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Auto-parking Control using Radio Frequency Identification (RFID)

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ABSTRACT

Over the last decade radio frequency identification (RFID) technology has grown at a formidable rate, thereby creating new and improved service at lower cost. This is resulted in an increasing number of users and different applications such as an auto parking. Simulations on MATLAB environment are carried before actual implementation, especially when RFID is used in regions in which strict regulations and standards must be adhered to. The simulation is focused on reader side. A simple wireless channel and a simple reflection model of tag are used for evaluating the performance of reader and tag with respect to distance and transmit power.

Keywords: *Radio Frequency Identification, Auto Parking, Reader and Tag, Wireless Technology.*

1. INTRODUCTION

Radio frequency identification (RFID) has received much attention since it has been discovered that RFID can lead to fully automated item identification. This new technology started to be used in library management system and has slowly begun to replace the traditional barcodes [1-4] on library items. In this paper the radio frequency identification (RFID) technology is going to be used in auto parking. The RFID system composed of a reader which emits radio signals to activate the transponder and identify the data encoded on it, and then issuing signal to the interfaced hardware for activation. Therefore, RFID system can be divided into two parts, readers and tags. Generally, an RFID system contains several readers and a large amount of tags in practical application. The sliding gate control circuit consists of, induction motor, relays, contactors and limit switches. The collision problems of both tags and readers are resolved in the arithmetic and MAC protocol [5, 6]. For a simple analysis, a single reader and a single tag bi-directional communication can be investigated to reveal the physical parameters. The communication link is half duplex, reader to tag and then tag to reader. In forward link, reader sends a modulated carrier to powers up the tags. The tags arbitrate their state and determine which tag responds to reader. In return link, reader sends a continuous wave carrier; tag receives the carrier for power supply and backscatters by changing the reflection coefficients of antenna. In such a way, data is sent to reader from tag. Readers should be designed to comply with the local frequency regulatory in transmitter.

2. RFID MODEL

The reader is installed near the sliding gate and the tag is attached on the windshield of the vehicle. The tag stores the vehicle number and its owner's information a prepaid account can be linked to it. When a vehicle's approaching the reading distance of the reader, the standby reader is activated to read vehicle tag information to check its validity according to the data stored in the host computer database. If the car is authorized, then the reader transmits the entry data back to host computer and trigger a command to start motor and the gate will travel forward to open position. When we want to give access to a vehicle that has no tag/transponder, the system has the capability of opening manually.

RFID system can be partitioned into three simple blocks reader, tag and wireless channel as shown in figure (1). The transmitter and receiver both are the front end of reader.

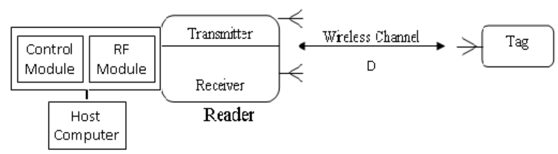

Figure (1): RFID Model [5]

The Friis transmission equation relates the power received to the power transmitted between two antennas separated by a distance $R > 2d^2/\lambda$, where d is the largest dimension of either antenna [7] and λ is the wave length. Assume that the transmitting antenna is initially isotropic. If the input power at the terminals of the transmitting antenna is P_t, then its isotropic power density W_0 at distance R from the antenna is**:**

$$W_0 = \eta_t \frac{P_t}{4\pi R^2} \qquad \text{.... (1)}$$

Where e_t is the radiation efficiency of the transmitting antenna.

Defining: Transmitting antenna and the receiving antenna parameters as: (P_t, G_t, D_t, Γ_t, ecd_t) and (P_r , G_r , Dr , Γ_r, ecd_r).

Where G the gains; D is directivity; Γ is the reflection coefficient for a non isotropic antenna, and ecd is conductivity and dielectric antenna radiation efficiency while suffice t, r indicate transmitter and receiver respectively. The power density in equation (1) in the direction θ_t, φ_t can be written as:

$$W_t = \frac{P_t G_t}{4\pi R^2}(\theta_t,\varphi_t) = \eta_t \frac{P_t D_t}{4\pi R^2}(\theta_t,\varphi_t) \quad \text{.... (2)}$$

Where; G_t (θ_t, φ_t) is the gain and D_t (θ_t, φ_t) is the directivity of the transmitting antenna in the direction θ_t, φ_t . Since the effective area A_r of the receiving antenna is related to its efficiency e_r and directivity D_r by

$$A_r = \eta_r D_r(\theta_r + \varphi_r)\frac{\lambda^2}{4\pi} \quad \text{.... (3)}$$

The amount of power P_r collected by the receiving antenna can be written, using (2) and (3) in the following equation:

$$W_t = \eta_t \eta_r \frac{\lambda^2 D_t(\theta_t,\varphi_t) D_r((\theta_t,\varphi_t))P_t}{(4\pi R)^2} \left|\hat{p}_t , \hat{p}_t\right| \quad \text{.... (4)}$$

Or the ratio of the received to the input power is:

$$\frac{P_r}{P_t} = \eta_t \eta_r \frac{\lambda^2 D_t(\theta_t,\varphi_t) D_r(\theta_t,\varphi_t)}{(4\pi R)^2} \quad \text{.... (5)}$$

