50-Ω coaxial cable (not shown in Fig. 1). The feed point A, to which the central conductor of the cable external end is connected, is located on the monopole at a distance d from the monopole base. The outer conductor of the cable is soldered to the ground plane at the point B just across from the feed point A.