The power received based on (5) assumes that the transmitting and receiving antennas are matched to their respective lines or loads (reflection efficiencies are unity) and the polarization of the receiving antenna is polarization matched to the impinging wave (polarization loss factor and polarization efficiency are unity). If these two factors are also included, then the ratio of the received to the input power in (5) is represented by:

$$\frac{Pr}{Pt} = ecdtecdr\left(1-|\Gamma_t|^2\right)\left(1-|\Gamma_r|^2\right)\left(\frac{\lambda}{4\pi R}\right)^2 D_t(\theta_t,\varphi_t) D_r(\theta_t,\varphi_t)\left|\hat{P}_t \cdot \hat{P}_r\right|^2$$

(6)

For reflection and polarization-matched antennas aligned for maximum directional radiation and reception, (6) reduces to:

$$\frac{Pr}{Pt} = \left(\frac{\lambda}{4\pi R}\right)^2 G_t G_r \quad \text{.... (7)}$$

$$\frac{P_r}{P_t} = \eta_{cdt}\eta_{cdr}(1-|\Gamma_t|^2)(1-|\Gamma_r|^2)\sigma\frac{D_t(\theta_t,\phi_t)D_r(\theta_r,\phi_r)}{4\pi}\left(\frac{\lambda}{4\pi R_1 R_2}\right)^2\left|\hat{\rho}_t \cdot \rho_r\right|^2$$

(8)

Equations (5), (6), (7) and (8) relate the power P_r (delivered to the receiver load) to the input power of the transmitting antenna P_t. The term $(\lambda/4\pi R)^2$ is called the free space loss factor.

3. SIMULATION RESULTS AND DISCUSSIONS

The simulation has been done using MATLAB M-file and the function used to invistigate the behaviour of RFID sniffer is base on radar reflection principle [7].

Figure (2) shows the relation between received power and range R_1 from transmitter to transponder with different values of R_2 range from reader to gate. The reader out of reach when R_2 at very far distance at approaching 10 meters. The reader must not be too far from the transponder. Pr is high as both distances are very small; it approaches 0 as reader is far from gate (Approx 10 meter).

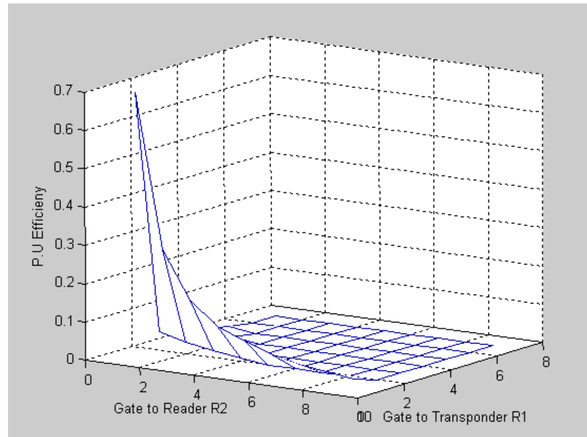

Figure (2): Relation between received power and R_1 with different values of range R_2.

Figure (3) illustrates the relation between received power P_r and range R_2 from gate to reader with different values of range R_1 from transponder to gate. The curve shows that the best location of R_2 is at 0.05 meter. Maximum power is achieved when R_1 in the nearest distance to the reader at 11 meters. The minimum value of received power at very far distance when R_1 = 19 meters. Indicate if the reader is too near to the gate, the tag can be detected from too far distance which makes the gate open even if the tagged vehicle is passing at the highway.

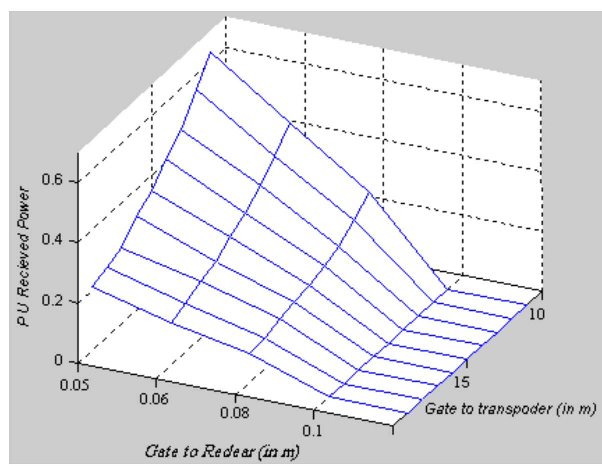

Figure (3): Relation between received power and R_2 with different values of range R_1

Figure (4) shows the efficiency of the received power can be improvement by increasing transmitter gain. The efficiency reaches 98% by increasing transmitter gain up 14 (11.46 dB) instead of 65% for transmitter gain of 11 (10.41dB).

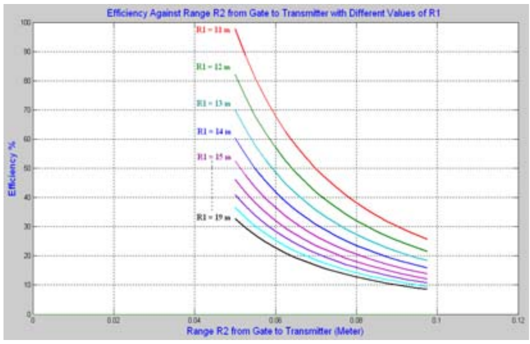

Figure (4): Efficiency Improvement

4. CONCLUSIONS

This paper is emphasized to the received power delivered to reader of RFID. This power is affected with the location of the reader with respect to the gate and the transponder. The reader should be close to both. But too much close distance to the gate may respond to far tags opening the gate for nothing. Also if most of the power were reflected, the tag would not work. If less power were reflected, reader would not be reached. The environment will mainly affect the operation of tag, so special attention should be paid to diminish the effect of the path losses and noise.

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